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Transitions in Electronic Cigarette Use among Adults in the Population Assessment of Tobacco and Health (PATH) Study, Waves 1 and 2 (2013–2015)

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Contributorship: BC designed the study and directed its implementation. BR conducted the data analysis, including quality assurance and control. SJ, AP, JP, CS, KC, GA, MG, KMC, KK, MS, CD, RN, DA, HK, NB, WC and AH contributed to the conceptual design of the study and assisted with drafting of the manuscript (e.g., preparing the literature review, identifying key findings, and interpretation of study findings in the Discussion section). All co-authors approved the final version of the manuscript prior to submission.

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Abstract

Introduction—This study assessed patterns of e-cigarette and cigarette use from Wave 1 to Wave 2 among adult e-cigarette users at Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study.

Methods—We examined changes in e-cigarette use frequency at Wave 2 among adult e-cigarette users at Wave 1 (unweighted n=2,835). Adjusted prevalence ratios (aPR) were calculated using a predicted marginal probability approach to assess correlates of e-cigarette discontinuance and smoking abstinence at Wave 2.

Results—Half (48.8%) of adult e-cigarette users at Wave 1 discontinued their use of e-cigarettes at Wave 2. Among dual users of e-cigarettes and cigarettes at Wave 1, 44.3% maintained dual use, 43.5% discontinued e-cigarette use and maintained cigarette smoking, and 12.1% discontinued cigarette use at Wave 2, either by abstaining from cigarette smoking only (5.1%) or discontinuing both products (7.0%). Among dual users at Wave 1, daily e-cigarette users were more likely than non-daily users to report smoking abstinence at Wave 2 (aPR=1.40, 95% CI:1.02, 1.91). Using a customizable device (rather than a non-customizable one) was not significantly related to smoking abstinence at Wave 2 (aPR=1.14, 95% CI:0.81, 1.60).

Conclusions—This study suggests e-cigarette use patterns are highly variable over a one-year period. This analysis provides the first nationally representative estimates of transitions among U.S. adult e-cigarette users. Future research, including additional waves of the PATH Study, can provide further insight into long-term patterns of e-cigarette use critical to understanding the net population health impact of e-cigarettes in the U.S.

INTRODUCTION

The popularity of electronic cigarette (e-cigarette) use in the United States (U.S.) has drawn considerable attention and has sparked a discussion about their potential risks and benefits for population health.[1,2] Few prospective studies of e-cigarette use among adults have examined frequency and stability of e-cigarette use over time, including the impact of dual use of cigarettes and e-cigarettes on subsequent smoking and e-cigarette use behaviors. These questions are key to understanding e-cigarettes' future population health effects.

Several cross-sectional studies have shown that most adult e-cigarette users are current or former users of other tobacco products.[3–6] In particular, e-cigarette users are most likely to be current cigarette smokers or recent quitters (i.e., ≤ one year), rather than never smokers or longer-term quitters.[5, 7] In retrospective studies, many e-cigarette users report using e-cigarettes as a way to quit or cut down on smoking or as an alternative in places where smoking is prohibited.[8–10] Though limited, a small number of longitudinal studies have examined the role of e-cigarette use frequency in smoking cessation over time and found that more frequent use (i.e., daily use) was associated with reduced cigarette consumption[11] and greater likelihood of smoking cessation at follow-up.[12] Additionally, a prospective study of Atlanta-area smokers making a first-time e-cigarette purchase found that, eight weeks

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later, 23% reported having quit smoking for at least the past 30 days, and 92% reported having reduced the number of cigarettes smoked per day.[13] Long-term, prospective, and U.S. nationally representative studies can be used to monitor such outcomes on a national scale over longer periods of time.

The Population Assessment of Tobacco and Health (PATH) Study tracks tobacco product use in a representative sample of U.S. adults,[14] 5.5% of whom reported currently (every day or some days) using e-cigarettes at Wave 1 in 2013–2014.[15] These users exhibited a wide variety of use patterns, with 42% using e-cigarettes infrequently (0–2 days of the past 30), 37% using moderately (≥3 days of the past 30, but not every day) and 21% using daily.[3] Most e-cigarette users also reported current cigarette smoking (70%), with current smoking more common among infrequent (77%) and moderate users (73%) than daily users (50%). Additional analyses indicated that exclusive daily e-cigarette users reported less dependence on their product than comparable cigarette smokers.[16] These findings provide a foundation for assessing changing use patterns and their correlates among a nationally representative group of adult e-cigarette users.

In this study, we analyze data from Wave 1 (2013–2014) and Wave 2 (2014–2015) of the PATH Study to examine changes in e-cigarette use behavior over approximately one year using longitudinal data. We assess whether e-cigarette users discontinue use, progress to more frequent use, or maintain use at Wave 2. We also estimate the proportion of Wave 1 dual e-cigarette and cigarette users who (a) completely switch to e-cigarettes at Wave 2, (b) remain dual users, or (c) completely switch to cigarette smoking, and the rates at which Wave 1 exclusive e-cigarette users (a) maintain this pattern or (b) begin or resume cigarette smoking at Wave 2. Additionally, we assess correlates of e-cigarette discontinuance and cigarette smoking abstinence at Wave 2. Lastly, we examine changes in e-cigarette users' device types from Wave 1 to Wave 2. This analysis provides the first nationally representative estimates of each of these key transitions among U.S. adult e-cigarette users.

METHODS

Data source

The PATH Study is an ongoing, nationally-representative, longitudinal cohort study of adults and youth in the U.S. The National Institutes of Health, through the National Institute on Drug Abuse, is partnering with the Food and Drug Administration's Center for Tobacco Products to conduct the PATH Study under a contract with Westat. The study was approved by the Westat Institutional Review Board.

Wave 1 data collection was conducted from September 12, 2013 to December 14, 2014; Wave 2 was conducted from October 23, 2014 to October 30, 2015. The PATH Study recruitment employed a stratified address-based, area-probability sampling design at Wave 1 that oversampled adult tobacco users, young adults (18–24 years), and African American adults. Interviews were completed with 32,320 adults aged ≥18 years at Wave 1 and 28,362 adults at Wave 2 for an overall weighted response rate of 83.2%. The differences in the number of completed interviews between Wave 1 and Wave 2 reflect attrition due to non-

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response, mortality, and other factors. The numbers at Wave 2 also reflect the addition of 1,915 participants who aged from the youth sample at Wave 1 to the adult sample at Wave 2.

This paper specifically examines Wave 2 tobacco use among the 3,642 adults who reported current (every day or some day) e-cigarette use at Wave 1 (demographics and tobacco use characteristics have been reported previously), of whom 2,959 have follow-up information at Wave 2. Further details regarding the PATH Study design and methods are published elsewhere[14] and can be viewed, along with information on accessing the data, at https://doi.org/10.3886/Series606.

Tobacco use categories

The PATH Study Wave 1 e-cigarette use questions and categories used in this analysis have been described previously.[3] Briefly, we classified Wave 1 e-cigarette users as "infrequent users" if they reported use on some days and 0–2 of the past 30 days; "moderate users" if they reported use on some days and ≥3 of the past 30 days; and "daily users" if they reported every day use.[3] Wave 1 e-cigarette users were also asked whether the e-cigarette they usually used was rechargeable and/or refillable. Users of rechargeable e-cigarettes were asked if their device used cartridges. Devices that were rechargeable, refillable, and did not use cartridges were classified as "customizable," and devices that were neither rechargeable nor refillable or used cartridges were classified as as "non-customizable."

In the Wave 2 questionnaire, participants who had ever used an "electronic nicotine product" were then asked in separate questions if they had ever used an e-cigarette (including vape pens and personal vaporizers), e-cigar, e-hookah (including hookah pens), e-pipe, or something else. We classified respondents who reported current every day or some day use of an electronic nicotine product as "current e-cigarette users." Those who reported some day use of e-cigarettes (but not the other subtypes) were asked how many of the past 30 days they had used this product, and were categorized as "infrequent" or "moderate users" identical to Wave 1 definitions. Some day users of e-cigars, e-hookah, and e-pipes were not asked the number of days that they used the product in the past 30 days, and as a result 86 users of these other electronic nicotine products but not e-cigarettes are not included in analyses of frequency of use. We categorized respondents who reported current e-cigarette use at Wave 1 and not current or ever use of e-cigarettes at Wave 2 as "former e-cigarette users."

At Wave 2, users of e-cigarettes (but not users of other electronic nicotine products) were asked if the device was rechargeable and/or refillable; those who reported using rechargeable e-cigarettes were asked if the device used cartridges or a tank system. Devices that were rechargeable, refillable, used a tank system, and did not use cartridges were classified as "customizable". Devices that were neither rechargeable nor refillable or used cartridges were classified as "non-customizable" devices. Devices with other combinations of characteristics at Wave 2 were classified as "other" types of devices.

Cigarette smoking status at Waves 1 and 2 was classified as: 1) current established cigarette user, who reported lifetime smoking of ≥100 cigarettes and currently smoked cigarettes either some days or every day; 2) recent former established user, who reported having

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smoked ≥100 cigarettes, currently not smoking at all, and having completely quit smoking within the past year (hereafter referred to as "recent quitter"); 3) long-term former established user, who reported having smoked ≥100 cigarettes, currently not smoking at all, and having completely quit smoking more than a year ago (hereafter referred to as "long-term quitter"); and 4) never-established smoker, who reported smoking fewer than 100 lifetime cigarettes (hereafter referred to as "never smoker"). In this analysis, dual use is defined as current established cigarette use and current e-cigarette use, irrespective of other tobacco product use. Respondents were also asked about current (every day or some day) use of combusted tobacco products other than cigarettes (i.e., filtered cigars, cigarillos, traditional cigars, pipes, hookah) and non-combusted products (i.e., snus pouches, loose snus, moist snuff, dip, spit or chewing tobacco, dissolvables).

Demographic characteristics

Demographic characteristics, including age, were reported by participants at Wave 1. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, non-Hispanic other, and Hispanic any race. Educational attainment was categorized as less than high school graduate, high school graduate or equivalency degree, some college or associate's degree, bachelor's degree, and more than a bachelor's degree.

Data analysis

To examine changes in e-cigarette use behavior, first we looked at changes in self-reported frequency of e-cigarette use from Wave 1 to Wave 2 (discontinued use, decreased use, maintained the same level of use, or increased use) overall and by age group. Next, we examined transitions in e-cigarette use from Wave 1 to Wave 2 by cigarette smoking status (former established cigarette user, never established cigarette user, or dual user of cigarettes and e-cigarettes). To explore transitions in device types across waves, we examined self-reported device type at Wave 2 by device type used at Wave 1 (non-customizable vs. customizable) overall and by age group. Lastly, we examined factors associated with (a) discontinuance of e-cigarette use at Wave 2 and (b) cigarette smoking abstinence at Wave 2 (i.e., smoking "not at all" at Wave 2) among dual users of e-cigarettes and cigarettes at Wave 1. An additional analysis examined factors associated with cigarette smoking abstinence at Wave 2, stratifying by those who reported using e-cigarettes at Wave 1 because "they help people quit smoking or" not (Supplemental Table).

The PATH Study population and replicate weights were used to adjust for complex study design characteristics such as oversampling and nonresponse. The weights produce estimates that are representative of the U.S. non-institutionalized, civilian population ages 18 years and older adjusting for non-response from Wave 1. All estimates in this study were calculated with balanced repeated replication methods using a Fay's adjustment value of 0.3. Prevalence ratios were calculated using a predicted marginal probability approach[17] in SUDAAN 11.0.1, and all other analyses were conducted using SAS version 9.4. Confidence intervals for proportions were constructed using the Wilson method, and tests of proportions were conducted using chi-squared tests.

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RESULTS

Patterns of e-cigarette use frequency

Among adult e-cigarette users at Wave 1 with follow-up information at Wave 2 (unweighted n=2,835), 48.8% discontinued e-cigarette use, 11.4% decreased frequency of use, 28.6% reported the same frequency of use, and 11.1% increased use by Wave 2 (Table 1). Those who reported daily use at Wave 1 were less likely to discontinue use of e-cigarettes at Wave 2 (23.7%) compared to moderate (49.0%, $P<0.0001$) or infrequent users (62.1%, $P<0.0001$). Conversely, daily users were more likely to maintain their same level of use (53.5%) compared to infrequent (19.3%, $P<0.0001$) or moderate users (24.1%, $P<0.0001$). Compared to daily e-cigarette users aged ≥25 years, young adult (aged 18–24 years) daily e-cigarette users at Wave 1 were less likely to maintain the same level of use at Wave 2 (43.1% vs. 55.3%, $P<0.05$) and were more likely to decrease their frequency of e-cigarette use at Wave 2 (30.8% vs. 21.4%, $P<0.05$).

E-cigarette and cigarette smoking transitions from Wave 1 to Wave 2

As shown in Table 2, across both exclusive e-cigarette users (i.e., those who did not report current cigarette smoking) and dual e-cigarette and cigarette users at Wave 1, there was a high degree of variability in use status at Wave 2. Among dual users at Wave 1, 87.8% smoked cigarettes at Wave 2: 43.5% discontinued e-cigarette use but continued cigarette smoking and 44.3% maintained dual use at Wave 2. Among this group, 19.6% (95% CI=17.1,22.3) reduced the number of cigarettes smoked per day at Wave 2 by at least 50%, whereas 17.1% (95% CI=14.0,20.8) increased the number of cigarettes smoked per day by at least 50% (data not shown). About 12% of dual users at Wave 1 abstained from cigarette smoking at Wave 2 either by discontinuing both products (7.0%) or maintaining e-cigarette use but not cigarette smoking (5.1%). Among exclusive e-cigarette users at Wave 1, 43.4% maintained exclusive e-cigarette use at Wave 2, and 30.9% discontinued use by Wave 2. Furthermore, among exclusive e-cigarette users who were former established cigarette users at Wave 1, 53.1% reported maintaining exclusive use of e-cigarettes at Wave 2, whereas 27.6% returned to current cigarette smoking at Wave 2 either as dual users of e-cigarettes and cigarettes (16.4%) or as exclusive established cigarette users (11.2%).

Factors associated with discontinuation of e-cigarette use

Discontinuation of e-cigarette use at Wave 2 was associated with Wave 1 tobacco use behaviors, including e-cigarette use frequency, cigarette smoking status, use of other combusted products, and device type (Table 3). Compared to non-daily e-cigarette users, daily users at Wave 1 were half as likely to discontinue e-cigarette use at Wave 2 (aPR=0.49, 95% CI=0.40,0.59). Additionally, long-term quitters at Wave 1 were less likely than never smokers to discontinue e-cigarette use (aPR=0.68, 95% CI=0.53,0.87). Users of other (non-cigarette) combusted products (compared to those who did not use other combusted products) at Wave 1 were also less likely to discontinue e-cigarette use at Wave 2 (aPR=0.87, 95% CI=0.80,0.95). Lastly, those who reported use of customizable devices at Wave 1 were less likely to discontinue e-cigarette use at Wave 2 compared to those who used non-customizable devices (aPR=0.89, 95% CI=0.81,0.99).

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Factors associated with smoking abstinence at Wave 2 among dual cigarette and e-cigarette users at Wave 1

The likelihood of cigarette smoking abstinence at Wave 2 varied based on race/ethnicity, e-cigarette use frequency at Wave 1, and cigarette dependence at Wave 1 (Table 4). Compared to non-Hispanic whites, Hispanics were more likely to abstain from smoking at Wave 2 (aPR=1.62; 1.09, 2.41). In addition, compared to non-daily e-cigarette users at Wave 1, daily users were more likely to abstain from smoking at Wave 2 (aPR=1.40, 95% CI=1.02, 1.91). Indicators of cigarette smoking dependence at Wave 1 were all negatively associated with smoking abstinence at Wave 2, including smoking a cigarette within the first 30 minutes of waking (aPR=0.65, 95% CI=0.48, 0.88), smoking >15 cigarettes per day (aPR=0.62, 95% CI=0.43, 0.90), and initiating cigarette smoking before the age of 16 (aPR=0.76, 95% CI=0.58, 0.99). Using a customizable device (rather than a non-customizable one) was not a significant predictor of smoking abstinence at Wave 2 (aPR=1.14, 95% CI=0.81, 1.60). In a sensitivity analysis, we re-ran the same regression model for the subset of dual users of e-cigarettes and cigarettes who endorsed using e-cigarettes at Wave 1 because “they help people quit smoking.” The results were similar to those reported above in terms of the associations between predictor variables in the model and smoking abstinence at Wave 2 (Supplemental Table).

Patterns of e-cigarette device type use from Wave 1 to Wave 2

As shown in Figure 1, over half (52.1%) of e-cigarette users with a non-customizable device reported discontinuing use at Wave 2, compared to 38.4% of users with a customizable device. Among non-customizable device users at Wave 1, 32.0% reported use of a non-customizable device at Wave 2, while 13.4% reported use of a customizable device. Among those who used a customizable device at Wave 1, 45.4% reported use of a customizable device, while 11.3% reported use of a non-customizable device at Wave 2.

DISCUSSION

This study reported changes in e-cigarette and cigarette use over a one-year period among a nationally representative sample of U.S. adult e-cigarette users. It also examined how changes in e-cigarette and cigarette use were associated with age, use frequency, device type, and other factors. Nearly two-thirds of adult e-cigarette users at Wave 1 of the study either decreased or discontinued their e-cigarette use by Wave 2. Among dual users of e-cigarettes and cigarettes at Wave 1, nearly half discontinued use of e-cigarettes by Wave 2 but remained cigarette smokers, while 7% discontinued use of both e-cigarettes and cigarettes at Wave 2. Further, daily e-cigarette users were less likely to discontinue e-cigarette use and more likely to abstain from cigarette smoking at Wave 2, compared to non-daily e-cigarette users.

The negative association observed in this study between use of a customizable device at Wave 1 and e-cigarette discontinuance at Wave 2 is consistent with prior reasearch suggesting more advanced generation devices can deliver cigarette-like amounts of nicotine, [18] perhaps facilitating sustained use among smokers. However, in the current study users of customizable devices were no more likely to abstain from cigarette smoking at Wave 2.

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The observed patterns of e-cigarette use and discontinuation between Waves 1 and 2, particularly among infrequent users, suggest a high level of transitory experimentation at Wave 1. As an emerging product on the U.S. market in 2013–2014, the novelty of e-cigarettes may have prompted some people to try them out of curiosity, perhaps without any intention for sustained use. Indeed, curiosity about e-cigarettes is understandable when considering the context in which they emerged—namely, a marketplace of nicotine delivery products that had remained largely unchanged for decades. Moreover, e-cigarettes—and the culture that developed around them—received widespread media attention, potentially fueling curiosity. Prior research found that people who used e-cigarettes only occasionally (≤5 times in the past 30 days) were more likely than other users to cite curiosity as their reason for use,[19] and ever-users who cited curiosity as a primary motive for use were particularly likely to discontinue use.[8] Additionally, a 2014 study of current and former cigarette smokers who have tried e-cigarettes found that the majority of current smokers eventually stopped using the devices, citing they were less enjoyable than cigarettes.[20] The relatively high rates of discontinuance reported here are consistent with emerging trends from cross-sectional surveillance data showing, after several years of sharp increase in use prevalence, a recent decrease in the prevalence of e-cigarette use among youth,[21,22] which may also suggest a role of novelty in driving earlier rises in e-cigarette use prevalence.

Across both exclusive e-cigarette users and dual e-cigarette and cigarette users at Wave 1, a high degree of variability in use status was observed at Wave 2. One in four exclusive e-cigarette users at Wave 1 reported current cigarette smoking at Wave 2 (28% of which were former cigarette users and 24% were never established cigarette users). Thus, for these adults, e-cigarette use did not discourage relapse to cigarette smoking among former smokers, nor smoking initiation among never smokers. Whereas many discontinued e-cigarette use, others maintained their same pattern and level of use. For instance, slightly over 40% of Wave 1 exclusive e-cigarette users and dual users maintained their respective patterns of use at Wave 2. Consistent with prior research showing an association between frequency of e-cigarette use and likelihood of cigarette smoking cessation,[11,23,24] results from the current study highlight smoking abstinence was positively associated with frequency of e-cigarette use, which may in turn facilitate product substitution of e-cigarettes for cigarettes in adults. Finally, changes observed in device type from Wave 1 to Wave 2 suggest some e-cigarette users were experimenting with different devices, which is consistent with prior research suggesting users differ in their device style preferences.[25,26] Future analyses of the PATH Study can assess patterns of change in device type and their potential implications for frequency of use, and the relationship of these factors on product substitution.

Limitations

Although this analysis provides useful information on transitions in e-cigarette and cigarette use over two time-points, we lack information about participants' behaviors *between* waves; for instance, an e-cigarette user who reported the same frequency of use at both waves may have used more or less frequently between waves. Also, between waves, several changes were made to the PATH Study questionnaire. Specifically, in Wave 2, unlike in Wave 1, questions about e-cigarette use were preceded with a question about whether the participant

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had ever used an electronic nicotine product. Participant responding negatively were not asked about using e-cigarettes. Furthermore, to adapt to the expanding e-cigarette marketplace, changes were made to items assessing product design features. It is unclear if changes noted in device type across the two waves reflect actual changes or artifacts of the way the device type questions were asked. Lastly, given the limited evidence available from prospective studies to suggest meaningful behavioral cut-points for e-cigarette use frequency (e.g., infrequent vs. moderate), we devised cut-points based on the distribution of the number of days used out of the past 30 days among those who reported use on some days—which is consistent with the distribution of the Wave 1 sample of e-cigarette users.[3]

Conclusions

This analysis extends prior cross-sectional findings on e-cigarette use in adults in Wave 1 of the PATH Study[3] by tracking patterns of e-cigarette and cigarette use over two time-points. Longitudinal analyses of the PATH Study data show nearly two-thirds of all adult e-cigarette users in the U.S either decreased or discontinued e-cigarette use over a one-year period. The high degree of discontinuation may suggest that many e-cigarette users experimented without intention for continued or sustained use, or that the products they tried were not to their liking. Given the variability in trajectories of e-cigarette and cigarette use, questions remain as to how stable these patterns will be over time. The extent to which dual use is a transient state that eventually leads to discontinuation of nicotine vs. exclusive use of one product, and what factors facilitate smoking cessation over time, are important public health questions. Future research, including additional waves of the PATH Study, can provide further insight into long-term patterns of e-cigarette use critical to understanding the net population health impact of e-cigarettes in the U.S.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

- Cross-sectional analyses of Wave 1 of the PATH Study showed that the majority of adult e-cigarette users in this study reported less than daily use, with nearly half reporting 0–2 days of use in the past month.
- To date few longitudinal studies have been published examining changes in e-cigarette use behavior; namely, the stability of e-cigarette use patterns, and their relationship to use of other tobacco products. Our study addresses this gap by examining changes in e-cigarette use behavior over one year.
- Longitudinal analyses suggest e-cigarette use patterns are highly variable. Half of adult e-cigarette users at Wave 1 discontinued their use by Wave 2. Among dual users of e-cigarettes and cigarettes at Wave 1, compared to non-daily e-cigarette users, daily users were more likely to report cigarette smoking abstinence at Wave 2.

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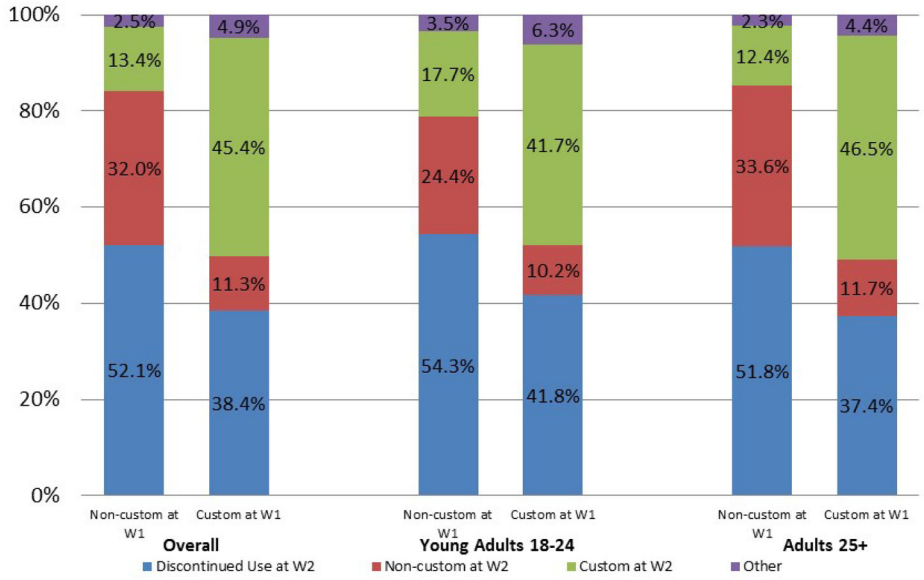

Figure 1.

Self-reported device type at Wave 2[1] by Device Type Used at Wave 1[2] Among All Adult Current E-cigarette Users at Wave 1, PATH Study (N=2,781)

[1]At Wave 2, “non-customizable” devices were defined as either 1) not rechargeable, not refillable; 2) rechargeable, not refillable, and uses cartridges, or 3) rechargeable, refillable and user cartridges. “Customizable” devices were defined as products that are rechargeable, refillable, use a tank system, and does not use cartridges “Other” was defined as any other combination of device attribute responses

[2]At Wave 1, “non-customizable” devices were defined as either. 1) not rechargeable, not refillable, 2) rechargeable, not refillable, and uses cartridges, or 3) rechargeable, refillable and uses cartridges “Customizable” devices were defined as a device that is rechargeable, refillable, and does not use cartridges (note use of a tank was not asked at W1) A small number of adult e- cigarette users (n=23) at Wave 1 reported some other combination of device attributes that are not presented in the figure above

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Tob Control. Author manuscript; available in PMC 2019 January 01.

Table 1

Patterns of E-Cigarette Use Frequency from Wave 1 (2013–2014) to Wave 2 (2014–2015) among Adult E-Cigarette Users at Wave 1[a], PATH Study (N= 2,797)

Age Category	Frequency of Use at Wave 1[b]	Frequency of Use at Wave 2 (%; 95% CI)							
		Reported the same level of frequency of use		Increased frequency of use (infrequent to moderate; or moderate to daily)		Decreased frequency of use (daily to moderate; or moderate to infrequent)		Ceased use (reported currently not using at all or never use at Wave 2)	
		%	95% CI	%	95% CI	%	95% CI	%	95% CI
All Adults 18+	All Users (n=2,797)	28.6	26.5, 30.9	11.1	9.9, 12.4	11.4	10.3, 12.7	48.8	46.4, 51.3
	Infrequent Users (n=1,173)	19.3	17.2, 21.7	18.6	16.2, 21.2	n/a		62.1	58.8, 65.2
	Moderate Users (n=1,031)	24.1	21.6, 26.8	9.4	7.7, 11.3	17.5	15.3, 20.0	49.0	46.0, 52.1
	Daily Users (n=590)	53.5	48.6, 58.4	n/a	n/a	22.8	19.4, 26.5	23.7	19.7, 28.3
Young Adults 18–24	All Users (n=814)	24.8	21.5, 28.3	12.3	10.2, 14.7	11.7	9.6, 14.3	51.2	46.9, 55.5
	Infrequent Users (n=406)	21.2	17.1, 26.0	18.2	14.5, 22.7	n/a		60.6	55.0, 65.9
	Moderate Users (n=282)	21.5	16.5, 27.5	9.6	6.5, 14.0	19.5	15.3, 24.6	49.4	42.9, 55.9
	Daily Users (n=125)	43.1	33.5, 53.4	n/a	n/a	30.8	23.2, 39.7	26.0	18.3, 35.5
Adults 25+	All Users (n=1,981)	29.5	27.0, 32.1	10.8	9.4, 12.4	11.4	10.1, 12.9	48.3	45.7, 51.0
	Infrequent Users (n=765)	18.3	15.7, 21.2	18.8	15.8, 22.1	n/a		62.9	59.0, 66.7
	Moderate Users (n=749)	24.7	21.7, 27.9	9.3	7.4, 11.6	17.1	14.5, 19.9	48.9	45.4, 52.5
	Daily Users (n=465)	55.3	49.9, 60.5	n/a	n/a	21.4	17.8, 25.5	23.3	19.1, 28.2

Abbreviations: CI, confidence interval.

Note. Frequencies are based on unweighted data and all other estimates are weighted.

[a]Among the 3,642 current (every day or some day) users at Wave 1, 683 do not have follow-up information and 245 reported never having used an e-cigarette at Wave 2. For this analysis, the 683 who do not have follow-up information at Wave 2 are excluded from the Wave 2 totals shown above; the 245 who reported current e-cigarette use at W1 but reported never use at W2 are treated as former e-cigarette users. Respondents at Wave 1 were asked about their "e-cigarette" use; whereas in Wave 2 respondents were asked about their e-cigarette use as well as other electronic nicotine products (ENPs) including "e-cigars", "e-pipes" and "e-hookah". Of the 3,642 W1 e-cigarette users, a total of 86 respondents indicated they currently used other ENPs (and not e-cigarettes), and 53 reported formerly using other ENPs (but not e-cigarettes) at Wave 2. The use states in the table above for W2 reflect use of ONLY e-cigarettes (not other ENP) as the ENP questionnaire does not ascertain the number of days used in the past 30 days. Additionally, 23 adult e-cigarette users were dropped from the current analysis due to missing data on e-cigarette use behavior.

[b]Infrequent use was defined as those who reported using an e-cigarette "some days" and reported using an e-cigarette on 0 to 2 of the past 30 days; Moderate use was defined as those who reported using an e-cigarettes on "some days" and reported using an e-cigarette on ≥3 of the past 30 days' Daily use was defined as those who reported using an e-cigarette "every day".

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Table 2

E-Cigarette Transitions from Wave 1 (2013–2014) to Wave 2 (2014–2015) by Cigarette Smoking Status and Age[a], PATH Study (N= 2,932)

Age Category	Product Use State at Wave 1	Product Use State at Wave 2 (%; 95% CI)							
		Dual Use[b]		Exclusive E-cigarette Use[c]		Exclusive Established Cigarette Use[d]		Neither E-cigarette nor Established Cigarette Use[e]	
		%	95% CI	%	95% CI	%	95% CI	%	95% CI
All Adults 18+	Dual Use (n=2036)	44.3	41.7, 47.0	5.1	4.0, 6.6	43.5	40.9, 46.2	7.0	5.9, 8.3
	Exclusive E-cigarette Use (n=896)	13.5	11.3, 16.3	43.4	40.0, 46.8	12.2	10.0, 14.9	30.9	27.5, 34.5
	- Former Established Cigarette Use (n=394)	16.4	12.7, 21.0	53.1	48.1, 58.1	11.2	8.2, 15.3	19.2	15.3, 23.8
	- Never Established Cigarette Use (n=502)[f]	10.7	7.9, 14.5	34.2	29.5, 39.2	13.2	10.4, 16.6	41.9	37.0, 47.0
Young Adults 18–24	Dual Users (n=538)	45.5	40.3, 50.8	5.3	3.5, 7.9	39.4	34.5, 44.4	9.9	7.3, 13.2
	Exclusive E-cigarette Use (n=341)	13.1	9.0, 17.1	37.1	31.5, 43.0	11.2	7.8, 16.0	38.6	32.9, 44.5
	- Former Established Cigarette Use (n=68)	23.5	14.6, 35.5	27.1	17.5, 39.5	***	***	29.7	19.2, 42.8
	- Never Established Cigarette Use (n=273)[f]	10.2	6.8, 14.9	39.9	33.5, 46.7	8.8	5.7, 13.5	41.1	34.2, 48.3
Adults 25+	Dual Use (n=1497)	44.0	41.3, 46.8	5.1	3.9, 6.7	44.5	41.7, 47.4	6.4	5.2, 7.8
	Exclusive E-cigarette Use (n=554)	13.2	10.4, 16.6	46.0	41.9, 50.2	12.7	9.9, 16.0	28.1	23.9, 32.8
	- Former Established Cigarette Use (n=326)	15.4	11.6, 20.2	56.9	51.4, 62.2	10.0	7.0, 14.2	17.7	13.6, 22.6
	- Never Established Cigarette Use (n=228)[f]	10.0	6.5, 15.1	30.4	24.4, 37.2	16.5	12.3, 21.9	43.1	35.8, 50.8

Abbreviations: CI, confidence interval.

Note. Frequencies are based on unweighted data and all other estimates are weighted.

[a]Among the 3,642 current (every day or some day) users at Wave 1, 683 do not have follow-up information and 245 reported never having used an e-cigarette at Wave 2. For this analysis, the 683 who do not have follow-up information at Wave 2 are excluded from the Wave 2 totals shown above; the 245 who reported current e-cigarette use at Wave 1 but reported never use at Wave 2 are treated as former e-cigarette users. Respondents at Wave 1 were asked about their "e-cigarette" use; whereas in W2 respondents were asked about their e-cigarette use as well as other electronic nicotine products (ENPs) including "e-cigars", "e-pipes" and "e-hookah".

The use states in the table above for Wave 2 reflect use of any ENP, including e-cigarettes.

[b]Those who reported current e-cigarette use (every day or some day) as well as current (every day or some day use) established (have smoked at least 100 cigarettes in their lives) cigarette use.

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[c] Those who reported current e-cigarette use (every day or some day) but not current established cigarette use (either not smoking every day or some days OR not having smoked at least 100 cigarettes in their lives).

[d] Those who reported current (every day or some day use) established (having smoked at least 100 cigarettes in their lives) cigarette use and reported currently not using e-cigarettes.

[e] Those who reported not currently using e-cigarettes and not being current established cigarette smokers.

[f] Never established cigarette users includes those who may have reported cigarette smoking in W1, but reported not having smoked 100 in their lifetime. Overall, this includes 52 never smokers (not even a puff) and 455 who reported ever smoking but did not meet the 100 threshold. By age, among young adults 43 reported never smoking and 231 who reported ever cigarette use but had not met the threshold; and among adults, 9 reported never smoking and 223 who reported ever cigarette use but had not met the threshold.

*** Relative standard error > 30%.

Tob Control. Author manuscript; available in PMC 2019 January 01.

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Table 3

Percent of Discontinuance of E-Cigarettes at Wave 2 among Adult E-Cigarette Users at Wave 1 and Factors Associated with Discontinuance (N = 2,939)[a], PATH Study

	% Discontinuing E-Cigarette Use at W2		Unadjusted Prevalence Ratio (PR)		Adjusted Prevalence Ratio (APR)	
	%	95%CI	PR	95%CI	APR	95%CI
Sex						
Male	49.2	46.1, 52.4	Ref.	Ref.	Ref.	Ref.
Female	47.4	44.4, 50.4	0.96	0.89, 1.05	0.94	0.86, 1.03
Age						
18–24	49.6	45.4, 53.9	Ref.		Ref.	Ref.
25–34	48.4	44.2, 52.7	0.98	0.87, 1.09	1.02	0.92, 1.14
35–44	47.8	42.9, 52.7	0.96	0.83, 1.11	1.01	0.88, 1.17
45–54	49.3	44.0, 54.5	0.99	0.88, 1.12	1.03	0.91, 1.16
55–64	47.6	42.1, 53.2	0.96	0.82, 1.12	1.01	0.87, 1.18
65+	44.2	33.8, 55.1	0.89	0.69, 1.15	1.03	0.81, 1.30
Race/Ethnicity						
White, non-Hispanic	46.6	44.0, 49.3	Ref.	Ref.	Ref.	Ref.
Black, non-Hispanic	50.7	43.4, 58.0	1.09	0.93, 1.27	0.99	0.83, 1.17
Asian, non-Hispanic	43.3	29.1, 58.7	0.93	0.64, 1.35	0.96	0.68, 1.36
Other, non-Hispanic	46.9	40.1, 53.9	1.01	0.87, 1.17	1.00	0.86, 1.16
Hispanic	56.3	51.1, 61.4	1.21	1.09, 1.34	1.08	0.97, 1.21
Education						
Less than HS	52.7	47.1, 58.3	1.06	0.90, 1.25	1.04	0.89, 1.22
HS or equivalency degree	49.6	43.8, 55.4	Ref.	Ref.	Ref.	Ref.
Some college or associate’s degree	49.2	44.2, 54.2	0.99	0.85, 1.15	1.00	0.85, 1.17
Bachelor’s degree	46.7	43.4, 50.0	0.94	0.81, 1.09	0.97	0.84, 1.12
More than bachelor’s degree	46.0	40.7, 51.3	0.93	0.78, 1.11	0.95	0.80, 1.14
Frequency of e-cigarette use at Wave 1[b]						
Daily	24.2	20.2, 28.8	0.44	0.37, 0.53	0.49	0.40, 0.59

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	% Discontinuing E-Cigarette Use at W2		Unadjusted Prevalence Ratio (PR)		Adjusted Prevalence Ratio (APR)	
	%	95%CI	PR	95%CI	APR	95%CI
Non-daily	55.0	52.6, 57.4	Ref.	Ref.	Ref.	Ref.
Cigarette smoking status at Wave 1						
Current smoker	50.5	47.8, 53.3	0.92	0.82, 1.02	0.91	0.81, 1.03
Recent quitter (<=1 year)	31.2	24.9, 38.2	0.56	0.44, 0.72	0.83	0.66, 1.03
Long-term quitter (>1 year)	29.1	22.3, 37.0	0.53	0.40, 0.69	0.68	0.53, 0.87
Never smoker	55.2	50.1, 60.2	Ref.	Ref.	Ref.	Ref.
Current use of other combusted products at Wave 1[c]						
Yes	47.7	44.3, 51.1	0.98	0.90, 1.06	0.87	0.80, 0.95
No	48.8	46.0, 51.7	Ref.	Ref.	Ref.	Ref.
Current use of other non-combusted products at Wave 1[d]						
Yes	51.0	43.8, 58.0	1.06	0.91, 1.23	1.04	0.88, 1.23
No	48.1	45.7, 50.6	Ref.	Ref.	Ref.	
Device type at Wave 1[e]						
Customizable	38.5	34.2, 43.0	0.74	0.66, 0.83	0.89	0.81, 0.99
Non-customizable	52.2	49.8, 54.6	Ref.	Ref.	Ref.	Ref.

Abbreviations: CI, confidence interval; HS, high school; PR, prevalence ratio.

Note. Unadjusted PRs were estimated using only the relevant variable as a predictor variable; all variables, including demographic characteristics, are based on responses at Wave 1. Frequencies are based on unweighted data and all other estimates, including proportions and prevalence ratios are weighted.

[a]Analysis includes those who were current (every day or some days) e-cigarette users at Wave 1 and reported either using e-cigarettes “not at all” at Wave 2 or reported at Wave 2 they never used e-cigarettes (n=1419).

[b]Respondents who reported using an e-cigarette “every day” or “some days”

[c]Other combusted products are filtered cigars, cigarillos, traditional cigars, hookah, and pipes.

[d]Other non-combusted tobacco products are smokeless tobacco (snus pouches, loose snus, moist snuff, dip, spit or chewing tobacco) and dissolvable tobacco.

[e]Device type at Wave 1 is defined here as either customizable (rechargeable, refillable, and does not use cartridges) or non-customizable (any other combination of responses to rechargeable/refillable survey items).

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Table 4

Percent of Cigarette Smoking Abstinence[a] at Wave 2 among Adult Dual Cigarette and E-cigarette Users at Wave 1[b] and Factors Associated with Smoking Abstinence (N= 2,050), PATH Study

	Abstinent from Cigarette Smoking at W2		Unadjusted Prevalence Ratio (PR)		Adjusted Prevalence Ratio (APR)	
	%	95%CI	PR	95%CI	APR	95%CI
Sex						
Male	13.1	11.1, 15.4	Ref.	Ref.	Ref.	Ref.
Female	10.9	8.9, 13.4	0.83	0.66, 1.05	0.89	0.67, 1.19
Age						
18–24	15.0	11.7, 19.0	Ref.		Ref.	
25–34	12.9	10.1, 16.4	0.86	0.62, 1.20	0.94	0.63, 1.38
35–44	12.0	8.8, 16.1	0.80	0.53, 1.21	1.02	0.61, 1.73
45–54	6.4	4.0, 10.2	0.43	0.25, 0.74	0.65	0.35, 1.22
55–64	12.1	8.4, 17.1	0.80	0.54, 1.20	1.12	0.69, 1.83
65+	19.2	11.1, 31.0	1.28	0.70, 2.34	1.38	0.63, 3.02
Race/Ethnicity						
White, non-Hispanic	11.0	9.2, 13.0	Ref.	Ref.	Ref.	Ref.
Black, non-Hispanic	10.3	6.1, 17.1	0.94	0.55, 1.63	0.82	0.44, 1.52
Asian, non-Hispanic	***		1.86	0.78, 4.46	1.53	0.52, 4.49
Other, non-Hispanic	***		0.85	0.45, 1.59	0.83	0.44, 1.57
Hispanic	21.3	16.2, 27.4	1.94	1.40, 2.69	1.62	1.09, 2.41
Education						
Less than HS	9.1	5.4, 15.0	0.93	0.44, 1.94	0.91	0.46, 1.79
HS or equivalency degree	9.8	6.2, 15.2	Ref.	Ref.	Ref.	Ref.
Some college or associate’s degree	11.9	9.2, 15.2	1.21	0.74, 1.98	1.18	0.71, 1.97
Bachelor’s degree	11.6	9.3, 14.3	1.18	0.69, 2.01	1.06	0.61, 1.86
More than bachelor’s degree	18.5	13.3, 25.1	1.88	1.01, 3.50	1.53	0.79, 2.99
Frequency of e-cigarette use at Wave 1						
Daily	16.8	12.7, 21.8	1.49	1.11, 1.99	1.40	1.02, 1.91
Non-daily	11.3	9.7, 13.1	Ref.	Ref.	Ref.	Ref.

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	Abstinent from Cigarette Smoking at W2		Unadjusted Prevalence Ratio (PR)		Adjusted Prevalence Ratio (APR)	
	%	95%CI	PR	95%CI	APR	95%CI
Current use of other combusted products at Wave 1[c]						
Yes	12.8	10.3, 15.8	1.11	0.86, 1.44	1.03	0.74, 1.42
No	11.5	9.7, 13.7	Ref.	Ref.	Ref.	Ref.
Current use of other non-combusted products at Wave 1[d]						
Yes	10.8	7.1, 16.1	0.89	0.56, 1.40	0.90	0.50, 1.63
No	12.2	10.5, 14.1	Ref.	Ref.	Ref.	Ref.
Device type at Wave 1[e]						
Customizable	14.2	11.3, 17.6	1.24	0.96, 1.62	1.14	0.81, 1.60
Non-customizable	11.4	9.6, 13.4	Ref.	Ref.	Ref.	Ref.
Endorsed using e-cigarettes because they help people quit smoking cigarettes[f]						
Yes	12.1	10.3, 14.2	1.03	0.79, 1.34	0.86	0.63, 1.16
No	11.8	9.3, 15.0	Ref.	Ref.	Ref.	Ref.
Quit attempts reported at Wave 1[g]						
Yes	12.6	10.5, 15.2	1.11	0.84, 1.46	1.07	0.79, 1.44
No	11.4	9.3, 14.0	Ref.	Ref.	Ref.	Ref.
Time to first cigarette <30 min of waking						
Yes	8.3	6.7, 10.3	0.50	0.39, 0.65	0.65	0.48, 0.88
No	16.0	13.5, 18.9	Ref.	Ref.	Ref.	Ref.
Cigs smoked per day (CPD) at Wave 1						
<15	16.3	14.0, 19.0	Ref.	Ref.	Ref.	Ref.
15+	7.3	5.4, 9.7	0.46	0.33, 0.65	0.62	0.43, 0.90
Smoking initiated before age 16						
Yes	10.3	8.5, 12.4	0.68	0.54, 0.85	0.76	0.58, 0.99
No	15.2	12.8, 17.9	Ref.	Ref.	Ref.	Ref.

Abbreviations: CI, confidence interval; PR, prevalence ratio; HS, high school.

Note. Unadjusted PRs were estimated using only the relevant variable as a predictor variable; all variables, including demographic characteristics, are based on responses at Wave 1. Frequencies are based on unweighted data and all other estimates, including proportions and prevalence ratios are weighted.

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[a] Those who were current established smokers at Wave 1 and reported smoking cigarettes “not at all” at Wave 2 (n=238).

[b] Dual users at Wave 1 includes those who reported current established cigarette smoking (every day or some day use and had smoked at least 100 cigarettes in their lifetime) and current (every day or some day) e-cigarette use.

[c] Other combusted products are filtered cigars, cigarillos, traditional cigars, hookah, and pipes.

[d] Other non-combusted tobacco products are smokeless tobacco (snus pouches, loose snus, moist snuff, dip, spit or chewing tobacco) and dissolvable tobacco.

[e] Device type at Wave 1 is defined here as either customizable (rechargeable, refillable, and does not use cartridges) or non-customizable (any other combination of responses to rechargeable/refillable survey items).

[f] Current (every day or some day) e-cigarette users at Wave 1 were shown a randomized set of 13 potential reasons why they use e-cigarette and asked to indicate which reason(s) they endorse. This stated reason read, “Using e-cigarettes helps people to quit smoking cigarettes”

[g] Current cigarette smokers at Wave 1 were asked, “In the past 12 months, have you tried to quit smoking cigarettes?” Response options include (in a choose all that apply format): 1) Yes, I have tried to quit completely; 2) Yes, I have tried to quit by reducing or cutting back; 3) No, I have reduced or cut back instead of trying to quit; 4) No, I have not tried to quit at all. Responses were coded as “yes” if a respondent selected options 1 or 2 (alone in combination with another response option).

*** Relative standard error > 30%.

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