Trajectories of smoking among freshmen college students with prior smoking history and risk for future smoking: data from the University Project Tobacco Etiology Research Network (UpTERN) study

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ABSTRACT

Aims Little is known about smoking during the transition to college. The current study examined trajectories of smoking among college freshmen, how trajectories predicted later smoking and the social context of smoking. Design Weekly assessments of daily smoking were collected via the web during the first year of college for a large cohort with a previous history of smoking. Participants and setting A total of 193 college freshmen from a large public university with a previous history of smoking who smoked frequently enough to be included in trajectory analysis. Measurements Measures included weekly reports of daily smoking, family smoking, perceived peer attitudes and smoking, social norms and social smoking environment. Findings Seven trajectories were identified: one of low-level sporadic smoking, one of low-level smoking with a small increase during the year, two classes with a substantial decrease during the year, two classes with relatively small decreases and one class with a substantial increase in smoking. Trajectories of smoking in the freshman year predicted levels of sophomore year smoking, and some social context variables tended to change as smoking increased or decreased for a given trajectory class. Conclusions The transition into college is marked by changes in smoking, with smoking escalating for some students and continuing into the sophomore year. Shifts in social context that support smoking were associated with trajectories of smoking. Despite the focus of developmental models on smoking in early adolescence, the transition into college warrants further investigation as a dynamic period for smoking.

Keywords Cigarette smoking, college students, emerging adulthood, mixture modeling, social effects, social influence, trajectories.

INTRODUCTION

Young adult and college smoking continues to be a public health concern [1,2]. However, much of what we have learned about the correlates of initiation and escalation of cigarette smoking is based upon data from adolescent samples prior to the college years. Risk and protective factors for smoking may vary across different developmental periods [3], and what we know about smoking prior to age 18 years may not apply to college-age smoking. Thus, exporting prevention programs designed for adolescents prior to college may not be appropriate or effective. There is a need for basic research on young adult smoking that may inform the development of preventive interventions. The goal of the current study was to identify trajectories of smoking during the freshman year of college, and their association with social context and smoking later in college.

Several prospective studies have identified a pattern of cigarette use characterized by low levels of smoking in early adolescence followed by a period of escalation late in adolescence [4–6]. Chassin et al. [4] speculated that late-escalation smokers may follow prohibitions about smoking during adolescence, but with the transition into adulthood they may no longer view smoking as a deviant behavior. Thus, for some individuals the transition from
adolescence to young adulthood may be a period of heightened vulnerability for escalation in smoking.

College may be an important context in which to study smoking because for many adolescents it marks the beginning of the transition from adolescence to adulthood [7]. Upon entering college, many students experience a change in social context and increased freedom and independence [8], and previous inhibitions about a variety of risk behaviors may weaken due to declines in adult supervision and the perception that many risk behaviors are considered adult behaviors. Indeed, evidence suggests an increase in smoking for some students when they start college [9,10].

There is a notable dearth of longitudinal research on college smoking and this is troublesome, given the rise in prevalence of cigarette use observed in the 1990s on college campuses [9,10]. We could find only one study that used a prospective design to examine college smoking. Wetter et al. [11] categorized students into one of three groups at baseline and follow-up (4 years later) and found that most non-smokers at baseline remained non-smokers at follow-up (88.5%), but that 11.5% transitioned into occasional smoking. Occasional smokers at baseline transitioned into either daily smoking (14.4%) or quit smoking (50.7%) at the follow-up assessment. Daily smokers at baseline were most likely to remain daily smokers 4 years later (58.5%), with 28.2% transitioning to occasional smoking and 13.4% quitting. These findings suggest considerable heterogeneity in the progression of smoking during the college years.

The University Project of the Robert Wood Johnson Foundation Tobacco Etiology Research Network (UpTERN) used a longitudinal design and gathered weekly assessments of daily smoking behavior in a large sample of freshman college students. This design allowed us to model trajectories of smoking during the entire first year of college, a period characterized by substantial change in multiple psychosocial domains. Colder et al. [12] found that on average smoking declined during freshman year for the UpTERN sample, but this report did not attempt to identify different longitudinal patterns of smoking or correlates of change. The first goal of this paper was to describe heterogeneity in longitudinal patterns of smoking during the freshman year of college among students who had some level of smoking prior to college. Students with previous experience with cigarette smoking are of particular interest, because past research suggests that this group is at risk for escalation of smoking in early adulthood [4,5,11].

Our second goal was to examine correlates of change. Some of the freshmen were followed-up during the spring semester of their sophomore year, which allowed us to examine how smoking trajectories in the freshman year impacted smoking later in college. We also examined several aspects of social context that might be associated with different longitudinal patterns of smoking. We focused upon social context for several reasons. First, there is ample evidence to support the role of peer influence on adolescent smoking [13], including college smoking [14,15]. Secondly, previous research suggests that incoming students seek to establish new social relationships that provide support and intimacy, and facilitate the transition to college [16,17]. Thirdly, most youth experience increased freedom and independence upon entering college [8] due partly to declines in parental control of adolescent behavior as youth approach college age [18,19]. Thus, social norms, peer attitudes and peer smoking, all of which are key components of social learning and cognitive theories of adolescent substance use [20], may be particularly important influences of smoking during the transition to college.

**METHODS**

Participants

Subjects were selected from responses to a screener survey (n = 4690, response rate of 71% of 6560) administered to incoming freshmen during the summer orientation program of 2002. The screener survey included 27 items that assessed smoking, use of tobacco products and smoking attitudes and expectancies. The survey was administered when students came to campus for a 1-day university orientation program between 11 June and 5 July 2002. At the campus survey locations, students were directed to a desk where they were greeted by a research assistant who described the project and administered the survey. Students were told that they might be contacted in a few weeks to find out if they were interested in participating in a follow-up project. Students were paid $5.00 in cash for completing the screener survey.

Incoming freshmen with some previous smoking experience were considered for inclusion because we anticipated that smoking behavior would be most likely to occur and change during the transition into college for this population. Almost 43% (n = 2000) of the students who completed the screener reported at least some experience with smoking (i.e. one or more puffs in their lifetime) and were invited to participate in the study. As shown in Table 1, these 2000 students compared to the 2690 non-smokers had more experience with smoking, were more likely to have parents and siblings who smoked and were more likely to be male and white. The first 912 (46%) of the 2000 eligible students who agreed to participate were enrolled and completed a computer-based baseline survey during the weekend before classes started, for which they were paid $35, and 905 (45%) took part in weekly web-based surveys for which they
were paid typically $5 for each week. The retention rate was 96% over the 35 weeks of the study. More details about sample selection and retention including bonus payments are reported in Tiffany et al. [21].

Recruitment was stopped at \( n = 912 \) because we did not have the funds to run an intensive longitudinal study for a larger sample. Comparison of students who were recruited into the study (\( n = 912 \)) and other eligible students (\( n = 1088 \)) are presented in Table 1. Results suggested statistically significant but small differences on gender and minority status, such that the recruited sample was slightly less likely to be male and minority. Students who were recruited into the study reported lower rates of recent daily smoking, but the two groups did not differ on monthly smoking or intentions to smoke in the next year.

Our goal was to identify smoking trajectories, and accordingly we selected participants for whom trajectories could be estimated reasonably. We considered only those subjects who reported smoking during the freshman year (\( n = 636 \)). Our 245 days of daily data exceeded the maximum number of points that growth mixture modeling software can deal with [22]. Accordingly, means of daily smoking over 4 weeks (the last interval was 3 weeks) were computed for nine intervals to yield ‘monthly’ smoking values. To reduce bias due to disproportional weekday/weekend rates, weekday and weekend observations were multiplied by \( 5/7 \) and \( 2/7 \), respectively, before calculating monthly smoking values.

Of the 636 students who smoked, 193 were selected for inclusion in the analyses based on the criteria below (also see Fig. 1). First, 73 subjects were excluded for: (i) having more than 2 consecutive months of missing smoking data (as defined above) or (ii) having fewer than 90 days of observations during the year. This level of missing data did not provide adequate information to compute reliable trajectory estimates. Secondly, 370 subjects were excluded because of low level (did not smoke 30 cigarettes, average of one per day, in at least 1 month) or infrequent smoking (smoked on fewer than 15% of reported days in the year or smoked on fewer than 40% of reported days in at least 1 month). Our goal was to be as inclusive as possible, and we considered a variety of selection criteria, all of which suggested that inclusion of low level infrequent smokers produced estimation difficulties (e.g. non-convergence), which suggests that the longitudinal pattern for this group of subjects could not be modeled.

The final resulting sample of 193 students did not differ from those excluded from our analysis on minority status or gender, but they were more likely to have smoked daily and monthly, have siblings who smoked and had stronger intentions to smoke in the next year (see Table 1). As expected, the smoking experience of our included sample differed from those who had never smoked and also from those who completed the screener survey but did not participate in this study, such that our analysis sample was more likely to report monthly and daily smoking and had stronger intentions to smoke (see Table 1).

In the spring semester of sophomore year, we did a short follow-up mail-in survey of smoking, which allowed us to examine how trajectories of smoking in the freshman year predicted smoking levels in the sophomore year. Of the 193 participants included in our freshman year analysis, 118 (61%) returned the sophomore year survey. Multivariate analysis of variance (MANOVA) results with the nine repeated measures of smoking

Table 1 Characteristics of the 4690 freshmen who completed the screener (\( n = 2690 \) non-smokers and \( n = 2000 \) students with previous smoking experience invited to participate in the longitudinal University Project Tobacco Etiology Research Network (UpTERN study), 2000 students invited to participate (\( n = 1088 \) not enrolled and \( n = 912 \) enrolled in UpTERN) and 912 students enrolled in UpTERN (\( n = 719 \) participants excluded from the analysis sample and \( n = 193 \) included the final analysis sample).

<table>
<thead>
<tr>
<th>Characteristic (%)</th>
<th>4690 screened freshmen</th>
<th>2000 previous smokers invited to participate</th>
<th>1088 participants not enrolled</th>
<th>912 participants enrolled</th>
<th>719 participants excluded</th>
<th>193 participants included</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2690 non-smokers</td>
<td>2000 non-smokers invited to participate</td>
<td>1088 participants not enrolled</td>
<td>912 participants enrolled</td>
<td>719 participants excluded</td>
<td>193 participants included</td>
</tr>
<tr>
<td>White</td>
<td>88.40</td>
<td>91.55*</td>
<td>89.26</td>
<td>93.09*</td>
<td>92.63</td>
<td>94.82</td>
</tr>
<tr>
<td>Male</td>
<td>55.93</td>
<td>58.86*</td>
<td>57.45</td>
<td>54.88*</td>
<td>55.18</td>
<td>52.33</td>
</tr>
<tr>
<td>Parents/guardians smoke</td>
<td>30.16</td>
<td>38.95*</td>
<td>37.89</td>
<td>37.83</td>
<td>37.83</td>
<td>37.82</td>
</tr>
<tr>
<td>Siblings smoke</td>
<td>11.78</td>
<td>22.62*</td>
<td>22.45</td>
<td>22.83</td>
<td>21.17</td>
<td>29.02*</td>
</tr>
<tr>
<td>Smoked monthly for 3 months</td>
<td>0.00</td>
<td>51.33*</td>
<td>51.57</td>
<td>51.05</td>
<td>41.00</td>
<td>88.54*</td>
</tr>
<tr>
<td>Smoked daily for past 4 weeks</td>
<td>0.00</td>
<td>24.96*</td>
<td>27.10</td>
<td>22.42*</td>
<td>9.48</td>
<td>70.47*</td>
</tr>
<tr>
<td>Think will smoke next year</td>
<td>1.15</td>
<td>57.66*</td>
<td>50.92</td>
<td>47.63</td>
<td>45.95</td>
<td>92.74*</td>
</tr>
</tbody>
</table>

* Asterisk indicates significant differences (\( P < 0.05 \)) between the two adjacent columns.
during the freshman year as dependent variables suggested no difference between those who returned the sophomore year survey and those who did not (Wilkes' Λ = 0.96; F(9, 164) = 0.81, P > 0.05). Thus, whether or not students returned the sophomore questionnaire was not related to smoking during the freshman year.

Procedures

Weekly internet-based assessments started the first week of September and ended the first week of May 2003. Smoking was assessed using daily diaries that were completed on the internet on a weekly basis. Additional questions were included on the survey each week, but to keep the survey brief these additional measures were administered on a rotating basis, typically once a month, but for some measures less frequently. For the purposes of this report we focused upon social context variables. Perceived social norms were assessed in weeks 3, 7, 11, 15, 19, 23, 27 and 31, perceived close friend smoking and approval of smoking were assessed in weeks 2, 6, 10, 14, 18, 22, 26, 30, and 34, and social smoking environment was assessed in weeks 14 and 34. We also administered some questions prior to the start of the semester in August. Our August assessment was not part of the weekly internet assessments, and was administered in three campus computer laboratories. Of interest from the August survey for this report were items that assessed social context of smoking during high school, and parent and sibling smoking.

Measures

Smoking

Weekly assessments included a question about whether the participant smoked in the past week. If participants responded 'yes', they were administered a 7-day follow-back calendar, which asked them to report on the number of cigarettes they smoked on each day of the previous week. The number of cigarettes smoked in a typical week during the sophomore year was calculated by taking the mean of two items (number of cigarettes smoked during a typical week during the autumn and spring semesters).

Perceived close friend smoking and approval of smoking

Participants were asked to list three people with whom they currently spend the most time, other than a romantic partner. After listing the names, participants reported on each person's smoking behavior (0 = does not smoke to 6 = smokes a lot) and the degree to which each person would disapprove or approve of his/her smoking (−3 = would disapprove strongly to +3 = would approve strongly). The mean of the three peer smoking items and the three peer approval items was taken to form close friend smoking and approval of smoking scores for each of the nine assessments.

Social smoking environment

Participants were asked how often they spend their social time in places where people are smoking on weekdays and at weekends (1 = never to 5 = very often). The mean of these two items was taken to form a scale score at each assessment.

Perceived social norms

Two items rated on an 11-point scale (0 = 0 to 10 = 10) assessed perceived social norms about smoking ('out of every 10 students, how many do you think smoke cigarettes?' and 'out of every 10 freshmen, how many do you...
think smoke cigarettes?'). The mean of the two items was taken to form a perceived social norms score at each assessment.

**Social context prior to college**

Participants reported the number of their five closest friends in high school who smoked and how often they were around friends who were smoking in high school (1 = not at all, 2 = a little, 3 = a lot). Participants also reported the number of their family members (parents and siblings) who smoked while they lived with them. Very few participants reported more than two family members smoking (n = 14), so this variable was collapsed into three categories (0 = none, 1 = one, and 2 = two or more family members).

**Statistical methods**

**Models**

Growth mixture modeling (GMM) was used to classify subjects into discrete trajectory classes based on longitudinal smoking data [22]. One aspect of a subject’s trajectory is their intercept, which reflects their level of smoking at midpoint (we centered time-points). In typical applications of GMM, trajectory class membership is determined by their intercept, as well as rate of change (slope). Here, we were interested in basing the classification of trajectory groups on changes in smoking over time and not intercepts. Therefore, we allowed the intercept to be treated as a random subject effect (that is, to vary across subjects) and for the linear and quadratic time trends to be used in determining trajectory classes. This model estimates a separate intercept for each subject and separate time-trends (i.e. linear and quadratic trend components) for each trajectory class. That is, variation in individual growth is treated in two ways: as (normally) varying intercepts over subjects and varying time-trends over classes in our model. Additionally, the error variances were allowed to vary across the trajectory classes in order to reflect differences in smoking levels across the groups. Accordingly, our model can be viewed as a hybrid of a hierarchical linear model (in terms of intercept) and a GMM (in terms of linear and quadratic trend components). In presentation of the class-specific growth trajectories in our figures, we calculated average class intercepts based on the estimated subject-varying intercepts for subjects identified as belonging to each class, augmented by the class-estimated linear and quadratic trend components of the model. Final model selection was based on the Baysian information criterion (BIC) [23], which has been shown to be useful in identifying the optimal number of classes in finite mixture models [24].

For the final model, we present the proportion of subjects belonging to each class and the growth trajectories for each class. We also report entropy for our final model. Mplus provides estimates of probabilities of membership in each class for each individual. For each individual these probabilities sum to 1.0. Ideally, for each individual, one probability would be very high (around 1.0) and the others very low (close to 0), indicating little ambiguity about class membership. Entropy ranges from 0 to 1 and is a summary measure of classification based upon these probabilities. The closer entropy values are to 1.0 the better the classification.

**RESULTS**

**Growth mixture model**

A seven-class model provided the best fit to the data according to the BIC (6574.1). Entropy was 0.87, suggesting minimal ambiguity in classification of subjects. Trajectories for each class are depicted in Fig. 2. There were two increasing classes (classes 1 and 2; 30 subjects, 15%), one class of little change (class 3; 34 subjects, 18%) and four decreasing classes (classes 4–7; 129 subjects, 67%). Change in smoking was significant in all classes except for class 3. Average levels of smoking at the beginning of the school year for classes 1 and 2 were...
4.5 and 0.5 cigarettes/day, respectively. The amount of increase in classes 1 (20 subjects, 10%) and 2 (10 subjects, 5%) were 4.0 and 1.6 cigarettes/day, respectively. Thus, we labeled classes 1 and 2 large and small increasers, respectively.

Among the decreasing classes, the decline in smoking by classes 4 and 5 (75 subjects, 39%) occurred over the course of the entire academic year (steady decreasers) while for classes 6 and 7 (54 subjects, 28%) the decline in smoking occurred during the first semester (early decreasers). Average levels of smoking at the beginning of the year for classes 4–7 were 4.6, 2.9, 6.4 and 12.2, respectively. Smoking for classes 4–7 decreased 1.4, 2.2, 4.9 and 8.9 cigarettes/day, respectively.

Although class 3 is characterized as the class of little change, they are probably better characterized as sporadic triers. The average intercept for this class was approximately 0.3 cigarettes/day or about two cigarettes/week on average. However, the sporadic nature of smoking for this class is illustrated by looking at one week in more detail (data not presented), which shows that during a week at the beginning of the freshman year, 20 of the 34 students never smoked at all, some tried just one cigarette on one occasion, four smoked five to eight cigarettes in 1 day and one student appears to have smoked two to five cigarettes every day.

The 370 students omitted from the class mixture analysis because of extremely low levels of smoking might be considered an eighth class characterized by some sporadic smoking. The average number of cigarettes per day for this group was only 0.07, changing from 0.14 to 0.05 from the beginning to the end of the study, or an average of 3.8 to 1.4 cigarettes/month.

Classes 4 and 5 showed small changes throughout the year, with some variability in level of smoking. Classes 6 and 7 showed larger decreases in smoking levels, mainly during the first semester, again with some variability in levels, especially in class 7.

Associations between social context and trajectory classes

Repeated-measures analyses of variance (ANOVAs) were used to examine the relationship between our trajectory classes and changes in social context. These models included a social context variable as the dependent variable, time with polynomial contrasts as a within-subject factor and trajectory class as a between-subject factor. For close friend approval of smoking there was a statistically significant effect of time ($F_{(6,728)} = 3.18, P < 0.01$) and statistically significant time x trajectory class interaction term ($F_{(48, 728)} = 1.59, P < 0.01$). As shown in Fig. 3, the two classes with the highest levels of smoking at the beginning of the study also had the highest levels of close friend approval of smoking at this time. There was a general decline in close friend approval of smoking for most classes except for classes 1 and 2. Classes 1 and 2 both showed an increase in smoking during the freshman year (see Fig. 2) that was associated with an increase in close friend approval of smoking. In contrast to close friend approval of smoking, neither time ($F_{(8,728)} = 1.51, P < 0.21$) nor the time x trajectory class interaction term ($F_{(48,728)} = 1.59, P < 0.01$) were statistically significant for close friend smoking.

With respect to social smoking environment, there was a statistically significant time effect ($F_{(1,169)} = 5.14, P < 0.01$) and time x trajectory class interaction term ($F_{(6,169)} = 3.06, P < 0.01$). There was a general trend for stability from weeks 14 to 35 in the amount of social time spent in environments where other people were smoking, with the exception of classes 1 and 6 (data not shown, but available upon request). There was an increase in social time spent where others were smoking for class 1, whereas there was a decrease for class 6. Examination of Fig. 2 suggests that smoking for class 1 increased during the second half of the study, whereas it decreased during this time for class 6. This pattern suggests
correspondence between changes in levels of smoking and changes in spending social time where others are smoking. Perceived social norms about smoking did not change over time ($F(6,760) = 0.95$, $P < 0.46$), and the time x trajectory class interaction term was also not statistically significant ($F(48,760) = 1.06$, $P < 0.36$).

When we considered social context prior to college, ANOVA and $\chi^2$ results suggested that the number of close friends in high school who smoked ($F(6,186) = 1.39$, $P > 0.20$) and the number of family members who smoked ($\chi^2(12) = 9.34$, $P > 0.65$) were unrelated to trajectories of smoking during freshman year. However, frequency of being around friends while they were smoking was associated with trajectory classes ($\chi^2(12) = 23.11$, $P < 0.03$). A smaller proportion of students in classes 2 and 3 (40% and 53%, respectively) reported that they were around friends while they were smoking ‘a lot’ compared to the remaining classes (between 70% and 83% of remaining classes). This suggests that students in the two classes characterized by the lowest level of smoking in the beginning of the freshman year were around friends who smoked less often in high school.

**Association between trajectory classes and sophomore year smoking**

Failure to return the sophomore year survey was unrelated to membership in the freshman year trajectory classes ($\chi^2(6) = 11.37$, $P > 0.05$). Average reported number of weekly cigarettes smoked in the sophomore year ranged from 0 to 180 with a mean of 24.75 (standard deviation = 31.65). ANOVA results suggested significant differences across the classes on sophomore year smoking ($F(6,117) = 7.58$, $P < 0.001$). Means and pairwise comparisons are presented in Table 2. Classes 1 and 7 had the highest levels of smoking in the sophomore year, whereas classes 3 and 5 had the lowest levels of smoking.

Slopes (rates of change) are often correlated with levels of the dependent variable, and an important question is whether the association we observed between trajectory classes and sophomore year smoking was indeed a function of change, or would this relationship be reduced to 0 when levels of freshman year smoking were taken into account? We ran an analysis of covariance (ANCOVA) with class membership as a factor and mid-year smoking as a covariate predicting sophomore year smoking. Results were remarkably similar to those described above. Class membership significantly predicted sophomore year smoking ($F(6,107) = 4.07$, $P < 0.01$), and all the significant mean comparisons reported in Table 2 remained significant in this ANCOVA model, suggesting that change in smoking during the freshman year provides unique information for the prediction of smoking in the sophomore year.

**DISCUSSION**

One goal of this study was to describe different trajectories of cigarette smoking during the freshman year for college students with some prior smoking experience. We identified seven classes of students that differed in their pattern of smoking. Some groups increased and some decreased with some slopes being linear (representing steady change during the year) and some being quadratic (representing more change at the beginning or the end of the year). Two classes exhibited an increase in smoking during the school year. One class (plus the 370 students not included in the formal analysis) displayed no significant or consistent change in smoking level during the school year—only sporadic trying. The most common pattern was a decline in smoking, which was evident for four groups (67%).

The decline in smoking we observed for the majority of students in our smoking sample may be a function of an increase in experimentation followed by a decline in smoking due to increasing academic demands. Qualitative interviews from the UpTERN study are consistent with this notion, and suggest that students experience the initial weeks of freshman year to be a time of freedom and exploration, but that the increasing demands of academics necessitates moderation of partying and socializing.

<table>
<thead>
<tr>
<th>Trajectory class</th>
<th>n</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Significant Tukey’s HSD comparisons ($P &lt; 0.05$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (large increasers)</td>
<td>10</td>
<td>3.70</td>
<td>0.64</td>
<td>1 $&gt;$ 3, 5</td>
</tr>
<tr>
<td>2 (small increasers)</td>
<td>5</td>
<td>2.22</td>
<td>1.02</td>
<td>No significant differences</td>
</tr>
<tr>
<td>3 (sporadic smokers)</td>
<td>28</td>
<td>1.55</td>
<td>1.09</td>
<td>3 $&lt; 1$, 6, 7</td>
</tr>
<tr>
<td>4 (steady increasers, moderate levels of smoking)</td>
<td>22</td>
<td>2.30</td>
<td>1.66</td>
<td>4 $&lt;$ 7</td>
</tr>
<tr>
<td>5 (steady decreasers, low levels of smoking)</td>
<td>22</td>
<td>1.99</td>
<td>1.25</td>
<td>5 $&lt; 1$, 7</td>
</tr>
<tr>
<td>6 (early decreasers, low levels of smoking)</td>
<td>15</td>
<td>2.97</td>
<td>1.01</td>
<td>6 $&gt;$ 3</td>
</tr>
<tr>
<td>7 (early decreasers, moderate levels of smoking)</td>
<td>16</td>
<td>3.56</td>
<td>1.31</td>
<td>7 $&gt;$ 3, 4, 5</td>
</tr>
</tbody>
</table>

HSD: honestly significant difference.
Moreover, most smoking in the UpTERN sample occurred at weekends and was accompanied frequently by alcohol and marijuana use [12,26], suggesting that smoking in our sample was part of partying and socializing. It is notable that close friend approval of smoking declined during freshman year for the four classes (classes 4, 5, 6 and 7) that showed declines in smoking. This suggests that peer attitudes about smoking may mirror the broader social context of initial experimentation and exploration followed by restraint due to increased academic demands.

In contrast to the majority pattern of declining smoking, the two increasing classes were associated with increases in close friend approval of smoking. Smoking for class 1 began to accelerate during the middle of the year, which corresponds to about the time that close friend approval of smoking began to increase (or disapproval began to weaken) for this class. Class 1 was also associated with an increase in spending social time in environments where others were smoking during the second half of the year. Smoking and close friend approval began to increase together, albeit at a later point in the year for class 2. However, class 2 showed only modest increases in spending time in places where others were smoking, which corresponds with the more modest increases in smoking for this class relative to class 1. Overall, these findings suggest that as some students begin to smoke more, particularly when smoking for the majority of students is declining, they may select peers and contexts that are supportive of their behavior. Alternatively, their social context may influence smoking behavior. Our data cannot distinguish between selection and influence, but past research suggests that both may be operating [27].

Several of our social context variables, including perceived social norms, close friend smoking (in college and high school) and family smoking prior to college, were not associated with the trajectory classes. Social learning theory suggests that imitation and modeling and social reinforcement are important mechanisms of social influence [28,29]. Involvement with smokers and the perception that smoking is normative did not distinguish our trajectories, which suggests that imitation and modeling are not operating. Rather, the perception of approval/disapproval by close friends, as described above, distinguished longitudinal patterns of smoking, and this suggests that the social consequences of smoking may be particularly important with respect to smoking during freshman year.

Our smoking classes were related to smoking in the sophomore year, and this was true above and beyond levels of smoking during freshman year. This suggests that trajectories provide unique information in predicting sophomore year smoking. It is notable that the class that showed the most dramatic escalation of smoking during the freshman year (class 1) exhibited the highest level of smoking in the sophomore year. It is also notable that despite the rapid decline in smoking during the freshman year for class 7, sophomore year smoking was relatively high for this group. It may be that smoking for this group plateaus at some moderate level that continued into the sophomore year. Although classes 2 and 6 showed evidence of small increases in smoking during the freshman year, these increases did not seem to result in high levels of smoking in the sophomore year. Our two stable low smoking groups (classes 3 and 5) seemed to continue this behavior into the sophomore year as these two classes exhibited the lowest levels of sophomore smoking across the seven classes.

Overall, our findings are important because they suggest that freshman year is a dynamic period with regard to smoking for some students. Importantly, how smoking changes during freshman year predicts levels of smoking later in college. Thus, it may be important to tailor the timing of interventions for different subgroups depending on longitudinal patterns of smoking. Intervening too early, prior to when smoking is viewed as a personal concern, may be ineffective [30]. Two longitudinal patterns seem to indicate vulnerability to continued elevated levels of smoking after the freshman year. One pattern is characterized by high levels of smoking in the beginning of freshman year followed by a rapid decline to moderate levels. However, despite this decline, smoking begins to rebound at the end of the freshman year. Another pattern of concern was characterized by moderate levels of smoking early in the freshman year followed by an increase in smoking that begins at the end of the autumn semester. These subgroups may be important targets of intervention, and it may be fruitful to try to move them to contemplating quitting smoking during the rebound period at the end of the year, or the point of escalation at the end of the autumn semester. Changing perceived peer attitudes may be useful to this end.

The current study has some limitations that should be noted. First, there are clear limits on the generalizability of our findings. College smoking is likely to vary across academic institutions. Our sample was drawn from a large university (student body of 38 000), where the overwhelming majority of undergraduates are Caucasian and a substantial number of students live on campus. A variety of institutional characteristics such as size, demographic characteristics of students, prominence of fraternities and sororities and residential/non-residential campuses may influence the smoking behavior of freshmen. Thus, some caution is warranted when generalizing our findings to other college settings. It should be noted that our goal was not to generalize incidence or prevalence of smoking to college students or
even to students at one university. Our goal, instead, was to understand more clearly cigarette smoking trajectories over 1 year in close to real time.

Secondly, we limited this study to students who had already tried smoking because an unselected sample would have resulted in an overwhelming majority of students who never smoked during the freshman year, thus requiring a much larger sample. Such a sample would probably make collection of daily smoking data feasible. Thus, for economy of design, we selected incoming freshmen with some previous experience with smoking, and this should be kept in mind when generalizing our results. Thirdly, we stopped recruitment because of financial constraints. Although participation rates for this study are commensurate with other studies of college smoking and substance use [25,31,32], the fact that more than 56% of eligible students did not participate should also be kept in mind when generalizing results from this study. Although there were only a few small differences between participating and non-participating students, the fact that participating students were lower-level smokers may warrant some caution in generalizing our results. Fourthly, the low levels of smoking in our sample and the frequent assessment of smoking provided data that were inappropriate for conventional data analytical strategies. Our approach provides an illustration of class mixture analysis for researchers with similar kinds of data, which is likely to become more common as studies increasingly use intensive data collection methods. Finally there is the issue of what and for whom influences on smoking trajectories are most salient. Here, we found effects for social context on the smoking trajectories of relatively light smokers. However, it is not known how this context might influence heavier (regular) smoking. Further, although not as important for low-level smokers [33], stress and negative affect (e.g. during examinations) are relevant for regular college smokers [34] and were not tested here. Future research should examine additional correlates of college smoking across the full range of stages of smoking.

Our goal was to provide a description of the natural history of smoking by students with some previous smoking history over the course of freshman year, and to examine the social context of smoking during this time. We focused upon the freshman year of college because it is a time of transition. No studies have considered this important transition with respect to smoking. Our data suggest considerable variability in how smoking changes during the freshmen year and that these changes mirror changes in social context. Extending developmental models of smoking into the college years is likely to be an important direction for future research that has the potential to inform the timing and content of college smoking preventive interventions.

Declarations of interest
None.

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