



## Short Communication

# The relationship between family history of tobacco use and progression to tobacco use among young adult e-cigarette users

Lyric K. Tully<sup>a,\*</sup>, John B. Correa<sup>a,b</sup>, Neal Doran<sup>a,b</sup><sup>a</sup> Department of Psychiatry, University of California, 8950 Villa La Jolla Drive, Suite B109, San Diego, CA 92037, United States of America<sup>b</sup> Psychology Service, VA San Diego Healthcare System, 3350 La Jolla Village Drive, MC116B, San Diego, CA 92161, United States of America

## ARTICLE INFO

## Keywords:

e-Cigarettes  
Tobacco  
Family history  
Young adults

## ABSTRACT

Family history of tobacco use and use of e-cigarettes have both been associated with increased tobacco use among young adults. However, to our knowledge, these variables have not been considered simultaneously. This study was designed to evaluate the hypothesis that family history of tobacco use would predict tobacco product use over time among young adult e-cigarette users with limited combustible tobacco use experience. A sample of 124 participants were recruited online from across the United States, completed five surveys over 12 months, and reported use of nicotine and tobacco products over the previous two weeks at each survey. Family history of nicotine and tobacco use was reported at the 6-month assessment, and data were collected in 2017 and 2018. Regression models indicated that family history was associated with likelihood of cigarette use (odds ratio = 1.02 [95% confidence interval = [1.00, 1.04]). Significant interactions between family history and linear (OR = 1.05 [1.01, 1.10]) and quadratic (OR = 0.99 [0.98, 1.00]) time terms indicated that the association between family history and likelihood of combustible product use shifted over time. In both cases, more extensive family histories predicted greater use frequency, and follow-up analyses showed that more extensive family history was associated with greater combustible tobacco product use 3, 6, and 9 months following baseline. Family history of nicotine/tobacco use may promote initiation of tobacco use among e-cigarette users. These results suggest family history of tobacco use may comprise a risk factor for combustible tobacco use within the evolving tobacco product landscape.

## 1. Introduction

Recent research has indicated that e-cigarette use is becoming increasingly common among young adults (Ramo et al., 2015). Although long-term health consequences of using e-cigarettes remain uncertain, some studies suggest that using e-cigarettes is associated with respiratory disorders and exposure to chemicals that can promote respiratory disease (Farsalinos et al., 2015; Wills et al., 2019). Although some data characterize e-cigarettes as a healthier alternative to tobacco cigarettes (Choi and Forster, 2013; Sutfin et al., 2013), other findings suggest that e-cigarette use could promote tobacco use, especially within younger populations (Leventhal et al., 2015; Primack et al., 2015).

Research has also shown that individuals with a family history of smoking tobacco cigarettes are more likely to smoke cigarettes themselves (Peterson et al., 2006). However, little is known about whether family history of nicotine and tobacco product use is associated with subsequent combustible tobacco use among young adults. It is possible

that e-cigarette use and family history of combustible tobacco use might work synergistically to promote transitions to use of combustible tobacco products. This analysis was intended to evaluate the hypothesis of an association between family history of using nicotine/tobacco products and transitions to use of combustible tobacco products among young adult e-cigarette users. More specifically, we expected that participants with more family members with histories of nicotine/tobacco use would be more likely to begin using cigarettes and other combustible tobacco products.

## 2. Materials and methods

### 2.1. Participants

The sample included 124 young adults aged 18–24 who had reported using e-cigarettes at least monthly for the past six months. Participants were required to have reliable Internet access, to be fluent in English, to have not smoked cigarettes in the past sixty days, to have

\* Corresponding author at: 8950 Villa La Jolla Drive, Suite B109, San Diego, CA 92037, United States of America.

E-mail addresses: [ltully@ucsd.edu](mailto:ltully@ucsd.edu) (L.K. Tully), [john.correa@va.gov](mailto:john.correa@va.gov) (J.B. Correa), [nmdoran@ucsd.edu](mailto:nmdoran@ucsd.edu) (N. Doran).

smoked ten or fewer lifetime cigarettes, and to have not smoked hookah, cigars, or cigarillos more than three times in the past six months.

### 2.2. Procedure

All study materials and procedures were approved by the University of California, San Diego Institutional Review Board, and data were collected between January 2017 and March 2018. Participants were recruited via advertisements on Facebook. All screening, consent, and survey materials were completed online by participants via [surveymonkey.com](http://surveymonkey.com) (SurveyMonkey, Inc., San Mateo, CA). After completing an eligibility screen that asked about history of e-cigarette and tobacco product use, eligible individuals were emailed a link to the consent form and baseline survey by study staff. Those who were interested in participating provided electronic informed consent before completing the baseline survey. Participants then completed online assessments quarterly for the next 12 months, resulting in five total assessments per person. Participants received virtual gift cards as compensation, which increased in amount for every two assessments completed.

### 2.3. Measures

Demographic characteristics were collected at baseline and included age, gender, race/ethnicity, years of education, student status, and employment status. Gender was categorized as male, female, or in another way. Race/ethnicity was collapsed into four categories: Caucasian, Asian or Pacific Islander, Hispanic or Latino, and multiple/other/unknown.

At each assessment, participants were asked to recall the number of cigarettes smoked on each of the past fourteen days using the timeline follow-back procedure (Sobell and Sobell, 1996). This variable was transformed into a binary variable indicating whether or not participants reported any past 14-day cigarette use at each timepoint. Past-14-day use of other combustible tobacco products – hookah, cigars, and cigarillos more specifically – was measured at each survey assessment with one yes/no item per product. These items, along with the binary tobacco cigarette item, were combined to create a single binary variable evaluating whether or not participants reported using any combustible tobacco products over the past fourteen days at each timepoint.

Family history of tobacco use was measured at the 6-month survey. Participants reported whether parents, siblings, or maternal and paternal grandparents were non-users, former users, or current users of e-cigarettes, cigarettes, or other tobacco products (i.e., hookah, cigars, cigarillos, snus, or smokeless tobacco). This allowed for the calculation of a continuous family use variable, which accounted for the number of family members who were reported by participants to be former or current users of any of these products (range 0–7).

### 2.4. Data analytic plan

All analyses were conducted in Stata version 15 (StataCorp LP, College Station, TX). Race/ethnicity, age, and gender were included as covariates in all analyses, and family history was entered as a continuous predictor in all statistical models. Outcomes were binary and time-varying, and reflected whether or not participants reported using either cigarettes or any combustible tobacco product at each timepoint. An alpha level of  $p < .05$  was used as the criterion for identifying statistical significance.

To test whether family history of tobacco use predicted participants' use of any combustible tobacco products or any use of cigarettes over time, two separate generalized estimating equations (GEE) models evaluated whether time, family history, and their interaction predicted these two outcomes. GEE is a common analytic approach for evaluating changes in binary smoking-related outcomes over time (Lee et al.,

2007). An exchangeable correlation structure was implemented in both models, and both linear and quadratic time terms were entered into each model as predictors. Thus, initial models included family history X time and family history by time<sup>2</sup> interactions, and significant interactions were followed by simple effects tests consisting of binary logistic regression models at each timepoint to examine how the relationship between family history and the outcome changed over time. Non-significant interaction terms were removed and the model refit.

## 3. Results

### 3.1. Descriptive statistics and rates of product use

The sample of 124 participants was 49.2% male, 73.4% Caucasian, 54.8% full-time students, and reported a mean age of  $19.5 \pm 1.6$  years. Past-two-weeks use of any combustible tobacco product (i.e., tobacco cigarettes, hookah, cigars, or cigarillos) varied at each timepoint – 21.0% at baseline, 35.5% at 3 months, 31.5% at 6 months, 22.6% at 9 months, 23.4% at 12 months. Cigarette use also varied at each timepoint: 4.0% at baseline, 15.3% at 3 months, 13.7% at 6 months, 13.7% at 9 months, 10.5% at 12 months. The average number of family members with a history of e-cigarette, cigarette, or other tobacco use was  $2.37 \pm 1.77$  (median = 2, interquartile range = 2). Data were missing for 0 participants at baseline, 5 participants at 3 months, 0 participants at 6 months, 5 participants at 9 months, and 12 participants at 12 months. Missingness was not associated with family history, age, gender, race/ethnicity, or student status.

### 3.2. Predictors of tobacco product use over time

Table 1 summarizes GEE results evaluating predictors of any combustible tobacco product use and of cigarette use. For the former model, race/ethnicity (odds ratio = 1.07 [95% confidence interval = 1.02, 1.12]), family history X time (OR = 1.05 [1.01, 1.10]) and family history X time<sup>2</sup> (OR = 0.99 [0.98, 1.00]) were significantly associated with combustible product use. In the latter model, the association between family history and likelihood of cigarette use was consistent over time (OR = 1.02 [1.00, 1.04]); each additional family member with a history of nicotine/tobacco use was associated with a 2% increase in the

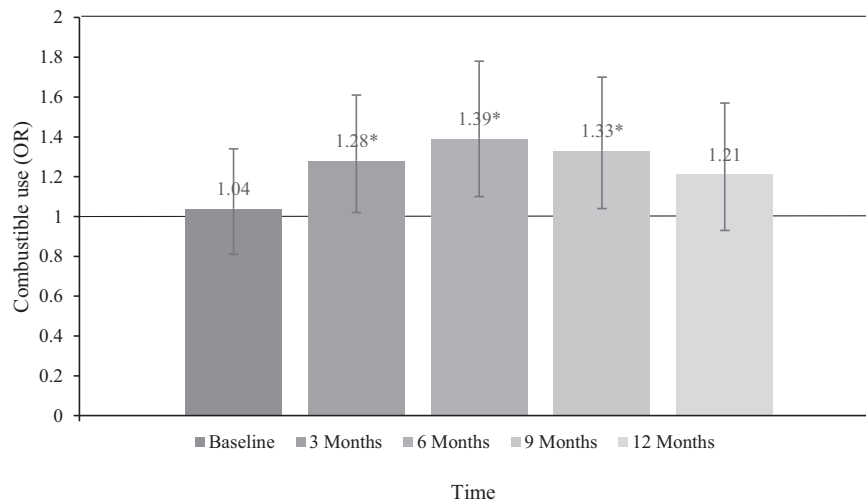
**Table 1**  
GEE results evaluating predictors of combustible tobacco product use and predictors of cigarette use.

Predictor of combustible use	Odds ratio	95% CI	SE	z	p
<b>Race</b>	<b>1.07</b>	<b>[1.02, 1.12]</b>	<b>0.03</b>	<b>2.98</b>	<b>.003</b>
Age	0.99	[0.96, 1.02]	0.02	-0.69	.488
Gender	0.95	[0.87, 1.04]	0.04	-1.17	.242
Family History	1.01	[0.97, 1.05]	0.02	0.51	.613
Time	0.96	[0.85, 1.09]	0.06	-0.57	.568
Time <sup>2</sup>	1.00	[0.97, 1.04]	0.02	0.32	.752
<b>Family History X Time</b>	<b>1.05</b>	<b>[1.01, 1.10]</b>	<b>0.02</b>	<b>2.24</b>	<b>.025</b>
<b>Family History X Time<sup>2</sup></b>	<b>0.99</b>	<b>[0.98, 1.00]</b>	<b>0.01</b>	<b>-1.99</b>	<b>.046</b>

Predictor of cigarette use	Odds ratio	95% CI	SE	z	p
Race	1.03	[1.00, 1.06]	0.02	1.65	.098
Age	0.99	[0.97, 1.01]	0.01	-1.09	.275
Gender	0.95	[0.89, 1.01]	0.03	-1.72	.086
Family History	1.02	[1.00, 1.04]	0.01	2.15	.031
Time	1.09	[1.03, 1.15]	0.03	2.92	.004
Time <sup>2</sup>	0.98	[0.97, 1.00]	0.01	-2.49	.013

Notes: SE = standard error, CI = confidence interval. Statistically significant predictors are in **bold italics**. Race was coded as 0 = Caucasian, 1 = Asian or Pacific Islander, 2 = Hispanic or Latino, 3 = multiple/other/unknown. Gender was coded as 0 = male, 1 = female, 2 = in another way. Time was coded as 0 = baseline, 1 = 3 months post baseline, 2 = 6 months post baseline, 3 = 9 months post baseline, 4 = 12 months post baseline.



**Fig. 1.** Odds ratios for the association between combustible tobacco use and family history, adjusted for age and gender, at each timepoint. Values with a \* and with a bar where confidence interval does not contain one are significant ( $p < .05$ ).

odds of cigarette use over time.

### 3.3. Simple effects analyses

Simple effects tests were performed to better interpret the significant family history  $\times$  time<sup>2</sup> association with combustible product use. Results are presented in Fig. 1. Family history of tobacco use was not related to combustible tobacco use at baseline but was a significant predictor at the 3-month, 6-month, and 9-month follow-ups. These results suggest that at these assessments, for each additional family member with a history of tobacco use, there was a 28–39% increase in odds of participants using a combustible tobacco product. However, the association appeared to decrease between the 9- and 12-month follow-ups and was no longer significant at the latter assessment.

## 4. Discussion

This study was designed to evaluate the hypothesis that young adult, e-cigarette users were more likely to transition to tobacco use over one year of follow-up if they had stronger family histories of nicotine/tobacco use. Results supported this hypothesis and indicated that more frequent use of these products by family members was a significant predictor of use of combustible tobacco products, including cigarettes, hookah, cigars, and cigarillos, over time. Follow-up analyses indicated that this association increased between the baseline and 3-month assessments, and then decreased between 9 and 12 months in concert with the overall prevalence of combustible product use. Similarly, more extensive family history of nicotine/tobacco use was consistently associated with cigarette use across time.

These findings reinforce trends that have been previously established in the literature. First, they indirectly support the changing landscape of nicotine and tobacco product use, specifically among young adults. Recent epidemiological studies indicate that prevalence of smoking among young adults has declined in recent years (Jamal, 2016; Johnson et al., 2018). In contrast, prevalence of use of alternative tobacco products among young adults, including hookah and cigarillos, has increased in recent years (e.g., Soulakova et al., 2018). Further, a significant proportion of young adult e-cigarette users use multiple nicotine/tobacco products (King et al., 2018). Our data support these perspectives – more specifically, rates of cigarette use were lower than rates of other tobacco product use in this sample, while use of combustible tobacco products remained common. Results reported here can be used to support policies and public health initiatives aimed at limiting young adults' access to e-cigarettes and informing them that e-

cigarettes may promote use of combustible tobacco in general.

Second, these findings align with other research demonstrating that family history of tobacco use can have a significant impact on tobacco use among young adults (Chassin et al., 1994; Ling et al., 2009). Several biopsychosocial factors represent potential mechanisms through which family history could promote transitions from e-cigarettes to combustible tobacco products. Familial nicotine exposure combined with direct nicotine exposure might synergistically predispose younger e-cigarette users to develop nicotine dependence and to initiate combustible tobacco use. It is also possible that e-cigarette users' risk perceptions for combustible tobacco products might be influenced by family member use of tobacco, with parental modeling or cultural attitudes towards tobacco use possibly underlying reduced risk perceptions. Finally, these effects might also be influenced by changes in expectancies, which are outcomes or consequences associated with tobacco use (Spruijt-Metz et al., 2005). Expectancies moderate the relationship between family history of tobacco use and tobacco initiation (Khoddam and Doran, 2013) and are associated with concurrent e-cigarette and tobacco use among young adults (Doran and Brikmanis, 2016).

The results reported here should be evaluated within the context of the study's limitations. These include limited diversity in terms of race/ethnicity, increasing rates of attrition over time, and a composite combustible use outcome that did not allow for exploration of use specific tobacco products besides cigarettes. Generalizability to never-smokers may be limited in that 43% of participants had smoked 1–10 cigarettes prior to baseline. We also did not clarify in our assessments whether participants' biological family members or, where appropriate, their step-parents or step-siblings had a history of tobacco use. Further, we did not ask for a specific number of siblings who had a positive history of tobacco product use, instead simply asking if any siblings were previous or current tobacco users. Finally, because outcomes were measured at each timepoint and family history was only measured at the 6-month follow-up, we cannot be certain whether this assessment influenced combustible tobacco use at subsequent timepoints or whether family history might have changed between baseline and 6-months.

However, these results converge to identify a unique factor – family use of nicotine and tobacco products – that could play a role in promoting transitions to tobacco use among young adults using e-cigarettes. These results also support integrating familial exposure to nicotine and tobacco into prevention and intervention approaches targeting tobacco use within this population. However, early intervention programs are necessary to mitigate the effects of familial exposure to nicotine and tobacco products and to aid in preventing the uptake of

combustible tobacco products.

## Disclosure

This work was supported by the National Institutes of Health grant R01 DA037217. The authors declare no conflicts of interest.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2019.100914>.

## References

- Chassin, L., Presson, C.C., Sherman, S.J., Mulvenon, S., 1994. Family history of smoking and young adult smoking behavior. *Psychol. Addict. Behav.* 8 (2), 102–110. <https://doi.org/10.1037/0893-164X.8.2.102>.
- Choi, K., Forster, J., 2013. Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young US midwestern adults. *Am. J. Public Health* 103 (3), 556–561. <https://doi.org/10.2105/Ajph.2012.300947>.
- Doran, N., Brikmanis, K., 2016. Expectancies for and use of e-cigarettes and hookah among young adult non-daily smokers. *Addict. Behav.* 60, 154–159. <https://doi.org/10.1016/j.addbeh.2016.04.008>.
- Farsalinos, K.E., Kistler, K.A., Gillman, G., Voudris, V., 2015. Evaluation of electronic cigarette liquids and aerosol for the presence of selected inhalation toxins. *Nicotine Tob. Res.* 17 (2), 168–174. <https://doi.org/10.1093/ntr/ntu176>.
- Jamal, A., 2016. Current cigarette smoking among adults—United States, 2005–2015. *Morb. Mortal. Wkly Rep.* 65 (44), 1205–1211. <https://doi.org/10.15585/mmwr.mm6544a2>.
- Johnson, A.L., Collins, L.K., Villanti, A.C., Pearson, J.L., Niaura, R.S., 2018. Patterns of nicotine and tobacco product use in youth and young adults in the United States, 2011–2015. *Nicotine Tob. Res.* 20 (Suppl. 1), S48–S54. <https://doi.org/10.1093/ntr/nty018>.
- Khoddam, R., Doran, N., 2013. Family smoking history moderates the effect of expectancies on smoking initiation in college students. *Addict. Behav.* 38 (8), 2384–2387. <https://doi.org/10.1016/j.addbeh.2013.03.012>.
- King, J.L., Reboussin, D., Ross, J.C., Wiseman, K.D., Wagoner, K.G., Sutfin, E.L., 2018. Polytabacco use among a nationally representative sample of adolescent and young adult e-cigarette users. *J. Adolesc. Health* 63 (4), 407–412. <https://doi.org/10.1016/j.jadohealth.2018.04.010>.
- Lee, J.H., Herzog, T.A., Meade, C.D., Webb, M.S., Brandon, T.H., 2007. The use of GEE for analyzing longitudinal binomial data: a primer using data from a tobacco intervention. *Addict. Behav.* 32 (1), 187–193. <https://doi.org/10.1016/j.addbeh.2006.03.030>.
- Leventhal, A.M., Strong, D.R., Kirkpatrick, M.G., Unger, J.B., Sussman, S., Riggs, N.R., ... Audrain-McGovern, J., 2015. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA* 314 (7), 700–707. <https://doi.org/10.1001/jama.2015.8950>.
- Ling, P.M., Neilands, T.B., Glantz, S.A., 2009. Young adult smoking behavior: a national survey. *Am. J. Prev. Med.* 36 (5), 389–394. e2. <https://doi.org/10.1016/j.amepre.2009.01.028>.
- Peterson Jr., A.V., Leroux, B.G., Bricker, J., Kealey, K.A., Marek, P.M., Sarason, I.G., Andersen, M.R., 2006. Nine-year prediction of adolescent smoking by number of smoking parents. *Addict. Behav.* 31 (5), 788–801. <https://doi.org/10.1016/j.addbeh.2005.06.003>.
- Primack, B.A., Soneji, S., Stoolmiller, M., Fine, M.J., Sargent, J.D., 2015. Progression to traditional cigarette smoking after electronic cigarette use among US adolescents and young adults. *JAMA Pediatr.* 169 (11), 1018–1023. <https://doi.org/10.1001/jamapediatrics.2015.1742>.
- Ramo, D.E., Young-Wolff, K.C., Prochaska, J.J., 2015. Prevalence and correlates of electronic-cigarette use in young adults: findings from three studies over five years. *Addict. Behav.* 41, 142–147. <https://doi.org/10.1016/j.addbeh.2014.10.019>.
- Sobell, L.C., Sobell, M.B., 1996. *Timeline Follow Back: A Calendar Method for Assessing Alcohol and Drug Use (UsersUser's Guide)*. Addiction Research Foundation, Toronto.
- Soulakova, J.N., Pham, T., Owens, V.L., Crockett, L.J., 2018. Prevalence and factors associated with use of hookah tobacco among young adults in the US. *Addict. Behav.* 85, 21–25. <https://doi.org/10.1016/j.addbeh.2018.05.007>.
- Spruijt-Metz, D., Gallaher, P., Unger, J.B., Johnson, C.A., 2005. Unique contributions of meanings of smoking and outcome expectancies to understanding smoking initiation in middle school. *Ann. Behav. Med.* 30 (2), 104–111.
- StataCorp, L. P., 2015. *Stata Surv Data Ref Man Release*. StataCorp LP, College Station, TX, pp. 14.
- Sutfin, E.L., McCoy, T.P., Morrell, H.E.R., Hoepfner, B.B., Wolfson, M., 2013. Electronic cigarette use by college students. *Drug Alcohol Depend.* 131 (3), 214–221. <https://doi.org/10.1016/j.drugalcdep.2013.05.001>.
- Wills, T.A., Pagano, I., Williams, R.J., Tam, E.K., 2019. E-cigarette use and respiratory disorder in an adult sample. *Drug Alcohol Depend.* 194, 363–370. <https://doi.org/10.1016/j.drugalcdep.2018.10.004>.