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# Patterns of sustained *e*-cigarette use in a sample of young adults

**MeLisa Creamer**[a], **Kathleen Case**[a], **Alexandra Loukas**[b,*], **Maria Cooper**[a], and **Cheryl L. Perry**[a]

[a]School of Public Health, Austin Campus, The University of Texas Health Science Center at Houston (UTHealth), 1616 Guadalupe St, Austin, TX 78701, United States

[b]Department of Kinesiology and Health Education, The University of Texas at Austin, 2109 San Jacinto Blvd, Stop D3700, Austin, TX 78712-1415, United States

## Abstract

**Introduction:** *E*-cigarette use and devices are rapidly changing, yet there is not much scientific evidence examining these changes over time. The purpose of this study is to describe patterns of e-cigarette use in a sample of sustained (i.e., reporting past 30-day e-cigarette use at every wave) e-cigarette users over a two-year period.

**Methods:** Data are drawn from five waves of the Project M-PACT cohort. Analyses are limited to those reporting past 30-day e-cigarette use at each wave ($n = 75$). Mixed effects regressions were conducted for the following dependent variables: device type, number of days used, combustible tobacco product use, and symptoms of nicotine dependence. Each model used survey wave as the time variable, and controlled for sociodemographic variables.

**Results:** Among sustained users, the majority reported using a rechargeable device. The average number of days used was about 2 for disposable devices and 14 for rechargeable devices ($p < .0001$). The odds of combustible tobacco product use decreased over time (AOR = 0.71; 95% CI 0.57–0.89), while symptoms of e-cigarette nicotine dependence increased over time (β= 0.07 SE = 0.03, *p*-value = .02). For both e-cigarette device types, there were no changes in device type or number of days used over time.

**Conclusion:** This is one of the first studies to look at changes in e-cigarette use, including symptoms of dependence and number of days used over a two-year period. This brief report extends the current literature by examining more than the prevalence and frequency of e-cigarette use.

*Corresponding author. alexandra.loukas@austin.utexas.edu (A. Loukas).

Contributors

Author Creamer conceptualized research question and conducted analyses and wrote the initial draft of the manuscript. Author Case conducted literature searches of prior literature, and provided initial draft of discussion. Author Loukas is the PI of Project M-PACT and designed study and protocols. Author Cooper conducted literature searches. Author Perry is the overall PI of parent project. All authors contributed to and have approved the final manuscript.

Conflict of interests

All authors declare they have no conflicts of interest.

Declaration of interests

None.

**Keywords**

*E*-cigarettes; Young adults; Longitudinal research; Trajectories and transitions

## 1. Introduction

E-cigarettes have evolved rapidly since they emerged on the United States market in 2007 from disposable “cig-a-like” devices to larger modifiable and rechargeable devices (U.S. Department of Health and Human Services [HHS], 2016). The market for e-cigarettes continues to change rapidly, with the emergence of JUUL in 2016, which as of December 2017 controlled the greatest percentage of the market share (King, Gammon, Marynak, & Rogers, 2018).

Despite the diverse marketplace and increasing scientific base on e-cigarette research, there is a paucity of research on patterns of use (e.g., intensity and frequency) over time among young adults. There is ample research regarding the prevalence of e-cigarette use in young adults and adults (Coleman et al., 2017; Phillips et al., 2017; HHS, 2016). Young adult past 30-day e-cigarette use ranges from 3.7% to 13% (Amato, Boyle, & Levy, 2016; Coleman et al., 2017; Delnevo et al., 2015; Johnston, O’Malley, Bachman, Schulenberg, & Miech, 2016). There are a few studies examining the frequency (i.e., number of days used) of e-cigarette use (Amato et al., 2016; Amato, Boyle, & Levy, 2017; Biener, Song, Sutfin, Spangler, & Wolfson, 2015; Coleman et al., 2017; Delnevo et al., 2015), yet most are cross-sectional, and nearly all stratify by cigarette smoking status. In a national study, Coleman et al. examined adult data from the PATH study and found that 21.3% of e-cigarette users reported daily use, while 42.2% reported use on 0–2 days during the past month (2017).

There are few longitudinal research examining how young adult e-cigarette use changes over time. Amato et al. examined e-cigarette use over a one-year period in a sample of adult smokers and recent quitters (2017). Among those who had reported using e-cigarettes fewer than 5 days during the past 30 at baseline, only 27% reported use 1-year later, while 89% of those reporting daily use at baseline reported use 1-year later (Amato et al., 2017). Most research focuses on adults and does not necessarily focus on young adults (Etter & Bullen, 2014; Hitchman, Brose, Brown, Robson, & McNeill, 2015; Zhuang, Cummins, Sun, & Zhu, 2016). Yet, young adults have the highest prevalence of e-cigarette use among adult age groups, and emerging adulthood theory indicates that young adulthood is when tobacco use behaviors are solidified (Arnett, 2000; Bernat, Klein, & Forster, 2012). To our knowledge, no study has examined patterns of use in a sample of sustained (i.e., reporting e-cigarette use at multiple waves [Kasza et al., 2017]) young adult e-cigarette users. The purpose of this study is to describe patterns of e-cigarette use over a 2-year period in a longitudinal sample of young adults in Texas.

## 2. Methods

### 2.1. Project M-PACT

Data for this study are drawn from the Marketing and Promotions Across Colleges in Texas (Project M-PACT) study. Project M-PACT is a rapid response surveillance system, which examines tobacco product use, and factors associated with use, in a sample of college students from the four major metropolitan areas in Texas. A total of 24 colleges, three 2-year and three 4-year in each city, were recruited to draw participants. To be eligible to participate, students needed to be between 18 and 29 years old and enrolled in one of the 24 colleges.

Data collection began in Fall 2014; students were emailed a link to the online survey, which took approximately 25 min to complete. A total of 5482 students responded to the wave 1 survey. Every 6 months following, the same students were re-contacted (texted and emailed) and asked to complete the survey, for a total of 6 waves. At the time of these analyses only 5 waves were available. Retention rates for waves 2 to 5 ranged from 79 to 81%. More details regarding Project M-PACT are published elsewhere (Creamer et al., 2018; Loukas et al., 2016).

### 2.2. Statistical analyses

Analyses for this study were conducted in Stata 15 (College Station, TX) and were limited to those students who reported past 30-day e-cigarette use at all 5 waves of the project ($n$ = 75). Users who reported use of neither a rechargeable nor a disposable device were deleted (a total of 8 observations over the 5 waves). Mixed effects regression models were used to assess changes in the following dependent variables: device type; combustible tobacco product use; number of days e-cigarettes were used; and symptoms of nicotine dependence. Separate models were conducted for each dependent variable. Independent variables included in each model were time (survey wave), wave 1 age, sex, race/ethnicity, and school type.

### 2.3. Measures

For each product, a preamble, including a picture and description of product, was included. Past 30-day e-cigarette use was asked with the question, “During the past 30 days, have you used any ENDS product (i.e., an e-cigarette, vape pen, or e-hookah), even one or two puffs, as intended (i.e., with nicotine cartridges and/or e-liquid/e-juice)?” Answer choices were coded “0” for “no” and “1” for “yes.”

Device type was derived from the questions, “During the past 30 days, have you used a disposable e-cigarette or an e-cigarette with a disposable nicotine cartridge? Neither requires the addition of e-liquid/ e-juice;” and “During the past 30 days, have you used a vape pen, personal vaporizer, or any other device as intended (i.e., with nicotine e-liquid/e-juice)?” Pictures of devices were provided. Those who reported “yes” to disposable and “no” to vape pen were classified as “disposable users.” Those who reported “no” to disposable and “yes” to vape pen were classified as “rechargeable users.” Lastly, those who reported “yes” to both

questions were classified as “both users.” For both device type questions, a follow-up question asked, “On how many of the past 30 days have you used such a product?”

Combustible tobacco product use was derived using the following questions, “On how many of the past 30 days did you smoke cigarettes?”; “During the past 30 days, how many days did you smoke a cigar product as intended?”; and “On how many of the past 30 days have you smoked a hookah as intended?” If participants answered “yes” to one of these, then they were classified as combustible tobacco product users.

Symptoms of e-cigarette nicotine dependence were assessed using a scale of three items adapted from valid and reliable measures (DiFranza et al., 2002; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991): “Have you ever felt like you really needed to use an ENDS product?”; “Have you ever had a strong craving for an ENDS product?”; and “How soon after you wake up do you typically use your first ENDS product?” The first two questions were coded “0” for “no” and “1” for “yes.” The third was coded “1” for “within first 30 minutes,” and “0” for all other options. Responses were summed together for scores ranging from 0 to 3; a higher score indicates higher dependence.

## 3. Results

A total of 3510 participants responded to all five surveys, with the prevalence of past 30-day e-cigarette use ranging from 8.8% to 15.3% across the waves. Of these 3510 students, 75 (2.0%) were sustained users, reporting past 30-day use at all five waves. A majority (55%) of the sustained users were male; 40% white; 28% Hispanic; and 93% attended a four-year college. The average age of sustained users at wave 1 was 20.93 (SD = 2.34). Most participants reported use of a rechargeable device; and dual use of e-cigarettes and combustible tobacco was common (Table 1). Those reporting using a rechargeable device reported more days of use at each wave than those reporting use of a disposable e-cigarette product ($p < .0001$).

Results of the mixed effects models (Table 2) show that the odds of combustible tobacco product use decreased over time (AOR: 0.71, 95% CI 0.57, 0.89). The symptoms of nicotine dependence increased over time (b = 0.07, SE = 0.03, $p$-value = .02). There was no change in type of device used or number of days used over time for either device type. At wave 1 the mean number of days used was 1.8 and 14.1 for disposable and rechargeable devices, respectively, compared to 1.2 and 13.9 at wave 5.

## 4. Conclusions

To our knowledge, this is the first study to describe characteristics of sustained users of e-cigarette products over time in a sample of young adults. Previous studies of e-cigarette use in adults have primarily described the prevalence of e-cigarette use, often in the context of cigarette smoking. Of note, sustained e-cigarette use was uncommon among young adults, with only 2% of the cohort reporting use at all 5 waves. This could indicate most users are experimenting, consistent with the prior literature among smokers (Biener et al., 2015; Delnevo et al., 2015; Sutfin, McCoy, Morrell, Hoeppner, & Wolfson, 2013). The current study extends previous research by examining characteristics of regular e-cigarette use over

time, regardless of cigarette smoking status. Even though combustible tobacco product use decreased over time, dual/ poly use is still common, with over half of the sample (59.6%) reporting combustible tobacco product use at wave 5. This is similar to the prevalence of polytobacco use reported by King, Reboussin, et al. 2018, yet lower than the 69.7% of the dual use of cigarettes and e-cigarettes reported in Coleman et al. (2017).

Our finding that e-cigarette-specific symptoms of nicotine dependence increased over time is consistent with previous research on symptoms of nicotine dependence among *cigarette* users. Specifically, Heinz et al., 2010 found that symptoms of nicotine dependence increased over a two-year study period among a sample of adolescent cigarette smokers (2010). While there is indication that e-cigarette users experience lower levels of dependence as compared to cigarette users (Liu, Wasserman, Kong, & Foulds, 2017), research indicates that e-cigarettes are capable of producing symptoms of dependence among users (Case et al., 2018; Liu et al., 2017). Results add to the limited research on e-cigarette-specific symptoms of nicotine dependence by finding that symptoms significantly increase over time among a sample of sustained past 30-day users, even as use of combustible products decreased. These findings suggest that nicotine dependence may play an important role in the continued use of e-cigarettes among young adults. In a recent study of e-cigarette-specific symptoms of nicotine dependence among adolescents, Case et al. found that adolescents who reported more symptoms were less likely to want to quit e-cigarettes and report a past year quit attempt (2018). Thus, symptoms of e-cigarette dependence may be significant impediments to e-cigarette cessation among young adults.

This study shows the importance of examining more than the prevalence and correlates of e-cigarette use. There has been a focus on specific measures (Amato et al., 2016; Pearson et al., 2018; Weaver et al., 2017), but there is a paucity of research with empirical data to support definitions of sustained use (Amato et al., 2016). In this study, those reporting past 30-day use of a rechargeable e-cigarette reported using on less than fifteen days per month, yet those using disposable devices reported using on less than five days per month. Given the light levels of e-cigarette use, our findings seem to contradict the call to primarily assess daily use or former daily use (Pearson et al., 2018). Future research should consider how infrequent or low levels of e-cigarette use change over time; namely, do these users remain light users, quit using e-cigarette products altogether, or switch to other products? It is important to note that due to the small sample size of sustained e-cigarette users in the current study, these findings should be replicated in other samples of young adults.

### 4.1. Strengths and limitations

The study followed participants for two years, and drew from a large sample of participants. Despite the strengths, some limitations should be acknowledged. The study included a sample of 75 people, which is relatively small compared to the larger sample size. Generalizability is limited since these data are drawn from participants at Texas colleges. Due to the longitudinal nature of the study and maintaining consistency in items over time, we were limited in our ability to classify devices. Additional questions on devices were added as the e-cigarette marketplace diversified, but for this study, we could only classify devices as disposable or rechargeable.

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## HIGHLIGHTS

- Examines patterns and changes in e-cigarette use over 2 years among sustained users
- Highlights need for e-cigarette specific dependence measures
- Sustained e-cigarette (i.e., use every six months for two years) was uncommon.
- Dual/poly use decreased over time, yet remained common after two years.

**Table 1**

Dependent variables across time.

| | Wave 1 | Wave 2 | Wave 3 | Wave 4 | Wave 5 |
|---|---|---|---|---|---|
| | **n (%)** | **n (%)** | **n (%)** | **n (%)** | **n (%)** |
| Device type | | | | | |
| Disposable | 3 (4.2%) | 1 (1.4%) | 3 (4%) | 4 (5.5%) | 4 (5.4%) |
| Rechargeable | 54 (75%) | 61 (83.6%) | 63 (84%) | 61 (83.6%) | 61 (82.4%) |
| Both | 15 (20.8%) | 11 (15.1%) | 9 (12%) | 8 (10.9%) | 9 (12.2%) |
| Combustible tobacco product use[a] | 56 (77.8%) | 49 (69%) | 52 (69.3%) | 47 (64.4%) | 44 (59.5%) |
| | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| Days-disposable | 1.8 (5.6) | 1.0 (3.8) | 1.4 (4.7) | 1.8 (6.0) | 1.2 (4.2) |
| Days-rechargeable | 14.1 (11.4) | 14.7 (11.9) | 15.7 (11.9) | 15.6 (12.3) | 13.9 (12.4) |
| Nicotine dependence[b] | 1.04 (1.2) | 1.1 (1.2) | 1.2 (1.2) | 1.2 (1.2) | 1.3 (1.2) |

[a] Past 30-day use of cigarettes, cigar products, or hookah.

[b] Nicotine dependence is measured on a scale from 0 to 3, a higher score indicates more symptoms of nicotine dependence.

**Table 2**

Mixed effects regression models[*] evaluating changes in dependent variables over time (waves 1–5), while controlling for demographics ($n = 75$).

| Mixed effects logistic regression | | | | |
|---|---|---|---|---|
| Combustible tobacco product use[a] | | | | |
| Time | Adjusted odds ratio (AOR) | Std err | P > \|z\| | 95% CI |
| | 0.71 | 0.08 | 0.002 | 0.57, 0.89 |

| Mixed effects linear regressions | | | | |
|---|---|---|---|---|
| Device type | | | | |
| Time | Estimate | Std Err | P > \|z\| | 95% CI |
| | −0.21 | 0.11 | 0.06 | −0.43, 0.012 |
| Days-disposable | | | | |
| Time | Estimate | Std Err | P > \|z\| | 95% CI |
| | −0.05 | 0.14 | 0.71 | − 0.32, 0.22 |
| Days-rechargeable | | | | |
| Time | Estimate | Std Err | P > \|z\| | 95% CI |
| | 0.14 | 0.28 | 0.62 | − 0.40, 0.68 |
| Nicotine dependence[b] | | | | |
| Time | Estimate | Std Err | P > \|z\| | 95% CI |
| | 0.07 | 0.03 | 0.02 | 0.01, 0.13 |

[*] Results here are for the independent time variable of survey wave. Each model is controlled for wave 1 age, sex, race/ethnicity, and school type. For dependent variable “combustible tobacco product use” a logistic regression model was estimated; for dependent variables “device type,” “days-disposable,” “days-rechargeable,” and “nicotine dependence” linear regression models were estimated.

[a] Past 30-day use of cigarettes, cigar products, or hookah

[b] Nicotine dependence is measured on a scale from 0 to 3, a higher score indicates more symptoms of nicotine dependence.