HHS Public Access

Author manuscript

Drug Alcohol Depend. Author manuscript; available in PMC 2019 October 30.

Published in final edited form as:

Drug Alcohol Depend. 2018 July 01; 188: 281–287. doi:10.1016/j.drugalcdep.2018.03.055.

Cigarette use trajectories in young adults: Analyses of predictors across system levels

Carla J. Berg[a,*], **Regine Haardörfer**[a], **Milkie Vu**[a], **Betelihem Getachew**[a], **Steven A. Lloyd**[b], **Angela Lanier**[c], **Donyale Childs**[d], **Yasmeni Sandridge**[a], **Jennifer Bierhoff**[a], **Jingjing Li**[a], **Elliyah Dossantos**[a], **Michael Windle**[a]

[a]Department of Behavioral Sciences and Health Education, Rollins School of Public Health, Emory University, 1518 Clifton Rd NE, Atlanta, GA 30322, USA

[b]Department of Psychological Science, University of North Georgia, 82 College Circle, Dahlonega, GA 30597, USA

[c]Department of Kinesiology, Berry College, 2277 Martha Berry Hwy NW, Mount Berry, GA 30149, USA

[d]Department of Nursing, 504 College Drive Albany, GA 31705, USA

Abstract

Background: Cigarette smoking escalates most in early to middle young adulthood. However, little research has examined a range of multilevel factors in relation to smoking trajectories during this time.

Methods: We examined: 1) trajectories of cigarette smoking among 2967 US college students (aged 18–25) in a two-year, six-wave longitudinal study (using growth mixture modeling); and 2) intrapersonal- (i.e., other substance use, depressive symptoms, ADHD symptoms,); interpersonal- (i.e., adverse childhood events, social support, parental tobacco and marijuana use), and community-level (i.e., type of college, rural vs. urban setting) predictors of differing trajectories (using multinomial logistic regression).

Results: We identified three trajectory classes: 1) Dabblers, who used cigarettes at one point in their life or not at all (85.6%); 2) College Onset Smokers, who began smoking regularly during the college years (6.2%); and 3) Later Onset Smokers, who began smoking during the mid- to late-20s (8.2%). Multinomial regression (with Dabblers as the reference group) showed that predictors of

*Corresponding author at: Department of Behavioral Sciences and Health Education, Emory University School of Public Health, 1518 Clifton Road, NE, Room 524, Atlanta, GA 30322, USA. cjberg@emory.edu (C.J. Berg).

Contributors

Berg, Haardörfer, and Windle designed the study and wrote the protocol, with consultation from Getachew, Lloyd, and Lanier. Vu, Getachew, Sandridge, Bierhoff, and Li contributed to data collection and management. Haardörfer conducted the analysis and contributed to the writing of the manuscript. Berg wrote the first draft of the manuscript, with Vu, Getachew, Lloyd, Lanier, Childs, Sandridge, Bierhoff, Li, and Windle contributing additional components to the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2018.03.055.

being College Onset Smokers included being male (p = .031); Asian (p = .001) but not Black (p = .008; Ref: White); early onset smokers (i.e., initiation before age 15; p = .006); past 30-day users of little cigars/cigarillos (p = .024), alcohol (p < .001), and marijuana (p = .008); children of tobacco users (p = .050); and public (p = .031) or a technical college students (p < .001; Ref: private college); predictors of being Later Onset Smokers were being male (p = .019) and technical college students (p = .005).

Conclusions: Despite some young adults' smoking initiating/escalating in middle young adulthood, few risk factors were documented. This understudied period warrants greater examination to inform intervention.

Keywords

Substance use; Young adults; Risk factors; Tobacco use; Marijuana use

1. Introduction

Tobacco use is the number one preventable cause of death in the US (USDHHS, 2014). Nearly all cigarette use in the US starts during adolescence with experimentation, often leading to nicotine dependence and regular use (National Center for Chronic Disease et al., 2012, 2014). Smoking in young adulthood is of particular concern given that the 20 s are the decade when the intensity and frequency of smoking escalates the most (Johnston et al., 2014). Currently, 17.0% of adults aged 18–24 and 21.4% aged 25–44 smoke cigarettes (Hu et al., 2016).

Various trajectories of tobacco use have been documented across the young adulthood years, with some research extending from adolescents to young adulthood (Bernat et al., 2008; Brook et al., 2006; Dutra et al., 2017; Park et al., 2018; Riggs et al., 2007). Studies including the broader range from adolescence to young adulthood commonly found categories approximating never smokers, experimenters, light or occasional smokers, early established smokers, late escalators, and quitters or decliners (Bernat et al., 2008; Dutra et al., 2017; Riggs et al., 2007). Particularly relevant to the current study, one recent study analyzing a nationally representative, longitudinal sample of 9791 young adults (aged 18–34) modeled the distribution of cigarette smoking intensity over time and found three discrete classes, including no current use of cigarettes (79.3%), rapid escalators or daily cigarette users (11.3%), and dabblers (9.4%); moreover, smoking patterns were found to be stable by the age of 21 (Hair et al., 2017). Another study similarly documented three profiles among those in emerging adulthood (ave. age 19.87 years, SD = 1.54), with both progression and reduction in the lower-use groups and notable changes in tobacco use behaviors over the span of six months (Schweizer et al., 2014). These prior studies, as well as others (Mays et al., 2014; Nelson et al., 2015; Rose et al., 2012; Windle & Windle, 2012; Zhan et al., 2012), suggest that young adults' tobacco use is a temporally unstable behavior warranting future longitudinal research. This is particularly relevant given the current context of diverse tobacco product offerings in the US market that have disproportionately impacted the tobacco use patterns of young adults (McMillen et al., 2012).

According to the Socioecological Developmental Model (McLeroy et al., 1988) and Social Cognitive Theory (Bandura, 2004), tobacco use and use trajectories over time among young adults are influenced by a range of interacting multilevel factors (individual, interpersonal, community). Attending to the range of multilevel factors is critical during this pivotal developmental period (Bonnie et al., 2014).

At the *individual level*, sociodemographic differences in young adult tobacco use trajectories exist. Greater smoking progression is found among men (Chen & Jacobson, 2012; Hair et al., 2017; Mendel et al., 2012) and those with lower educational attainment and annual income (Hair et al., 2017). Also, the prevalence of smoking among Whites, albeit higher than Blacks in emerging adulthood (18–25 years), declines during the 20 s; in contrast, smoking prevalence does not decline among Blacks (Hair et al., 2017; Keyes et al., 2015; Watt, 2008). This results in roughly equal prevalence by age 30 (Keyes et al., 2015; Watt, 2008).

Tobacco use characteristics, such as early onset smoking (i.e., before the age of 15), have been associated with early onset tobacco dependence (Mays et al., 2014; Rose et al., 2012; Zhan et al., 2012). Moreover, cigarette smoking is highly correlated with use of other alternative tobacco products (ATPs; i.e., little cigars/cigarillos [LCCs], smokeless tobacco, e-cigarettes or electronic nicotine delivery systems [ENDS], hookah) as well as polytobacco use (Jamal et al., 2014; National Center for Chronic Disease et al., 2014; Richardson et al., 2014). Of note, polytobacco use may increase risk for nicotine dependence (Etter & Eissenberg, 2015; Fagerstrom & Eissenberg, 2012; National Center for Chronic Disease et al., 2014; Tomar et al., 2010; USDHHS, 2014). Moreover, young adults are at the greatest risk for substance use, and the use of any substance is associated with use of other substances (SAMHSA, 2015). In addition to tobacco, two other commonly used substances among young adults in the US are marijuana and alcohol (SAMHSA, 2015).

Several psychological characteristics also influence smoking trajectories in young adulthood. Depressive symptoms have been robustly documented as a predictor (and consequence) tobacco use and nicotine dependence (Breslau et al., 1998; Fergusson et al., 1996; Windle & Windle, 2001). ADHD symptomatology has been highly associated with substance use more broadly (Ortal et al., 2015; Roberts et al., 2014; Sibley et al., 2014), as well as tobacco use specifically (Elkins et al., 2017; Pal & Balhara, 2016); however, a recent review of the literature suggests that this association may be confounded by comorbidities such as depression (Glass & Flory, 2010). Thus, including both in studies of cigarette smoking trajectories is important.

At the *interpersonal level*, adverse childhood events (e.g., physical or sexual threat or abuse, parental divorce/separation) (CDC National Center of Injury Prevention and Control, 2014) and other stressful life events are associated with the development of substance abuse and dependence, including cigarette smoking (Ford et al., 2011; Hovdestad et al., 2015; Windle & Mason, 2004). Moreover, greater social support has been associated with lower likelihood of smoking initiation (Berg et al., 2009; Flay et al., 1999), as well as successful attempts at smoking cessation and prevention of relapse (Carlson et al., 2002; Fisher, 1997; Hanson et al., 1990). Additionally, parental smoking is a robust predictor of children taking up

smoking (Fairlie et al., 2012) and of trajectories that progress or advance more quickly among youth and young adults (Hair et al., 2017; Mays et al., 2014).

Community-level factors influencing young adults are also important to consider. For young adults pursuing post-secondary education, the type of college they attend may influence tobacco use; for example, community or technical colleges have been shown to have higher smoking prevalence among their student populations compared to four-year colleges and universities (Berg et al., 2011). Moreover, rural communities tend to have higher prevalence of smoking relative to urban or suburban areas (Doescher et al., 2006). These levels of influence are particularly relevant for the period of young adulthood given the varied individual and sociocontextual changes likely to influence tobacco use during this period (Bonnie et al., 2014).

Few prior studies have used a socioecological perspective in examining smoking trajectories among young adults. One study analyzing data from the National Longitudinal Study of Adolescent Health examined multilevel predictors of smoking trajectories among those 13–32 years old (Fuemmeler et al., 2013). They found that conduct problems and depressive symptoms, maternal and peer smoking, and state-level prevalence of adolescent smoking predicted a greater likelihood of belonging to any of the four identified smoking groups versus nonsmokers. This study and the broader literature regarding risks for tobacco use among youth and young adults highlight the importance of contextualizing smoking trajectories within these multilevel influences.

The current study aimed to extend the literature regarding smoking trajectories during young adulthood in the context of these multilevel factors. We examined: 1) trajectories of cigarette smoking over a two-year period among young adult college students in a longitudinal cohort study; and 2) intrapersonal- (i.e., sociodemographics, early onset smoking, other substance use, depressive symptoms, ADHD symptoms); interpersonal- (i.e., adverse childhood events, social support, parental tobacco and marijuana use), and community-level (i.e., type of college, rural vs. urban setting) predictors of differing trajectories. This study adds to the literature in particular by including some novel predictors, such as ATP and marijuana use, adverse childhood events, and college campus context, as limited (if any) prior research examined these factors in relation to *trajectories* of cigarette use in young adults. Based on the aforementioned literature, we hypothesize that being male, being racial/ethnic minority, lower socioeconomic status, earlier initiation of cigarette smoking, other tobacco and substance use, greater symptoms of depression and ADHD, more adverse childhood events, less social support, parental substance use, attending a technical college, and residing in a rural setting will predict greater escalation in cigarette smoking through young adulthood.

2. Materials & methods

2.1. Procedure and participants

The current study was conducted as part of a larger study, Project DECOY (**D**ocumenting **E**xperiences with **C**igarettes and **O**ther Tobacco in **Y**oung Adults), which is a two-year, six-wave longitudinal cohort study that involves 3418 racially/ethnically diverse students (ages 18 to 25) from seven colleges and universities in Georgia, a state ranked among the least

progressive in tobacco control consistently (American Lung Association, 2016). Project DECOY was approved by the Emory University and ICF Institutional Review Boards as well as those of the participating colleges and universities. Data collection began in Fall 2014 and consisted of self-report assessments via an online survey every four months for two years (Fall, Spring, Summer). Two campuses had existing tobacco-free campus policies established prior to the launch of the study (one in 2009 [technical college] and one in 2012 [private]); three implemented such policies in October 2014 [two public, one HBCU]; one implemented such a policy in August 2015 [private]; and one remains without a comprehensive smoke-free air policy [technical college]).

Detailed information on sampling and recruitment of the parent study, Project DECOY, are described elsewhere (Berg et al., 2016) and briefly summarized here. Eligible participants were college students between 18 and 25 years of age who were able to read English. A list of students was obtained from each institution's office of the registrar. One public and two private colleges/universities had 3000 students randomly selected from those that were eligible; the remaining colleges and universities had eligible student bodies < 3000, so all eligible students were contacted for enrollment. The invitation emails described the study and the incentives for participating. If potential participants were interested, they clicked on a link embedded in the email, which launched them to the consent form. After reading the consent form, they had the option to consent by clicking a link which then launched the baseline (Wave 1) survey.

Recruitment at each school was closed after recruitment goals at each school were reached. Response rates ranged from 12.0% to 59.4%, with an overall response rate of 22.9% (N = 3,574/15,607) observed within 72 h at each school, meeting recruitment targets. A week after completion of the baseline survey, participants were asked to "confirm" their participation in the study in an email sent to them; they were to re-read the consent form and what was entailed in the study and then click a link indicating that they "confirmed" their consent to participate. They were then provided their first gift card ($30). The response rate after confirmation was 95.6% (N = 3418/3,574). The baseline sample was largely representative of each school's demographic profile, although respondents were disproportionately female.

Participants provided their contact information and were emailed and text messaged prior to the launch of each wave of data collection, notifying them that the survey was upcoming and asking for updates on contact information. Retention across waves exceeded 70%. Current analyses focus on the 2967 participants who reported any information regarding cigarette smoking beyond wave 1, as we chose to model tobacco use from Waves 2 to 6 (86.8% of the baseline sample).

2.2. Measures

2.2.1. Individual-level factors—We obtained *sociodemographic* data, including age, sex, sexual orientation, race/ethnicity, and parental education level at Wave 1 (Fall, 2014). To assess *cigarette, other tobacco, and other substance use,* participants were asked at Wave 1 to indicate yes or no to the following assessment: "For each of the following products, indicate if you have ever tried them in your lifetime" for each tobacco product (cigarettes,

LCCs, smokeless tobacco, ENDS, hookah), marijuana, and alcohol. Those who reported use of cigarettes in their lifetime at Wave 1 were asked to report their age at first cigarette use; those who reported initiating use before age 15 were defined as *early onset cigarette smokers*, as in prior research (Windle & Windle, 2012). Additionally, those who indicated lifetime use of each substance were subsequently asked, "In the past four months, on how many days have you used each of the following products?" with answer choices ranging from 0 to 120. Those who indicated any use in the past 4 months were then asked, "How many days of the past 30 days did you use [the indicated product]?" with answer choices ranging from 0 to 30. All manifest variables were created by dichotomizing any versus no use in the past four months and any versus no use in the past 30 days. ATP and other substance use were conceptualized as baseline predictors rather than time-varying predictors.

We also assessed *depressive symptoms* at Wave 1 using the Patient Health Questionnaire – 9 item (PHQ-9) (Kroenke et al., 2003). Response options range from "not at all" to "nearly every day" in the past two weeks. Cronbach's alpha for the PHQ-9 in the current study was 0.87. The Adult ADHD Self-Report Scale Symptom Checklist (Kessler et al., 2005) was used to assess *ADHD symptoms* at Wave 2 (Spring, 2015). The six screening items from the checklist were used in this study because they provide the highest predictive validity of full-scale ADHD diagnosis. Each of the six items was rated along a five-point scale from "Never" to "Very Often" in the last six months. Sample items included "difficulty getting things in order when a task requires organization" and "feel overly active and compelled to do things as if you were driven by a motor". Cronbach's alpha for this scale in the current study was 0.74.

2.2.2. Interpersonal-level factors—*Adverse childhood experiences* were assessed at Wave 2 using the ten items from the CDC-developed Adverse Childhood Experiences (CDC National Center of Injury Prevention and Control, 2014; Felitti et al., 1998). Items assess events occurring prior to age 18 and include household exposures such as parents with mental health or substance use problems and parental partner interpersonal violence, as well as various forms of child maltreatment (e.g., neglect) and physical and sexual abuse. Response options were either "No" or "Yes". The total score was calculated as the number of "yes" responses. The internal consistency in this study was 0.75. *Social support* was assessed at Wave 2 using the Interpersonal Support Evaluation List – 12 item (ISEL-12) (Cohen et al., 1985), assessing the perceived availability of social support on a four-point scale ranging from "definitely false" to "definitely true." All items are summed to yield a total score (scores range 0–36); three subscales comprised of four items each can also be calculated (appraisal, belonging, *tangible;* scores range 0–12 for each subscale). (Note: Preliminary analyses indicated that the subscales showed similar results across analyses; thus, the total ISEL-12 score was used for all analyses.) Cronbach's alpha for this scale in the current study was 0.85. To assess *parental tobacco and marijuana use*, we asked at Wave 1 if any parent currently used each of the tobacco products (i.e., cigarettes, LCCs, smokeless tobacco, ENDS, and hookah) or marijuana, respectively (Berg et al., 2015).

2.2.3. Community-level factors—We coded the *type of school* attended (private, public, HBCU, technical college) and whether the school was located in an *urban or rural* location.

2.3. Data analysis

Descriptive statistics of sociodemographics and tobacco use characteristics were calculated. Growth mixture modeling (GMM) was used to analyze cigarette use across Waves 2 through 6 to identify classes of trajectories of use over time. GMM allows variation in trajectories across individuals based on a time-varying variable – age in this case – and estimates mean parameters for each trajectory (Muthén & Muthén, 1998-2012). We fitted linear curves, which identified trajectory classes of cigarette use, accounting for clustering of students in schools. We attempted quadratic curves, but analysis was discontinued after more than 48 h due to not yielding a convergent solution. The number of trajectories that best fit the data was determined using several statistics: relatively lower Akaike Information Criterion (AIC), non-significant likelihood ratio test, and relatively higher entropy value (Nylund et al., 2007).

We then used multinomial logistic regressions to assess the associations between cigarette use trajectory class (as assessed by class with highest membership probability) and participant characteristics. Due to the small number of participants in the two smoker classes, we combined them into one smoker class.

GMM analyses were conducted using Mplus 7.4 using Full Information Maximum Likelihood (FIML) estimation (Los Angeles, CA: Muthén & Muthén). Data cleaning and post-GMM regression analyses were conducted using SAS 9.4 (Cary, NC: SAS Institute Inc.).

3. Results

3.1. Participant characteristics

The sample was 20.54 (SD = 1.94) years of age on average, 64.5% female, and 22.6% Black (Table 1). Past 30-day use of ATPs ranged from 3.4% (smokeless tobacco) to 11.5% (hookah); 22.7% used marijuana.

3.2. GMM trajectories

Using AIC, difference tests, and entropy (Supplemental Table S1), we identified three trajectory classes (Fig. 1). We labeled the first and largest class (85.6%) the Abstainers/Dabblers – those participants who had used cigarettes at one point in their life (10.5%) or not at all (74.6%). The second trajectory represents those who began smoking regularly during their college years, labeled College Onset Smokers (6.2%). The third group represented those who began smoking during their mid to late twenties, labeled Later Onset Smokers (8.2%). The curve indicates that the overall probability declined with age from about 16.3% to 2.5% from age 19 to 27.

3.3. Predictors of being college and later onset smokers

Multinomial regression identifying predictors of class membership (Table 2) showed that predictors for being College Onset Smokers (vs. Abstainers/Dabblers) included being male ($p = .031$), Asian ($p = .001$) but not being Black ($p = .008$) versus White (referent), early onset cigarette smokers ($p = .006$), and past 30-day users of LCCs ($p = .024$), alcohol ($p < .001$), and marijuana ($p = .008$). Interpersonal- and community-level predictors included parental use of tobacco ($p = .050$) and attending a public ($p = .031$) or a technical college ($p < .001$) versus a private college (referent). The regression also identified two predictors of being Later Onset Smokers, including being male ($p = .019$) and attending a technical college ($p = .005$) versus a private college.

4. Discussion

This study aimed to extend the literature regarding young adult cigarette smoking trajectories, particularly from a socioecological perspective (McLeroy et al., 1988). Three trajectories resembling those documented in prior research (Hair et al., 2017; Schweizer et al., 2014) were found: Abstainers/Dabblers, College Onset Smokers, and Later Onset Smokers. The latter had distinct features – their smoking behaviors continued to progress beyond the age of 21. Moreover, some novel predictors included in this study, such as ATP use and college campus context, differentiated the three groups. Collectively, these findings highlight the need to examine smoking trajectories from early to middle young adulthood and to account for the current tobacco market and contextual factors.

Only two of our hypotheses were fully supported – that being male and attending a technical college would predict greater risk for smoking escalation, both college and later onset. We should note that we also considered including other campus attributes including time of tobacco-free campus implementation or baseline campus prevalence of smoking. However, these were too highly related to school type to be included in the model together. Because campus type has been so robustly associated with tobacco use (Berg et al., 2011), we retained school type rather than the others. One important note is that, regardless of tobacco-free campus policy, students at the technical colleges have the greatest ease of access to places where smoking was allowed (i.e., off-campus) given that the geographical sizes of these campuses are smaller. Moreover, these students may spend less time on campus than traditional college students, potentially minimizing the impact of campus smoke-free air policies.

Several of our hypotheses were not supported in any analyses, including those regarding parental education, symptoms of depression or ADHD, adverse childhood events, social support, or rural versus urban setting. The reasons for these null results are unclear, particularly related to depression, ADHD, adverse childhood events, and social support. Given the college student population, perhaps parental education is a less robust predictor. Null findings regarding rural vs. urban environment may suggest that college settings in rural areas may not have the same elevated risks that rural areas in general represent (Doescher et al., 2006).

Several hypothesized predictors of smoking initiation/escalation only applied to college onset smoking. For example, being White or Asian predicted college onset smoking, which aligns with the literature (Chen & Jacobson, 2012; Mendel et al., 2012); however, our sample did not show an escalation among Blacks in the later 20 s as documented elsewhere (Hair et al., 2017; Keyes et al., 2015; Watt, 2008). Early onset cigarette use and current use of alcohol and marijuana, as well as parental use of tobacco, were predictive of higher risk for college onset smoking, as the literature would suggest (Berg et al., 2015; Etter & Eissenberg, 2015; Fagerstrom & Eissenberg, 2012; National Center for Chronic Disease et al., 2014; Richardson et al., 2014; Tomar et al., 2010; USDHHS, 2014), but not later onset smoking. The reasons for the other substance use and parental tobacco use not showing these associations are unclear. In relation to ATP use, among users of ATPs in this sample, there was generally low frequency of ATP use and thus may contribute less to one's overall nicotine dependence. Regarding parental tobacco use, this developmental period may be less influenced by parents than during adolescence or emerging young adulthood.

The current findings have implications for research and practice. Collectively, these findings suggest that traditional predictors of smoking uptake in young adulthood, as documented in the literature, may be more relevant to earlier onset smoking rather than later onset smoking. Additional research is needed to better understand risk factors for later onset smoking in the young adulthood years. For example, this study did not include specific factors that may be more relevant for young adults as they transition out of the college student years and mature in executive functioning, gain more independence, change residences, advance their education and occupations, and establish stable relationships with marriage and children (Arnett & Tanner, 2006). Indeed, transitions to more conventional social roles (e.g., work, marriage) in young adulthood are often associated with the cessation of more risky behaviors, including tobacco use (Bachman et al., 2002; Flora & Chassin, 2005; Mendel et al., 2012). Future research should also assess sociocontextual factors (e.g., societal smoking prevalence and social norms, smoke-free air policies) that might influence tobacco use during this time. Qualitative research should also examine the experiences of young adults during this critical transitional period, as well as patterns of polytobacco and polysubstance use.

In practice, more progressive policies are needed to decrease access to tobacco and other substance use among young adults. Campus-based services must promote abstinence and aid in recovery among those struggling with addiction. Moreover, clinicians, particularly those in campus-based settings, must assess cigarette use – as well as other tobacco, alcohol, and marijuana use – on a systematic basis.

Limitations include limited generalizability given that the sample was drawn from colleges/universities in Georgia. However, it should be noted our sample is diverse in terms of race/ethnicity, geographic location (urban vs. rural), school types, and socioeconomic backgrounds. Second, although our measures included important measures related to tobacco use, they were not exhaustively inclusive; for example, other psychological characteristics such as anxiety were not included but may have been important predictors. Another limitation is that, while the Socioecological Model emphasizes the importance of studying interactions across other levels of analysis, our analyses did not consider any

interactions due to the large number of predictors included in our analyses (and thus limited power to test for interactions). Along the same lines, the small sample size, particularly in the Later Onset group, limited power to detect potentially significant findings. These analyses are also limited by the self-report nature of the assessments. Finally, these analyses are limited by missing data from participants lost to attrition over time.

5. Conclusions

Three distinct trajectories of cigarette use behaviors were identified within a sample of young adult college students. While the largest group included those who did not use cigarettes or only used experimentally, the two other classes identified included those who used early on in their college years and those who experienced a later onset of cigarette use. Of particular importance is that, while some hypothesized predictors examined did predict the earlier onset group, fewer factors significantly predicted the later onset group. Thus, greater research is needed to identify risk factors for smoking onset in middle young adulthood and to understand the context for this trajectory of cigarette use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We would like to thank our Campus Advisory Board members across the state of Georgia in developing and assisting in administering this survey. We also would like to thank ICF Macro for their scientific input and technical support in conducting this research.

Role of funding source

This research was supported by the National Cancer Institute (1R01CA179422-01; PI: Berg). The funders had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

References

American Lung Association, 2016 State of Tobacco Control, 2016. Retrieved from. www.stateoftobaccocontrol.org.

Arnett J, Tanner J, 2006 Emerging Adults in America: Coming of Age in the 21st Century. Retrieved from. American Psychological Association, Washington, DC.

Bachman J, O'Malley P, Schulenberg J, Johnston L, Bryant A, Merline A, 2002 The Decline of Substance Use in Young Adulthood: Changes in Social Activities, Roles, and Beliefs. Retrieved from:. Psychology Press, Mahwah, NJ.

Bandura A, 2004 Health promotion by social cognitive means. Health Educ. Behav 31 (2), 143–164. 10.1177/1090198104263660. [PubMed: 15090118]

Berg CJ, Choi WS, Kaur H, Nollen N, Ahluwalia JS, 2009 The roles of parenting, church attendance, and depression in adolescent smoking. J. Commun. Health 34 (1), 56–63. 10.1007/s10900-008-9118-4.

Berg CJ, An LC, Thomas JL, Lust K, Sanem JR, Swan DW, Ahluwalia JS, 2011 Differences in smoking patterns, attitudes, and motives among two-year college and four-year university students. Health Educ. Res 26 (4), 614–623. [PubMed: 21447751]

Berg CJ, Haardörfer R, Lewis M, Fakhouri T, Getachew B, Lloyd S, et al., 2016 DECOY: documenting experiences with cigarettes and other tobacco in Young adults. Am. J. Health Behav 40 (3), 310–321. [PubMed: 27103410]

Berg CJ, Stratton E, Schauer GL, Lewis M, Wang Y, Windle M, Kegler M, 2015 Perceived harm, addictiveness, and social acceptability of tobacco products and marijuana among young adults: marijuana, hookah, and electronic cigarettes win. Subst. Use Misuse 50 (1), 79–89. 10.3109/10826084.2014.958857. [PubMed: 25268294]

Bernat DH, Erickson DJ, Widome R, Perry CL, Forster JL, 2008 Adolescent smoking trajectories: results from a population-based cohort study. J. Adolesc. Health 43 (4), 334–340. 10.1016/j.jadohealth.2008.02.014. [PubMed: 18809130]

Bonnie R, Stroud C, Breiner H, National Research Council (U.S.), Board on Children, Y. a. F, 2014 Investing in the Health and Well-Being of Young Adults. Retrieved from. . https://www.nap.edu/resource/18869/YAreportbrief.pdf.

Breslau N, Kessler RC, Chilcoat HD, Schultz LR, Davis GC, Andreski P, 1998 Trauma and posttraumatic stress disorder in the community: the 1996 detroit area survey of trauma. Arch Gen. Psychiatry 55 (7), 626–632. [PubMed: 9672053]

Brook JS, Pahl K, Ning Y, 2006 Peer and parental influences on longitudinal trajectories of smoking among African Americans and Puerto Ricans. Nicotine Tob. Res 8 (5), 639–651. 10.1080/14622200600789627. [PubMed: 17008191]

Carlson LE, Goodey E, Bennett MH, Taenzer P, Koopmans J, 2002 The addition of social support to a community-based large-group behavioral smoking cessation intervention: improved cessation rates and gender differences. Addict. Behav 27 (4), 547–559. [PubMed: 12188591]

Centers for Disease Control and Prevention National Center of Injury Prevention and Control, 2014 Prevalence of Individual Adverse Childhood Experiences. Retrieved from. www.cdc.gov/violenceprevention/acestudy/prevalence.html.

Chen P, Jacobson KC, 2012 Developmental trajectories of substance use from early adolescence to Young adulthood: gender and racial/ethnic differences. J. Adolesc. Health 50 (2), 154–163. 10.1016/j.jadohealth.2011.05.013. [PubMed: 22265111]

Cohen S, Mermelstein R, Kamarck T, Hoberman H, 1985 Measuring the functional components of social support In: IG S, BR S (Eds.), Social Support: Theory, Research, and Applications. Martinus Niijhoff, The Hague, Netherlands.

Doescher MP, Jackson JE, Jerant A, Gary Hart L, 2006 Prevalence and trends in smoking: a national rural study. J. Rural Health 22 (2), 112–118. 10.1111/j.1748-0361.2006.00018.x.JRH18. [PubMed: 16606421]

Dutra LM, Glantz SA, Lisha NE, Song AV, 2017 Beyond experimentation: five trajectories of cigarette smoking in a longitudinal sample of youth. PLoS One 12 (2), e0171808 10.1371/journal.pone.0171808. [PubMed: 28182748]

Elkins IJ, Saunders GRB, Malone SM, Keyes MA, Samek DR, McGue M, Iacono WG, 2017 Increased risk of smoking in female adolescents who had childhood ADHD. Am. J. Psychiatry 175 (1). 10.1176/appi.ajp.2017.17010009.

Etter JF, Eissenberg T, 2015 Dependence levels in users of electronic cigarettes, nicotine gums and tobacco cigarettes. Drug Alcohol. Depend 147, 68–75. 10.1016/j.drugalcdep.2014.12.007. [PubMed: 25561385]

Fagerstrom K, Eissenberg T, 2012 Dependence on tobacco and nicotine products: a case for product-specific assessment. Nicotine Tob. Res 14 (11), 1382–1390. 10.1093/ntr/nts007. [PubMed: 22459798]

Fairlie AM, Wood MD, Laird RD, 2012 Prospective protective effect of parents on peer influences and college alcohol involvement. Psychol. Addict. Behav 26 (1), 30–41. 10.1037/a0023879. [PubMed: 21574670]

Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, Marks JS, 1998 Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The adverse childhood experiences (ACE) study. Am. J. Prev. Med 14 (4), 245–258. [PubMed: 9635069]

Fergusson DM, Horwood LJ, Lynskey MT, 1996 Childhood sexual abuse and psychiatric disorder in young adulthood: II. Psychiatric outcomes of childhood sexual abuse. J. Am. Acad. Child. Adolesc. Psychiatry 35 (10), 1365–1374. 10.1097/00004583-199610000-00024. [PubMed: 8885591]

Fisher EB Jr, 1997 Two approaches to social support in smoking cessation: commodity model and nondirective support. Addict. Behav 22 (6), 819–833. [PubMed: 9426800]

Flay BR, Petraitis J, Hu FB, 1999 Psychosocial risk and protective factors for adolescent tobacco use. Nicotine Tob. Res 1 (Suppl. 1), S59–S65.

Flora DB, Chassin L, 2005 Changes in drug use during young adulthood: the effects of parent alcoholism and transition into marriage. Psychol. Addict. Behav 19 (4), 352–362. 10.1037/0893-164x.19.4.352. [PubMed: 16366807]

Ford ES, Anda RF, Edwards VJ, Perry GS, Zhao G, Li C, Croft JB, 2011 Adverse childhood experiences and smoking status in five states. Prev. Med 53 (3), 188–193. 10.1016/j.ypmed.2011.06.015. [PubMed: 21726575]

Fuemmeler B, Lee CT, Ranby KW, Clark T, McClernon FJ, Yang C, Kollins SH, 2013 Individual- and community-level correlates of cigarette-smoking trajectories from age 13 to 32 in a U.S. population-based sample. Drug Alcohol. Depend 132 (1-2), 301–308. 10.1016/j.drugalcdep.2013.02.021. [PubMed: 23499056]

Glass K, Flory K, 2010 Why does ADHD confer risk for cigarette smoking? A review of psychosocial mechanisms. Clin. Child. Fam. Psychol. Rev 13 (3), 291–313. 10.1007/s10567-010-0070-3. [PubMed: 20582628]

Hair E, Bennett M, Williams V, Johnson A, Rath J, Cantrell J, et al., 2017 Progression to established patterns of cigarette smoking among young adults. Drug Alcohol Depend. 1 (77), 77–83. 10.1016/j.drugalcdep.2017.03.040.

Hanson BS, Isacsson SO, Janzon L, Lindell SE, 1990 Social support and quitting smoking for good. Is there an association? Results from the population study, "Men born in 1914," malmo, Sweden. Addict. Behav 15 (3), 221–233. [PubMed: 2378282]

Hovdestad W, Campeau A, Potter D, Tonmyr L, 2015 A systematic review of childhood maltreatment assessments in population-representative surveys since 1990. PLoS One 10 (5), e0123366 10.1371/journal.pone.0123366. [PubMed: 25993481]

Hu SS, Neff L, Agaku IT, Cox S, Day HR, Holder-Hayes E, King BA, 2016 Tobacco product use among adults - United States, 2013-2014. Mmwr-Morbidity Mortal. Wkly. Rep 65 (27), 685–691.

Jamal A, Agaku IT, O'Connor E, King BA, Kenemer JB, Neff L, 2014 Current cigarette smoking among adults–United States, 2005-2013. MMWR Morb Mortal. Wkly. Rep 63 (47), 1108–1112. [PubMed: 25426653]

Johnston L, O'Malley P, Bachman J, Schulenberg J, Miech R, 2014 Monitoring the Future National Survey Results on Drug Use, 1975–2013. Volume II: College Students and Adults Ages 19–55. Retrieved from:. http://www.monitoringthefuture.org/pubs/monographs/mtf-vol2_2013.pdf.

Kessler RC, Adler L, Ames M, Demler O, Faraone S, Hiripi E, et al., 2005 The world health organization adult ADHD self-report scale (ASRS): a short screening scale for use in the general population. Psychol. Med 35, 245–256. [PubMed: 15841682]

Keyes KM, Vo T, Wall MM, Caetano R, Suglia SF, Martins SS, et al., 2015 Racial/ethnic differences in use of alcohol, tobacco, and marijuana: Is there a crossover from adolescence to adulthood? Soc. Sci. Med 124,132–141. 10.1016/j.socscimed.2014.11.035. [PubMed: 25461870]

Kroenke K, Spitzer RL, Williams JB, 2003 The patient health questionnaire-2: validity of a two-item depression screener. Med. Care 41 (11), 1284–1292. [PubMed: 14583691]

Mays D, Gilman SE, Rende R, Luta G, Tercyak KP, Niaura RS, 2014 Parental smoking exposure and adolescent smoking trajectories. Pediatrics 133 (6), 983–991. 10.1542/peds.2013-3003. [PubMed: 24819567]

McLeroy KR, Bibeau D, Steckler A, Glanz K, 1988 An ecological perspective on health promotion programs. Health Educ. Q 15 (4), 351–377. [PubMed: 3068205]

McMillen R, Maduka J, Winickoff J, 2012 Use of emerging tobacco products in the United States. J. Environ. Public. Health 2012, 989474 10.1155/2012/989474. [PubMed: 22654922]

Mendel JR, Berg CJ, Windle RC, Windle M, 2012 Predicting young adulthood smoking among adolescent smokers and nonsmokers. Am. J. Health Behav 36 (4), 542–554. 10.5993/AJHB.36.4.11. [PubMed: 22488404]

Muthén LK, Muthén BO, 1998 Mplus User's Guide. −2012. 7th ed. Authors, Los Angeles, CA.

National Center for Chronic Disease, P, Health Promotion Office on, S, Health, 2012 Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. Retrieved from. Centers for Disease Control and Prevention (US), Atlanta (GA) https://www.surgeongeneral.gov/library/reports/preventing-youth-tobacco-use/full-report.pdf.

National Center for Chronic Disease, P, Health Promotion Office on, S, Health, 2014 The Health Consequences of Smoking-50 Years of Progress: A Report of the Surgeon General. Retrieved from:. Centers for Disease Control and Prevention (US), Atlanta (GA) https://www.ncbi.nlm.nih.gov/books/NBK179276/.

Nelson SE, Van Ryzin MJ, Dishion TJ, 2015 Alcohol, marijuana, and tobacco use trajectories from age 12 to 24 years: demographic correlates and young adult substance use problems. Dev. Psychopathol 27 (1), 253–277. 10.1017/S0954579414000650. [PubMed: 25017089]

Nylund KL, Asparouhov T, Muthen BOSEMAMJ, v14 n4 p535-569 10 2007, 2007. Deciding on the number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study. Struct. Equ. Model. Multidiscip. J 14 (4), 535–569.

Ortal S, van de Glind G, Johan F, Itai B, Nir Y, Iliyan I, van den Brink W, 2015 The role of different aspects of impulsivity as independent risk factors for substance use disorders in patients with ADHD: a review. Curr. Drug Abuse Rev 8 (2), 119–133. [PubMed: 26373850]

Pal R, Balhara YPS, 2016 A review of impact of tobacco use on patients with co-occurring psychiatric disorders. Tob. Use Insights 9, 7–12. 10.4137/Tui.S32201. [PubMed: 26997871]

Park E, McCoy TP, Erausquin JT, Bartlett R, 2018 Trajectories of risk behaviors across adolescence and young adulthood: the role of race and ethnicity. Addict. Behav 76, 1–7. 10.1016/j.addbeh.2017.07.014. [PubMed: 28734192]

Richardson A, Williams V, Rath J, Villanti AC, Vallone D, 2014 The next generation of users: prevalence and longitudinal patterns of tobacco use among US young adults. Am. J. Public Health 104 (8), 1429–1436. 10.2105/AJPH.2013.301802. [PubMed: 24922152]

Riggs NR, Chou CP, Li C, Pentz MA, 2007 Adolescent to emerging adulthood smoking trajectories: when do smoking trajectories diverge, and do they predict early adulthood nicotine dependence? Nicotine Tob. Res 9 (11), 1147–1154. 10.1080/14622200701648359. [PubMed: 17978988]

Roberts W, Peters JR, Adams ZW, Lynam DR, Milich R, 2014 Identifying the facets of impulsivity that explain the relation between ADHD symptoms and substance use in a nonclinical sample. Addict. Behav 39 (8), 1272–1277. 10.1016/j.addbeh.2014.04.005. [PubMed: 24813555]

Rose JS, Lee CT, Dierker LC, Selya AS, Mermelstein RJ, 2012 Adolescent nicotine dependence symptom profiles and risk for future daily smoking. Addict. Behav 37 (10), 1093–1100. 10.1016/j.addbeh.2012.05.004. [PubMed: 22673155]

Schweizer CA, Roesch SC, Khoddam R, Doran N, Myers MG, 2014 Examining the stability of young-adult alcohol and tobacco co-use: a latent transition analysis. Addict. Res. Theory 22 (4), 325–335.

Sibley MH, Pelham WE, Molina BSG, Coxe S, Kipp H, Gnagy EM, Lahey BB, 2014 The role of early childhood ADHD and subsequent CD in the initiation and escalation of adolescent cigarette, alcohol, and marijuana use. J. Abnorm. Psychol 123 (2), 362–374. 10.1037/a0036585. [PubMed: 24886010]

Substance Abuse and Mental Health Services Administration, 2015 Behaviroal Health Trends in the United States: Results from the 2014 National Survey on Drug Use and Health. Retrieved from:. https://www.samhsa.gov/data/sites/default/files/NSDUH-FRR1-2014/NSDUH-FRR1-2014.pdf.

Tomar SL, Alpert HR, Connolly GN, 2010 Patterns of dual use of cigarettes and smokeless tobacco among US males: findings from national surveys. Tob. Control 19 (2), 104–109. 10.1136/tc.2009.031070. [PubMed: 20008157]

U.S. Department of Health and Human Services, 2014 The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General. Retrieved from: Atlanta, GA. .

Watt TT, 2008 The race/ethnic age crossover effect in drug use and heavy drinking. J. Ethn. Subst. Abuse 7 (1), 93–114. 10.1080/15332640802083303. [PubMed: 19842303]

Windle M, Mason WA, 2004 General and specific predictors of behavioral and emotional problems among adolescents. J. Emot. Behav. Disord 12 (1), 49–61. 10.1177/10634266040120010601.

Windle M, Windle RC, 2001 Depressive symptoms and cigarette smoking among middle adolescents: prospective associations and intrapersonal and interpersonal influences. J. Consult. Clin. Psychol 69 (2), 215–226. [PubMed: 11393599]

Windle M, Windle RC, 2012 Early onset problem behaviors and alcohol, tobacco, and other substance use disorders in young adulthood. Drug Alcohol. Depend. 121 (1-2), 152–158. 10.1016/j.drugalcdep.2011.08.024. [PubMed: 21925804]

Zhan W, Dierker LC, Rose JS, Selya A, Mermelstein RJ, 2012 The natural Course of nicotine dependence symptoms among adolescent smokers. Nicotine Tob. Res 10.1093/ntr/nts031.

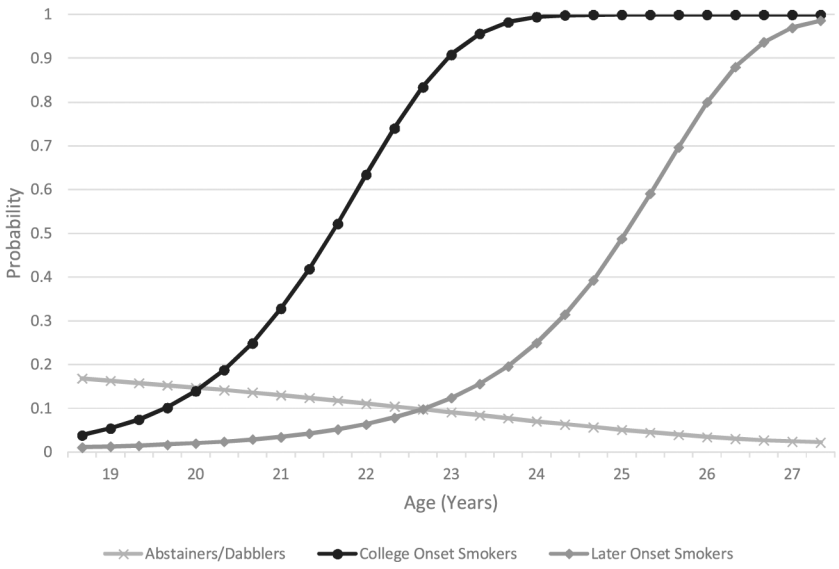

Fig. 1.
GMM Cigarette Trajectories.

Table 1

Participant Characteristics, N = 2967.

Parameter	Mean or N	SD or %
Individual-level		
Age at baseline, M (SD)	20.54	1.94
Sex, N (%)		
Male	1052	35.5
Female	1911	64.5
Sexual orientation, N (%)		
Heterosexual	2697	91.7
Not heterosexual	243	8.3
Race, N (%)		
White	1902	64.9
Asian	192	6.6
Black	663	22.6
Other	172	5.9
Hispanic, N (%)	230	7.8
Parental education, N (%)		
< Bachelor's degree	499	17.0
≥ Bachelor's degree	2431	83.0
Early onset cigarette smoking (< 15 years), N (%)	113	3.9
Participant past 30-day substance use, N (%)		
LCCs	301	10.1
Smokeless tobacco	102	3.4
ENDS	307	10.4
Hookah	341	11.5
Alcohol	1857	62.6
Marijuana	672	22.7
Depressive symptoms, M (SD)	6.24	5.27
ADHD symptoms, M (SD)	9.52	4.36
Interpersonal-level		
Adverse childhood events, M (SD)	1.33	1.82
Social support, M (SD)		
Appraisal	12.03	2.01
Belonging	11.39	1.82
Tangible support	13.44	2.34
Parental substance use, N (%)		
Tobacco	956	32.2
Marijuana	185	6.2
Community-level		
School type, N (%)		
Private	1235	41.6

Parameter	Mean or N	SD or %
HBCU	326	11.0
Public	825	27.8
Technical	581	19.6
Community type, N (%)		
Urban/suburban	1234	41.6
Rural	1733	58.4

Note: LCCs = little cigar/cigarillo; ENDS = electronic nicotine delivery systems.

Table 2

Predictors of Cigarette Class Membership (Reference Class = Abstainers/Dabblers).

	Earlier Onset Smokers N = 101				Later Onset Smokers N = 21			
Parameter	**OR**	**CI**		**p**	**OR**	**CI**		**p**
Individual-level								
Sex (male = ref.)	0.56	0.33	0.95	.031	0.29	0.105	0.81	.019
Sexual orientation (hetero = ref.)	1.35	0.66	2.74	.415	1.61	0.437	5.90	.477
Race								
White	ref.							
Asian	3.83	1.75	8.38	.001	1.85	0.339	10.12	.476
Black	0.23	0.08	0.68	.008	0.97	0.236	3.95	.962
Other	0.84	0.29	2.46	.754	0.53	0.056	5.01	.578
Hispanic (no = ref.)	0.63	0.20	1.96	.425	1.75	0.324	9.49	.514
Parental education (< BA = ref.)	0.72	0.41	1.26	.247	1.14	0.34	3.80	.836
Early onset smoking (no = ref.)	2.57	1.32	5.02	.006	1.37	0.272	6.93	.700
Past 30-day use (no = ref.)								
LCCs	2.05	1.10	3.83	.024	1.25	0.234	6.72	.792
Smokeless tobacco	1.68	0.76	3.71	.201	*	*	*	*
ENDS	1.65	0.93	2.93	.087	0.95	0.237	3.79	.938
Hookah	1.04	0.56	1.92	.907	0.82	0.163	4.17	.815
Alcohol	4.19	2.01	8.71	< .001	3.14	0.96	10.29	.058
Marijuana	2.02	1.20	3.41	.008	1.30	0.434	3.89	.641
Depressive symptoms	0.99	0.95	1.04	.747	1.01	0.933	1.10	.747
ADHD symptoms	1.00	0.95	1.06	.909	1.04	0.929	1.15	.533
Interpersonal-level								
Adverse childhood events	1.06	0.94	1.20	.342	1.19	0.958	1.48	.116
Social support	0.98	0.94	1.02	.262	0.98	0.899	1.06	.585
Parental substance use (no = ref.)								
Tobacco	1.65	1.00	2.72	.050	1.05	0.381	2.89	.925
Marijuana	0.86	0.39	1.90	.716	0.70	0.131	3.73	.675
Community-level								
School type								
Private	ref.							
HBCU	3.50	0.82	14.98	.091	*	*	*	*
Public	2.04	1.07	3.88	.031	0.21	0.024	1.77	.151
Technical	5.17	2.55	10.51	< .001	5.84	1.708	19.96	.005
Rural (urban = ref.)	0.98	0.57	1.67	.935	1.09	0.39	3.02	.871

Note: OR = odds ratio; CI = 95% Wald confidence interval; LCCs = little cigar/cigarillo; ENDS = electronic nicotine delivery systems.

* Due to small cell size, this parameter could not be estimated.