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## Reasons For Transition from Electronic Cigarette Use to Cigarette Smoking Among Young Adult College Students

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### Abstract

**Purpose:** Longitudinal studies indicate that e-cigarette use among youth and young adults is associated with cigarette smoking initiation. The purpose of this study was to identify reasons why non-smoking young adults transition from e-cigarette use to cigarette smoking.

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**Conflict interest:** Dr. Eissenberg is a paid consultant in litigation against the tobacco industry and is named on a patent application for a device that measures the puffing behavior of electronic cigarette users. All other authors have no conflicts.

**Methods:** The study used concept mapping (CM), a mixed-method participatory approach. Fifty-five college students who endorsed initiation of e-cigarettes prior to cigarettes (lifetime e-cigarette uses 100 and 100 cigarettes in lifetime) completed at least one part of the study. In an online program, participants brainstormed (n = 54) statements describing reasons for transition from e-cigarette use to cigarette smoking, sorted statements (n = 46) into conceptually similar categories, and rated (n = 47) how true each statement was for them.

**Results:** Participants generated 60 unique statements and multidimensional scaling analysis generated 8 thematic clusters characterizing reasons for transition which included: “Sharing with Others,” “Psychological Coping,” “Cigarette Appeal,” “Reinforcing Effects of Cigarettes,” “Accessibility,” “Social Influence,” “Vaping Stigma,” and “Vaping Deficiencies.” Participants rated “Sharing with Others” and “Psychological Coping” highest (most true) and “Vaping Deficiencies” lowest (least true). For college students, the ability to share cigarettes with peers, access cigarettes from peers, and smoking for stress/anxiety management were among the top reasons for transition.

**Conclusions:** Results suggest that tailored prevention efforts aimed at reducing cigarette smoking uptake among college students who use tobacco as a means for psychological coping or social facilitation may be warranted. Further, regulatory decisions aimed at limiting cigarette appeal, reinforcing effects, and accessibility may be relevant to reducing transition.

### Keywords

electronic cigarette; tobacco use; cigarette smoking; young adults; college students; tobacco transition

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Despite overall declines in cigarette smoking prevalence, smoking remains the leading preventable cause of death and disease in the U.S.<sup>1</sup> Cigarettes share the market with other tobacco products, such as e-cigarettes. E-cigarettes are battery-powered devices that aerosolize flavorants, solvents, and the dependence-producing drug nicotine for users to inhale. E-cigarettes are increasingly popular and have become the most prevalent tobacco product among U.S. youth.<sup>2</sup> Moreover, while many adult e-cigarette users are current tobacco cigarette smokers, a growing number of ECIG users include youth and young adults who are formerly nicotine-naïve and report never having smoked tobacco cigarettes.<sup>3</sup> Recent national surveys demonstrate that 40% to 60% percent of U.S. young adults aged 18-21 who use e-cigarettes have never smoked cigarettes.<sup>3</sup>

There are a myriad of public health concerns surrounding young adults’ use of e-cigarettes, including nicotine exposure that could foster nicotine dependence<sup>4</sup> and/or negatively impact the development of brain regions responsible for judgement and decision making that do not reach maturity until the mid-twenties.<sup>5, 6</sup> Also of particular concern, several longitudinal studies demonstrate that non-smoking youth (e.g.,<sup>7, 8</sup>) and young adults(e.g.,<sup>9-12</sup>) who use e-cigarettes are more likely to begin smoking cigarettes. A meta-analysis of nine such studies indicated that non-smoking young adults (aged 14-30) who began using e-cigarettes had a 3-fold increased risk for future cigarette smoking, even after controlling for factors known to be associated with susceptibility to cigarette smoking.<sup>13</sup>

Due to the known negative health consequences of cigarette smoking<sup>1</sup>, any factor that increases the risk of cigarette smoking uptake among young adults represents a major public health concern. Although it is well-documented that e-cigarette use increases the chances of cigarette smoking uptake among young adults, there is a dearth of research to explain why young adults transition from e-cigarettes to cigarettes. Understanding and addressing the factors that drive young adults to progress from one product to another will likely be important for reducing e-cigarette-to-cigarette transition. In the absence of known risk factors for transitioning from e-cigarettes to cigarettes and because reasons for tobacco use are complex,<sup>1, 6</sup> obtaining a comprehensive understanding of e-cigarette-to-cigarette transition necessitates a participatory-based research approach that combines the strengths of various methods. One mixed-methods approach, concept mapping (CM), combines the strengths of qualitative techniques to gather rich wide-ranging responses and established quantitative methods that convert those responses into interpretable results empirically.<sup>14</sup> CM provides an efficient and anonymous alternative to focus groups and more varied, participant-generated responses relative to close-ended surveys<sup>14</sup>. Importantly, CM has been used extensively to characterize various health-related attitudes and behaviors<sup>15, 16</sup> including tobacco use behavior.<sup>17-19</sup> Therefore, the purpose of this study was to use CM identify the self-reported reasons for transitioning to cigarette smoking in a sample of young adult college student e-cigarette users.

## METHOD

### Overview

This study used CM, a validated<sup>14</sup> research approach that incorporated multidimensional scaling and hierarchical cluster analyses to identify latent constructs related to reasons why young adult college students transition from e-cigarette use to cigarette smoking.<sup>20</sup> CM involves several steps, including participants generating statements in a brainstorming task and then sorting and rating these statements at a later time point. Sorting and rating data are used to generate a concept “map,” that visually represents a final model of theoretical clusters relevant to e-cigarette-to-cigarette transition. This study was approved by the university’s Institutional Review Board.

### Participants

The study sample was obtained from a large Mid-Atlantic University. Potential participants were identified prior to recruitment using an ongoing university-wide longitudinal cohort-based study assessing factors that influence college students’ emotional health and substance use trends.<sup>21</sup> Students from the longitudinal study who reported lifetime use of e-cigarettes, and no cigarette smoking at time 1, and subsequently reported smoking cigarettes one year later at time 2 were invited to complete an online screening survey to confirm eligibility. To be eligible during screening, individuals had to confirm being at least 18 years old, self-report use of at least 100 e-cigarettes and 100 cigarettes in their lifetime and endorse initiation of e-cigarettes prior to cigarettes. Of the pre-identified individuals, 61 indicated interest in the study and met inclusion criteria. Eligible participants were directed to a study website (The Concept System®Global MAX) where they provided informed consent, answered several questions assessing demographics (e.g., age, gender, race/ethnicity),

tobacco use (e.g., former/current e-cigarette device/liquid characteristics and reasons for e-cigarette initiation), and initiated CM exercises. CM tasks were completed online by participants between September and December of 2018. Participants selected either cash or an online gift card of \$10 for brainstorming, \$25 for sorting, and \$10 for rating.

### Concept Mapping Procedures

Concept mapping involves several steps that occur at different time points. In this study, of the 61 eligible individuals, 54 completed the brainstorming task. Participants were then invited to complete the sorting (n = 46) and rating (n = 47) tasks at a later time. Participants who completed the brainstorming task (n = 54) were invited to complete the sorting and rating tasks as were other eligible individuals who did not complete the brainstorming task. Therefore, some participants only completed brainstorming, and some only completed sorting and/or rating. As a result, 55 individuals completed at least one CM task with some, but not all overlapping with the 54 who completed brainstorming.

**Brainstorming.**—At the study website, participants were instructed to provide 5-8 statements to complete a focus prompt: “A specific reason I started smoking cigarettes in addition to/instead of using e-cigarettes/vaping is...” The words “e-cigarette” and “vaping” were included in the prompt to capture a wide range of products categorized as e-cigarettes. Although participants responded to the focus prompt individually, they were able to see statements generated by previous participants who completed the brainstorming task. Prior to submitting their own responses, participants were instructed to review prior statements to avoid duplicative responses and ideas. This method of electronic brainstorming may facilitate cognitive stimulation as group brainstorming can generate a greater number of ideas relative to individual brainstorming<sup>22, 23</sup>. Brainstormed statements were monitored continuously by investigators to monitor whether content saturation was reached (i.e., when enrolling additional participants no longer resulted in new ideas or content). Because no unique content was generated at the end of brainstorming, investigators determined that content saturation had been achieved. Of the 61 participants who initially were invited to participate in brainstorming 54 completed brainstorming.

**Sorting.**—In the brainstorming task, 177 statements that completed the focus prompt were generated by participants. These statements were reviewed independently by three study investigators who identified statements that did not relate to the focus prompt or were redundant with other statements in the list. Statements were removed if two or three investigators identified the statements as redundant or not relating to the focus prompt. A final list of 60 statements was established and uploaded to the CM website. For the sorting task,<sup>24, 25</sup> each participant was instructed to organize all 60 statements into ‘piles’ of similar content. In constructing ‘piles’, participants used the following rules: 1) piles were required to contain statements based on a similar construct or theme and not unrelated criteria (e.g., “does not apply to me”, “true and false”, “important”), 2) there could not be a miscellaneous/other pile, and 3) there could not be one single pile containing all statements or as many piles as statements. Of the 61 participants who initially were invited to participate in brainstorming (including the 54 who completed brainstorming) 46 completed the sorting task.

**Rating.**—After completing sorting, 47 participants rated each of the 60 listed statements based on the focus prompt. Ratings were made on a seven-point Likert-type scale with response anchors ranging from: 1- Definitely NOT true for me, to 7- Definitely TRUE for me.<sup>17,18</sup> In general, higher rated statements and clusters are “more true” for participants and may suggest these statements and clusters have more importance in promoting e-cigarette to cigarette transition. Rating data were monitored by investigators to ensure they were complete (i.e., 70% of statements rated) and valid (i.e., to ensure participants did not provide the same rating response for all statements). Altogether, less than 1% of rating data were missing.

**Representation.**—Each participant’s sorting data was converted into a  $60 \times 60$  matrix of similarities where a “1” was entered to represent the number of times two statements were sorted together. For example, if a participant sorted statement 3 and 20 into the same pile, that participant’s similarity matrix would have a “1” in the corresponding cell for the overlap of statements 3 and 20. Each participants’ matrix of similarities was aggregated and the cells in the resulting matrix of similarities representing the number of times two statements were sorted together during the sorting activity by all participants. Using multidimensional scaling (i.e., a method for visually representing distances or similarities of individual cases of data) an algorithm assigned each statement a coordinate (x, y) which resulted in a point map that portrays each statement in two-dimensional space based on the matrix of similarities.<sup>26</sup> Specifically, the algorithm assigned statements points on the map so that points on the map that are closer together represent statements that were sorted together often in the sorting task and therefore are related to similar content (see Figure 1). Conversely, points on the map that are distal represent statements sorted together less often during the sorting task and therefore do not relate to similar content. The stress value, a measure of goodness-of-fit in multidimensional scaling analysis, was calculated for the model and was 0.18, indicating good model fit.<sup>14</sup> Stress values closer to zero indicate greater consistency between the raw sorting data and the scaled data, and stress values from a pooled analysis of previous CM studies range from 0.17-0.34.<sup>14</sup>

**Analysis and Interpretation.**—Statements related to similar content were grouped into non-overlapping clusters using hierarchical cluster analysis, a statistical method which partitions individual data into distinct clusters that represent separate conceptual domains.<sup>27</sup> Initially, CM software identified two clusters of statements using an algorithm to define non-overlapping cluster arrangements of statements which limited the distance between points on the map to the centroid of the identified clusters<sup>27</sup>. From analysis, multiple cluster maps were generated using a hierarchical cluster analysis procedure, with each map containing varying numbers of clusters in the model. Subsequent models were generated based on previous models by adding an additional cluster to the model (i.e., by separating statements from one cluster into two clusters). The resulting “cluster map” (see Figure 1) displays the original statement points enclosed by polygon-shaped borders in an eight cluster model. While the research team reviewed maps with up to 10 clusters, the eight cluster model was selected based on interpretability (i.e., clusters relate to a single construct) and parsimony (i.e., preference was given to models with fewer clusters) as model fit indicators. Finally, an

average score was generated for each cluster, referred to as a mean cluster rating, and was calculated by averaging the mean value for all statements contained within a given cluster.

## RESULTS

### Participant Characteristics

Table 1 displays detailed participant demographic and tobacco use characteristics. The mean (SD) age of participants was 20.4 (2.1) years old and 63.6% were female. Overall, the racial breakdown of the study sample was as follows: 58.2% White/Caucasian, 16.4% Asian, 12.7% more than one race, Black/African American 10.9%, Unknown 1.8%. Notably, the characteristics of participants in the present study are comparable to the gender and racial makeup of the general student population of the university (~24,000 undergraduates) White/Caucasian: 48%; Black: 19%; Asian: 14%; mixed race/ethnicity: 5%.<sup>9</sup>

With regard to tobacco use behaviors, twelve participants (22%) reported current (past 30 day) use of cigarettes and no current e-cigarette use and were deemed to have transitioned to exclusive cigarette smoking. Forty-one participants (75%) reported current cigarette smoking and e-cigarette use and were deemed to have progressed to dual use of both of these tobacco products. Two participants (3%) reported transition from e-cigarette use to cigarette smoking but did not report current use of either product. Over half of the sample (64%) reported smoking cigarettes on more than 5 days of the past 30 and the majority (89.1%) of participants reported smoking 1-5 cigarettes per day. The majority of participants (65.5%) reported that their preferred current or former e-cigarette was a pod-style device, such as the brand Juul, and their preferred liquid nicotine concentration ranged from 1-5 mg/ml (40% of participants). Notably, while Juul and other pod-style e-cigarettes often are paired with high liquid nicotine concentrations (e.g., 59 mg/ml for Juul), the majority of the sample indicated using liquid nicotine concentrations of 1-5 mg/ml. One possible explanation for this contradiction is that study participants may have misreported or been unaware of the nicotine concentration in their liquid, a phenomenon previously reported with e-cigarette users who use the brand Juul.<sup>28</sup>

### Concept Map Clusters

The final cluster map included 8 clusters describing reasons for transition from e-cigarette use to cigarette smoking/dual use (see Figure 1). The cluster rating map provides a visual representation of conceptually similar themes describing reasons for transition; clusters with a greater number of layers indicate clusters with higher statement ratings. Table 2 provides a detailed list of clusters, statements, and individual statement ratings. The eight clusters are summarized below in descending order of mean cluster rating ranging from the highest possible rating (7 Definitely TRUE for me) to the lowest possible rating (1 Definitely NOT true for me).

**Sharing with Others.**—The four statements in this cluster had the highest mean statement rating ( $M = 4.0$ ;  $SD = 0.6$ ). Statements within this cluster suggested that relative to e-cigarettes, cigarettes are available more (e.g., “people are more likely to carry cigarettes,” and “cigarettes are often around at parties”) and more commonly are shared among young



adult college students. One statement indicated that “It’s more common to ask someone for a cigarette than a puff of their vape,” suggesting that sharing cigarettes may be more socially normative than sharing e-cigarettes.

**Psychological Coping.**—The eight statements within this cluster also had the highest mean statement rating ( $M = 4.0$ ;  $SD = 0.4$ ). Statements within this cluster described smoking cigarettes for emotion regulation and mental health management. More specifically, statements described smoking cigarettes to alleviate stress, to relax, and to calm down while consuming alcohol. One statement indicated that “Cigarettes provide better stress relief”. Cigarette smoking also was described as a means to manage depression and anxiety and as a break from school and work.

**Cigarette Appeal.**—The five statements in this cluster described cigarette appeal, curiosity, and dependence as reasons for transition to cigarette smoking ( $M = 3.5$ ;  $SD = 1.1$ ). Statements indicated curiosity, that cigarettes “looked appealing,” and sensory aspects of smoking (i.e., “smell of smoke”) as reasons for to cigarette smoking initiation. Other statements described aspects of cigarette smoking indicative of dependence such as “I crave cigarettes when drinking” and “I tried cigarettes and got hooked.”

**Reinforcing Effects of Cigarettes.**—The next highest rated cluster ( $M = 3.4$ ;  $SD = 0.6$ ) contained 12 statements related to pleasurable sensory stimuli and reinforcing effects associated with cigarette smoking such as “taste,” “hit,” “smoke feel,” and “buzz” as reasons for transition. Several statements indicated a preference for the sensory stimuli and reinforcing effects produced by cigarettes such as in the statements “They gave me a much faster and better buzz than vapes/e-cigarettes.” Other statements suggested some young adult college students seek a different experience provided by cigarette smoking: “I was looking for a different buzz [than from vaping].”

**Accessibility.**—This cluster contained 8 statements ( $M = 3.3$ ;  $SD = 0.7$ ) that described cigarette smoking as being more convenient and less expensive relative to e-cigarette use as reasons for transition. Young adults perceived cigarette smoking as being convenient because cigarettes are easier to “buy/access” and because they are “quick and easy to use.” Other statements highlighted the inconvenience of e-cigarette use indicating that “Vaping has too much maintenance”. Some statements indicated that uptake of cigarette smoking was a consequence of e-cigarette batteries not being charged or a lack of access to e-cigarette-liquid/pods: “I was out of vape juice/pods so I tried a cigarette and started smoking.” Finally, several statements implied that cigarette smoking is “cheaper than vapes/e-cigarettes.”

**Social Influence.**—The 17 statements in this cluster ( $M = 3.1$ ;  $SD = 0.7$ ) described reasons that relate to how social factors facilitated uptake of cigarette smoking. Several statements indicated transition to smoking because of friends, parents/family and significant others smoking cigarettes as well as the perception that “everyone smokes cigarettes.” For example, one statement indicated “I tried it with friends and then I started smoking even when I wasn’t with them.” Other statements described social perceptions of smoking that indicated smoking cigarettes is “socially acceptable,” “punk/liberal/free,” “welcoming,” and “cooler than vaping.” Other statements described that uptake of cigarette smoking can

facilitate social interaction: “Smoking is a fun social activity,” and “Smoking introduced me to a new crowd on campus.”

**Vaping Stigma.**—One of the smallest clusters contained 3 statements ( $M = 2.7$ ;  $SD = 0.1$ ) that described negative social perceptions and perceived stigma related with e-cigarette use as a reason for transition to cigarette smoking. One statement described that e-cigarettes are for younger age groups (i.e., “middle schoolers”). Another statements described e-cigarette use as being “lame” and not “cool anymore.”

**Vaping Deficiencies.**—This cluster’s three statements had the lowest mean statement rating ( $M = 2.6$ ;  $SD = 0.7$ ). Statements described negative aspects of e-cigarette use (e.g., “hit from vapes is too powerful”) and a desire to try something different (e.g., “Wanted to see how smoking was different from vaping”). One statement indicated the belief that “Cigarettes are the lesser of two evils” possibly indicating that e-cigarettes are perceived as more harmful than cigarettes by some individuals.

## DISCUSSION

This study is the first to identify reasons why young adult college students transition from e-cigarette use to cigarette smoking/dual use. Eight major themes describing reasons why young adults transitioned were identified and are discussed below as are the regulatory implications of these findings.

Several reasons for transition, such as peer and parental cigarette smoking, social contexts (i.e., when drinking alcohol), and coping with stress overlap with factors that predict cigarette initiation among young adults independently. Peer and parental smoking behavior are well-documented risk factors for cigarette smoking uptake among young adults.<sup>6, 29</sup> Further, cigarette smoking is often used for managing stress and anxiety and stressful experiences can maintain cigarette smoking.<sup>30</sup> Finally, young adults are more likely to smoke cigarettes in the presence of others and while drinking alcohol.<sup>6, 31</sup> In this study, young adults described “craving” cigarette smoking while drinking alcohol and indicated a more pleasurable “buzz” when combining cigarette smoking and drinking. Cigarettes have greater rewarding effects when combined with alcohol and young adults report greater pleasure when using cigarettes in combination with alcohol relative to e-cigarettes.<sup>32</sup> Given that experimentation with alcohol and other substances is common among young adult college students,<sup>6, 32</sup> young adulthood may be a particularly vulnerable time for e-cigarette-to-cigarette transition.

Several reasons reported for e-cigarette-to-cigarette transition may be specific to e-cigarette use being a precursor to cigarette initiation. Some of the statements generated by participants have previously been proposed as theories for why youth and young adults transition from e-cigarette use to cigarette smoking.<sup>34</sup> For example, in the present study, college students cited a preference for the sensory and pleasurable aspects associated with cigarette smoking (i.e., taste, buzz, hit, smoke feel) as a reason for transition. Several hypotheses indicate that e-cigarettes may facilitate transition because they allow individuals to initiate a tobacco product that is perceived to be less harmful and addictive while



becoming accustomed to the sensory effects of nicotine (i.e., throat hit, feeling of heated aerosol inhalation) and learning behavioral patterns (i.e., hand-to-mouth movements, inhalation) that mirror those of cigarette smoking.<sup>34</sup> Moreover, college students cited the perception that cigarettes are less expensive and can be purchased or accessed more easily relative to e-cigarettes as reasons for transition. Because younger individuals are deterred by tobacco-related financial costs<sup>35</sup> and limitations on accessibility<sup>36</sup> young adult college students may perceive the price of e-cigarettes and access to specialty “vape shops” as barriers to continued e-cigarette use. Similarly, inconveniences associated with e-cigarette use such as e-cigarette-related maintenance, e-cigarette liquid/pods being unavailable, or uncharged e-cigarette batteries were reported as reasons for transition to cigarette smoking. Finally, the perception that e-cigarettes are no longer “cool” and are for younger age groups suggests that changes in social norms regarding tobacco products may promote or reduce use of certain tobacco products.

The present study has several regulatory implications. Young adult college students cite perceived barriers to e-cigarette use (i.e., cost, access, ease of use) as reasons for transition to cigarette smoking. Therefore, regulation aimed at reducing transition from e-cigarettes to cigarettes may focus on increasing barriers to accessing both products. Given that the study sample was 20 years of age, on average, and many reasons for transition to cigarette smoking were related to access and peer smoking, local legislation aimed at increasing the minimum tobacco purchase age to 21 for all tobacco products, including e-cigarettes, may be one tool for reducing product initiation and transitions among this age group. Finally, the mean statement ratings and cluster ratings in the present study varied considerably. The variability in ratings indicates that the reasons for transition to smoking likely vary considerably by individual and participants endorse some statements and not others. To account for multiple reasons for transition to smoking, a multi-pronged approach involving restriction on accessibility, tailored interventions, and public health campaigns may be necessary.

This study had several limitations. This study included a sample of college students whose tobacco use behavior and reasons for use may differ from the general population of young adults and may not generalize to nonstudents. While some studies indicate that tobacco use rates are lower among young adults who attend college relative to nonstudents<sup>37</sup> others demonstrate similarities in tobacco use patterns across college students and nonstudents.<sup>38</sup> Nevertheless, examining reasons for e-cigarette-to-cigarette transition in a college sample is important as approximately half of U.S. young adults age 18-24 attend college<sup>39</sup> and tobacco use behavior may increase during this transitional period.<sup>6</sup> Also, while the study participants were sampled from a large and diverse university, the study sample was small and over half of the sample were women (63.6% of the study sample). The implications of this study could be extended by replicating these findings in larger and more diverse and nationally representative samples. In addition, the target sample was pre-identified and recruited through a longitudinal cohort-based survey study. While this method of recruitment served as a strength with regard to identifying individuals who transitioned from e-cigarettes to cigarettes, it also may have omitted recruitment of college students who chose not to participate in the longitudinal survey study or young adults outside of the college population. Finally, while anonymous online platforms, such as those used here, may encourage

disclosure of behaviors,<sup>40</sup> the study results were based on self-report and are limited by each participant's willingness to respond accurately and truthfully.

As e-cigarette use continues to increase among young adults, continued monitoring of transition from e-cigarette use to cigarette smoking and an understanding of the reasons for transition will be needed to provide clarity regarding the public health impact of e-cigarettes. Policymakers and public health officials seeking to minimize the negative public health impact of young adults transitioning to cigarette smoking should consider the reasons identified here when making regulatory decisions and when implementing tailored public health campaigns aimed at reducing e-cigarette-to-cigarette transition among young adults.

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## Abbreviations/Acronyms:

CM                      concept mapping

## References

1. U.S. Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health 2014; 17.
2. Gentzke AS, Apelberg BJ, Jamal A, & King BA. Notes from the field: Use of electronic cigarettes and any tobacco product among middle and high school students—United States, 2011–2018. *Morb Mortal Wkly Rep.* 2018; 67(45), 1276. doi: 10.15585/mmwr.mm6745a5.
3. Mirbolouk M, Charkhchi P, Kianoush S, et al. Prevalence and Distribution of E-Cigarette Use Among U.S. Adults: Behavioral Risk Factor Surveillance System, 2016. *Ann Intern Med;* 2018, 169(7), 429–438. doi: 10.7326/M17-3440. [PubMed: 30167658]
4. Morean M, Krishnan-Sarin S, & O'Malley SS. Comparing cigarette and e-cigarette dependence and predicting frequency of smoking and e-cigarette use in dual-users of cigarettes and e-cigarettes. *Addict Behav.* 2018; 87, 92–96. doi: 10.1016/j.addbeh.2018.06.027. [PubMed: 29975879]
5. Goriounova NA & Mansvelder HD. Nicotine exposure during adolescence alters the rules for prefrontal cortical synaptic plasticity during adulthood. *Front Synaptic Neurosci.* 2012; 4 (3). doi: 10.3389/fnsyn.2012.00003.
6. U.S. Department of Health and Human Services. The health consequences of tobacco use among young people: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health 2012.
7. Barrington-Trimis JL, Urman R, Berhane K, et al. E-cigarettes and future cigarette use. *Pediatrics.* 2016; 138(1). doi: 10.1542/peds.2016-0379.

8. Leventhal AM, Strong DR, Kirkpatrick MG et al. Association of Electronic Cigarette Use With Initiation of Combustible Tobacco Product Smoking in Early Adolescence. *JAMA*. 2015; 314(17), 700–707. doi: 10.1001/jama.2015.8950. [PubMed: 26284721]
9. Spindle TR, Hiler M, Cooke ME et al. Electronic cigarette use and uptake of cigarette smoking: A longitudinal examination of U.S. college students. *Addict Behav*. 2017; 67, 66–72. doi: 10.1016/j.addbeh.2016.12.009. [PubMed: 28038364]
10. Unger JB, Soto DW, & Leventhal A. E-cigarette use and subsequent cigarette and marijuana use among Hispanic young adults. *Drug Alcohol Depend*. 2016; 163, 261–264. doi: 10.1016/j.drugalcdep.2016.04.027. [PubMed: 27141841]
11. Primack BA, Soneji S, Stoolmiller M et al. Progression to traditional cigarette smoking after electronic cigarette use among US adolescents and young adults. *JAMA*. 169; 1018–1023. doi: 10.1001/jamapediatrics.2015.1742.
12. Loukas A, Marti N, Cooper M, et al. Exclusive e-cigarette use predicts cigarette initiation among college students. *Addict Behav*. 2018; 76, 343–347. doi: 10.1016/j.addbeh.2017.08.023. [PubMed: 28892771]
13. Soneji S, Barrington-Trimis JL, Wills TA, et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Pediatr*. 2017; 171(8), 788–797. doi: 10.1001/jamapediatrics.2017.1488. [PubMed: 28654986]
14. Rosas SR & Kane M. Quality and rigor of the concept mapping methodology: a pooled analysis. *Eval Program Plann*. 2013; 35(2), 236–245. doi: 10.1016/j.evalprogplan.2011.10.003.
15. Kazmerski TM, Prushinskaya OV, Hill K, et al. Sexual and reproductive health of young women with Cystic Fibrosis: A concept mapping study. *Acad Pediatr*. 2019; 19(3), 307–314. doi: 10.1016/j.acap.2018.08.011. [PubMed: 30176294]
16. Nuampa S, Tilokskulchai F, Patil CL, Sinsuksai N, & Phahuwatanakorn. Factors related to exclusive breastfeeding in Thai adolescent mothers: Concept mapping approach. *Matern Child Nutr*. 2019; 15(2), e12714. doi: 10.1111/mcn.12714. [PubMed: 30303630]
17. Soule EK, Lopez AA, Guy MC, & Cobb CO. Reasons for using flavored liquids among electronic cigarette users: A concept mapping study. *Drug Alcohol Depend*. 2016; 166, 168–176. doi: 10.1016/j.drugalcdep.2016.07.007. [PubMed: 27460860]
18. Soule EK, Maloney SF, Guy MC, Eissenberg T, Fagan P. User identified positive outcome expectancies of electronic cigarette use: A concept mapping study. *Psych Addict Behav*. 2017; 31(3), 343–353.
19. Trochim WM, Stillman FA, Clark PI, & Schmitt CL. Development of a Model of the Tobacco Industry's Interference with Tobacco Control Programmes. *Tob Control*. 2003; 12(2), 140–147. [PubMed: 12773723]
20. Kane M & Trochim WMK. *Concept mapping for planning and evaluation*. Thousand Oaks, CA: Sage publications 2007.
21. Dick DM, Nasim A, Edwards AC, et al. Spit for science: Launching a longitudinal study of genetic and environmental influences on substance use and emotional health at a large US university. *Front Genet*. 2014; 5(47), 1–12. doi: 10.3389/fgene.2014.00047. [PubMed: 24567736]
22. Dennis AR & Williams ML. *Electronic brainstorming: Theory, research, and future directions* In Paulus PB, & Nijstad BA (Eds.), *Group Creativity: Innovation Through Collaboration*. New York: Oxford University Press 2003: 160–178.
23. Derosa DM, Smith CL, & Hantula DA. The medium matters: Mining the long promised merit of group interaction in creative idea generation tasks in a meta-analysis of the electronic group brainstorming literature. *Comp Hum Behav*. 2007; 23, 1549–1581.
24. Rosenberg S & Kim MP. The method of sorting as a data gathering procedure in multivariate research. *Multivariate Behav Res*. 1975; 104, 1437–1444.
25. Weller SC, & Romney AK. *Systematic data collection*. Newbury Park, CA: Sage; 1988.
26. Kruskal JB, & Wish M. (1978). *Multidimensional scaling*. Beverly Hills, CA: Sage Publications.
27. Ward JH. Hierarchical grouping to optimize an objective function. *J Am Stat Assoc*. 1963; 58, 236–244

28. Willet JG, Bennett M, Hair EC et al. Recognition, use and perceptions of JUUL among youth and young adults. *Tob Control*. 2018; 28(7), 115–116. [PubMed: 29669749]
29. Gilman SE, Rende R, Boergers J, et al. Parental smoking and adolescent smoking initiation: an intergenerational perspective on tobacco control. *Pediatrics*; 2009, 123(2), e274–e281. doi: 10.1542/peds.2008-2251. [PubMed: 19171580]
30. Tyas SL & Pederson LL. Psychosocial factors related to adolescent smoking: a critical review of the literature. *Tob Control*. 1998; 7(4), 409–420. [PubMed: 10093176]
31. Dierker L, Stolar M, Richardson E, et al. Tobacco, alcohol and marijuana use among first Year U.S. college students: A time series analysis. *Subt Use Misuse*; 2008, 43(5), 680–699. doi: 10.1080/10826080701202684.
32. Thrul J, Gubner NR, Tice CL, Lisha NE & Ling PM. Young adults report increased pleasure from using e-cigarettes and smoking tobacco cigarettes when drinking alcohol. *Addict Behav*. 2019; 93, 135–140. doi: 10.1016/j.addbeh.2019.01.011. [PubMed: 30710807]
33. Substance Abuse and Mental Health Services Administration (SAMHSA). 2015 National Survey on Drug Use and Health (NSDUH). Table 6.84B—Tobacco Product and Alcohol Use in Past Month among Persons Aged 18 to 22, by College Enrollment Status: Percentages, 2014 and 2015.
34. Schneider S & Diehl K. Vaping as a catalyst for smoking? An initial model on the initiation of electronic cigarette use and the transition to tobacco smoking among adolescents. *Nicotine Tob Res*. 2016; 18(5), 647–653. [PubMed: 26386472]
35. Wills TA, Knight R, Williams RJ, et al. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics*. 2015; 135(1), e43–51. [PubMed: 25511118]
36. Schneider S, Meyer C, Yamamoto S, Solle D. Implementation of electronic locking devices for adolescents at German tobacco vending machines: intended and unintended changes of supply and demand. *Tob Control*. 2009; 18(4), 294–301. [PubMed: 19525278]
37. Lenk K, Rode P, Fabian L, Bernat D, Klein E, Forster J. Cigarette use among young adults: comparisons between 2-year college students, 4-year college students, and those not in college. *J Am Coll Health*. 2012; 60(4), 303–8. [PubMed: 22559089]
38. Sidani JE, Shensa A, Yabes J, et al. Waterpipe tobacco use in college and non-college young adults in the USA. *Fam Pract*. 2019; 36(2), 103–109. [PubMed: 29741621]
39. Population Reference Bureau. Analysis of data from the U.S. Census Bureau, Census 2000 Supplementary Survey, 2001 Supplementary Survey, 2002 through 2017 American Community Survey. Retrieved August 23, 2019.
40. Richman WL, Kiesler S, Weisband S, Drasgow F. A meta-analytic study of social desirability distortion in computer-administered questionnaires, traditional questionnaires, and interviews. *J. Appl Psychol* 1999; 84(5), 754.

**Implications and Contribution:**

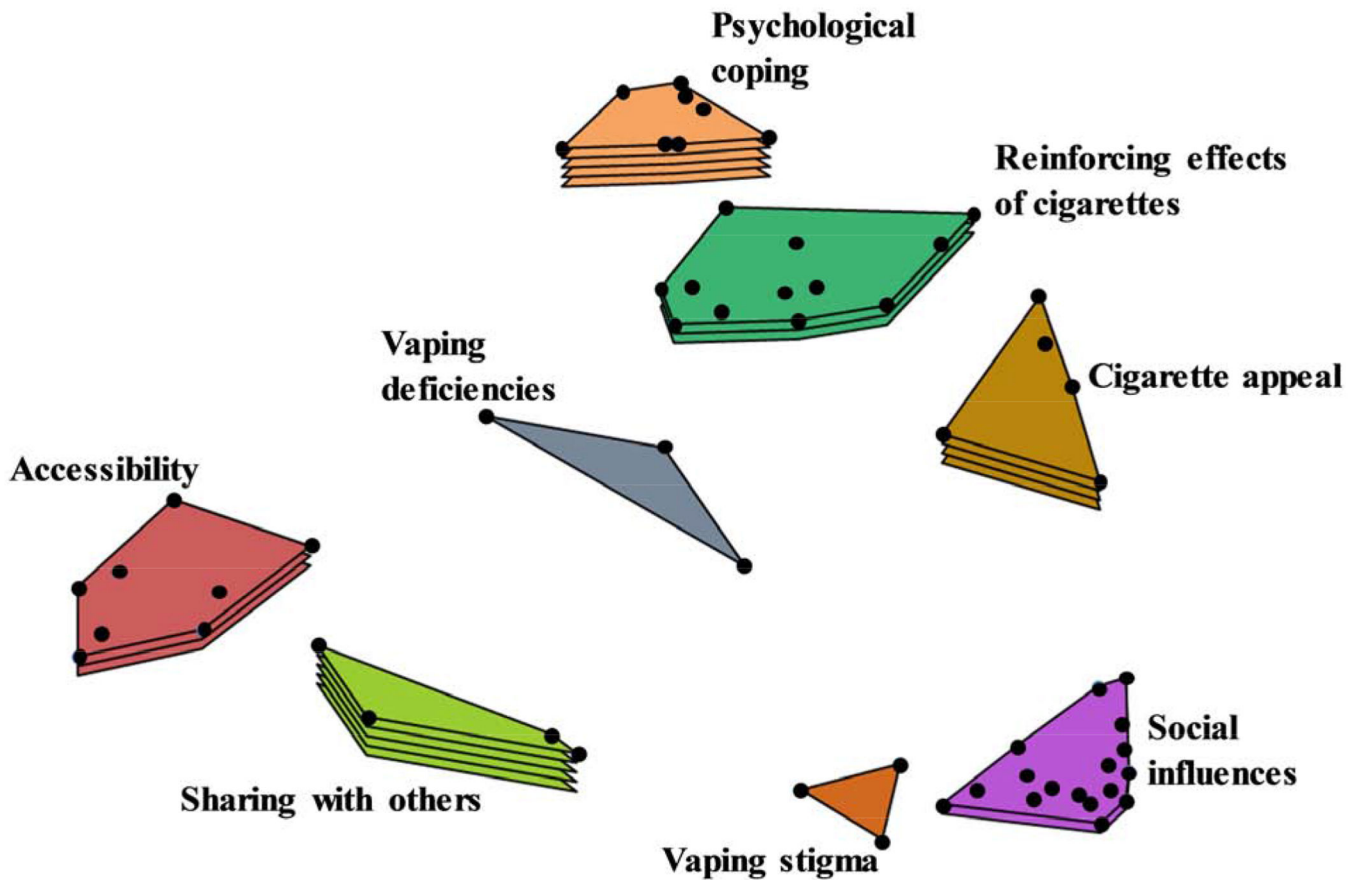
This study identifies reasons why young adults who use e-cigarettes transition to cigarette smoking. Young adult college students reported the ability to share cigarettes with others, psychological coping, cost/accessibility of cigarettes, social influences, as well as sensory effects of cigarette smoking as reasons for transition.

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**Figure 1.** Cluster rating map of the reasons why young adult college students began smoking cigarettes instead of or in addition to using e-cigarettes. Each cluster is a graphical depiction of a grouping of similar ideas or constructs (i.e., reasons for transition). Clusters with a greater number of layers indicate higher mean ratings of statements within the cluster on a scale from 1 (lowest) to 7 (highest). Clusters with 1 layer had average ratings of 2.63-2.91, 2 layers had average ratings of 2.91-3.19, 3 layers had average ratings of 3.19-3.47, 4 layers had average ratings of 3.47-3.76, and five layers had average ratings of 3.76-4.04. Points within each cluster represent statements generated by participants in the brainstorming task. Points closer to one another represent statements that were sorted together by more participants in the sorting task and therefore are similar in content. Points further apart on the map represent statements that were seldom or never sorted together by participants in the sorting task and relate to different content.



**Table 1**

Participant demographics and tobacco use characteristics (N = 55).

Characteristic	N	%
<i>Age (M, SD)</i>	(20.4, 2.1)	
<i>Gender</i>		
Female	35	63.6%
Male	20	36.4%
<i>Ethnicity</i>		
Not Hispanic / Latino	49	89%
<i>Race</i>		
Asian	9	16.4%
Black/African American	6	10.9%
White / Caucasian	32	58.2%
More than one race	7	12.7%
Unknown	1	1.8%
<i>E-Cigarette use Past 30 Days</i>		
None	14	25.5%
1-5 days	9	16.3%
6-10 days	6	10.9%
11-20 days	6	10.9%
21-29 days	10	18.2%
All 30 days	10	18.2%
<i>E-Cigarette Type (current or former)<sup>a</sup></i>		
Disposable cig-alike device (e.g., Blu, Vuse)	3	5.5%
Pod-style device (e.g., Juul)	36	65.5%
Rechargeable cartridge-based device	2	3.6%
Tank system/Mod	14	25.4%
<i>E-Cigarette Nicotine Concentration (current or former)<sup>a</sup></i>		
My liquid did not contain nicotine	2	3.6%
1-5 mg/ml	22	40.0%
6-10 mg/ml	5	9.1%
11-20 mg/ml	2	3.6%
20-30 mg/ml	3	5.5%
Over 30 mg/ml	8	14.6%
I don't know	13	23.6%
<i>Primary Reason for Using E-Cigarettes</i>		
Curiosity/just wanted to try them	10	18.2%
They come in flavors I like	0	0.0%
I like smoke tricks/clouds	4	7.3%
To relax/relieve stress	14	25.5%
To get a buzz	12	21.8%
I could use them anywhere	2	3.6%

Characteristic	N	%
They don't smell bad	0	0.0%
They are cool	1	1.8%
My friends use them	8	14.6%
My parents/family use them	0	0.0%
They are healthier than cigarettes	3	5.5%
Other	1	1.8%
<i>Cigarette Smoking Past 30 Days</i>		
None	2	3.6%
1-5 days	18	32.7%
6-10 days	6	10.9%
11-20 days	17	30.9%
21-29 days	9	16.4%
All 30 days	3	5.5%
<i>Number Cigarettes Per Day</i>		
1-5	49	89.1%
5-10	3	5.5%
10-15	2	3.6%
15-20	1	1.8%
More than 20	0	0.0%

<sup>a</sup>Indicates participants' preferred or most commonly used e-cigarette device and liquid nicotine concentration.

**Table 2.**

Clusters and statements of reasons for smoking cigarettes instead of/in addition to using e-cigarettes.

Cluster	Statement	Average Rating
Sharing with others		4.0
	Cigarettes are often around at parties.	5.0
	I'll smoke cigarettes if they are offered and I don't have my vape/e-cigarette.	3.8
	People are more likely to carry cigarettes than they are vapes/e-cigarettes.	3.7
	It's more common to ask someone for a cigarette than a puff of their vape.	3.6
Psychological Coping		
	To calm down.	4.5
	To deal with anxiety.	4.4
	Cigarettes help me relieve stress.	4.4
	Cigarettes provide better stress relief.	4.0
	Cigarettes calm me while drinking.	4.0
	Smoking is a good break from school/work.	3.8
	Smoking cigarettes is more relaxing.	3.7
To deal with depression.	3.5	
Cigarette Appeal		3.5
	I tried them because I was curious.	4.8
	I crave cigarettes when drinking.	4.5
	Cigarettes looked appealing.	3.1
	I tried cigarettes and got hooked.	2.7
Reinforcing Effects of Cigarettes		3.4
	I get a better buzz from cigarettes when drinking.	4.8
	I was looking for a different buzz.	4.3
	Cigarettes give a different smoke feel than vapes/e-cigarettes.	3.7
	Smoking cigarettes is a nice time passer.	3.6
	Nothing hits quite like a cigarette, not even vapes.	3.5
	Sometimes I prefer how cigarettes pull over vapes.	3.3
	They gave me a much faster and better buzz than vapes/e-cigarettes.	3.3
	I liked cigarettes better.	3.2
	The idea of having cigarettes was comforting.	3.0
	Cigarettes give me more energy.	2.9
Smoking gives a good wake up first thing in the morning.	2.9	
Cigarettes taste better.	2.7	
Accessibility		3.3
	Cigarettes are quick and easy to use.	4.4
	Convenience, cigarettes are easier to buy/access.	3.8
	Vaping has too much maintenance.	3.8
	Cigarettes come in packs instead of singles.	3.7
Cigarettes are cheaper than vapes/e-cigarettes.	3.3	

Cluster	Statement	Average Rating
	I was out of vape juice/pods so I tried a cigarette and started smoking.	2.7
	You can buy cigarettes loose.	2.5
	My vape was dead so I tried smoking and liked it.	2.4
Social Influence		3.1
	My friends offered me cigarettes.	4.9
	Smoking is a fun social activity.	4.2
	Cigarettes look cooler than vaping.	3.6
	Smoking seemed cool once I was in college.	3.6
	I tried it with friends and then I started smoking even when I wasn't with them.	3.4
	The culture seems welcoming.	3.4
	Everyone smokes cigarettes.	3.2
	My parents/family smoke cigarettes.	3.1
	My girlfriend/boyfriend was smoking.	3.0
	Smoking looks so punk/liberal/free.	2.9
	Smoking is socially acceptable.	2.9
	I thought smoking was cool.	2.8
	All my friends smoke and I don't like feeling left out.	2.6
	Smoking introduced me to a different crowd on campus.	2.5
	The cool art kids smoke.	2.5
	Girls love it when I smoke.	2.0
	My favorite celebrity/musician smokes cigarettes.	1.9
Vaping Stigma		2.7
	Vapes/e-cigarettes are lame.	2.8
	Vaping isn't cool anymore.	2.7
	Juuling and vaping is for middle schoolers.	2.6
Vaping Deficiencies		2.6
	Wanted to see how smoking was different from vaping.	3.4
	The hit from vapes is too powerful.	2.4
	Cigarettes are the lesser of two evils.	2.2