Original Investigation

Are college student smokers really a homogeneous group? A latent class analysis of college student smokers

Erin L. Sutfin, Beth A. Reboussin, Thomas P. McCoy, & Mark Wolfson

Abstract

Introduction: College smokers are often considered to be one homogenous group, those reporting smoking on at least one of the past 30 days. However, considerable heterogeneity exists among college students who report current smoking. The aim of this paper is to characterize disparate patterns of smoking among college students using latent class analysis (LCA).

Methods: The sample consisted of 1,102 past-month smokers from 10 colleges in North Carolina who completed a Web-based survey. LCA was used to create homogeneous groups of smokers with similar patterns defined by multiple indicators of smoking behavior, including quantity and frequency of smoking, smoking contexts, and weekly patterns of smoking.

Results: Five subclasses of smokers were identified: “heavy smokers” (28%), moderate smokers (22%), social smokers (19%), puffers (26%), and no-context smokers (4%). Demographic characteristics that varied among these subgroups were year in school, Greek membership, and residence location. Puffers were more likely to be younger students than heavy and social smokers, suggesting a transition from experimentation to regular use over time. Social smokers and puffers were more likely to be involved in Greek organizations than were heavy and moderate smokers. Moderate and social smokers were more likely to be current drinkers and to have engaged in binge drinking in the past month than were heavy smokers. This finding suggests that, for moderate and social smokers, a strong relationship exists between alcohol and tobacco use.

Discussion: The results highlight the heterogeneity of college student smokers and underscore the need for targeted interventions.

Introduction

Studies of smoking among college students have often considered smokers to be one group, those reporting smoking on at least one of the past 30 days (Rigotti, Lee, & Wechsler, 2000; Thompson et al., 2007; Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998). This definition assumes that past-30-day college smokers are a homogeneous group. However, considerable heterogeneity exists among college students who report current smoking. Only 30% of college students report smoking every day, with substantial variability in the frequency of smoking days among those who are not daily smokers (Sutfin, McCoy, Champion, Helme, O’Brien, & Wolfson, manuscript under review). Our goal here is to identify and characterize subgroups of college student smokers with similar patterns of smoking so that targeted interventions may be developed.

Few studies have highlighted the differences between those who smoke on a daily basis (“daily smokers”) and those who report smoking in the past 30 days but not every day (“nondaily smokers”; Hines, Fretz, & Nollen, 1998; Kenford et al., 2005; Ridner, 2005; Wetter et al., 2004). Daily and nondaily smokers vary in some factors associated with patterns of smoking. Dimensions on which they differ include peer influences, smoking expectancies, harm risk beliefs, and illicit drug use. Dimensions on which they do not differ include their use of alcohol and other health risk behaviors, including marijuana use and having multiple sex partners (Hines et al., 1998; Schorling, Gutgesell, Klas, Smith, & Keller, 1994; Sutfin et al., manuscript under review; Wetter et al., 2004).

Some important differences exist between nondaily and daily smokers, above and beyond quantity and frequency of smoking. Similarly, nondaily smokers may themselves be a heterogeneous group, with different patterns of smoking and

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contexts in which smoking occurs. For example, considerable variability exists in the quantity and frequency of cigarettes smoked by nondaily smokers (Sutfin et al., manuscript under review; Wortley, Husten, Trosclair, Chrismon, & Pederson, 2003).

Different types of smokers may require different types of interventions (Wortley et al., 2003). For instance, pharmacotherapy or nicotine replacement therapies, appropriate for daily smokers, may be ineffective with other groups of smokers. In addition, college students who are nondaily smokers do not typically consider themselves to be smokers and may underestimate their risk for future smoking, overestimate their ability to quit, and underestimate the health risks associated with their tobacco use (Levinson et al., 2007; Thompson et al., 2007). Traditional cessation programs may not be successful with nondaily smokers, primarily because they do not perceive themselves to be smokers. New and innovative interventions need to be developed to target this population.

Before specific interventions for college student smokers can be developed and tested, research needs to characterize patterns of smoking in this population and examine whether evidence exists for a classification of smokers that goes beyond the traditional "current smoker" or "daily versus nondaily" taxonomy. In this study, we used latent class analysis (LCA) to identify subgroups (classes) of college smokers with similar smoking patterns (Lazarsfeld & Henry, 1968; McCutcheon, 1987). LCA is an empirically based statistical method for explaining heterogeneity in response patterns in terms of underlying classes. We aimed to (a) use LCA to characterize patterns of smoking in a sample of college students; (b) estimate the prevalence of these patterns of smoking; and (c) better understand the variation in smoking patterns by examining the associations with demographic variables, health risk variables, and other aspects of smoking behavior, including efficacy to quit, nicotine dependence, and perceived health effects.

Methods

Population and sample

In fall 2006, a random sample of undergraduate students attending 10 universities (eight public and two private) in North Carolina were invited to complete a Web-based survey as part of a randomized group trial of an intervention to prevent high-risk drinking behaviors and their consequences (Wolfson et al., 2007). Students from each campus were selected randomly from undergraduate enrollment lists provided by each school. The goal was to have 416 students (104 each of freshmen, sophomores, juniors, and seniors) from each university to complete the survey ($n = 4,160$). The number of students selected to participate was based on the expectation from previous studies and previous waves of the survey that approximately 30%–35% of the students would complete the survey within the allowed time period (Reed, Wang, Shillington, Clapp, & Lange, 2006). The Web site was shut down shortly after the target numbers from the 10 schools were achieved. The response rate across all 10 schools was 21.0% and varied quite a bit across campuses (9.3%–34.0%). Variation in the response rates across schools may reflect varying levels of technological capabilities (Mitra, Jain-Shukla, Robbins, Champion, & DuRant, 2007). The

response rate was likely affected by the survey link being deactivated after the quota (4,160 students) was reached (i.e., a higher response rate would have been achieved if a quota system had not been used).

All the students selected to participate were sent an E-mail inviting them to participate in a Web-based survey, which provided a link to a secured Web site where the survey could be completed. The E-mail notification protocol, including multiple, frequent reminders for the Web-based survey, was based on the Dillman (2000) approach (Mitra et al., 2007). All students who completed the survey were sent E-mails awarding them US\$10.00 in PayPal dollars. The protocol was approved by the Wake Forest University School of Medicine Institutional Review Board.

Measures

The Web-based College Drinking Survey was adapted from items used previously in the Harvard College Alcohol Survey (Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994), the Core Institute Drug and Alcohol Survey (Presley, Meilman, & Lyerla, 1994), the Youth Survey used in the National Evaluation of the Enforcing Underage Drinking Laws Program (Preisser, Young, Zaccaro, & Wolfson, 2003; Wolfson et al., 2004), and the Centers for Disease Control and Prevention (CDC) Youth Risk Behavior Survey (Kolbe, 1990). The survey focused on alcohol and measured demographic variables, alcohol consumption behaviors, and consequences experienced from alcohol use. It also assessed other health risk behaviors, including tobacco use and marijuana and other drug use.

To characterize patterns of smoking, we focused on responses to questions about quantity and frequency of smoking, weekly patterns of smoking, and contexts in which students smoke. Demographics, other health risk behaviors, nicotine dependence, perceived health effects, and quit efficacy were examined as potential factors that might explain the heterogeneity in smoking patterns. These items are described in more detail below.

Smoking behaviors. Using standard items from the Youth Risk Behavior Surveillance System (CDC, 2006), we assessed the number of days smoked in the past month and the number of cigarettes smoked on smoking days in the past month. Responses to the number of days smoked were as follows: 1 = 1–2 days, 2 = 3–5 days, 3 = 6–9 days, 4 = 10–19 days, 5 = 20–29 days, and 6 = all 30 days. This variable was treated as an ordinal variable with categories 1–6. The number of cigarettes smoked on smoking days had responses of 1 = 1 or less, 2 = 2–5, 3 = 6–10, and 4 = 11+. This variable also was treated as an ordinal variable with categories 1–4.

In their study of daily patterns of smoking among college freshman, Colder et al. (2006) found a weekly cycle of smoking, such that the likelihood of smoking increased on Fridays and Saturdays. Therefore, we assessed how likely participants were to smoke on each day of the week. Response options included "never," "rarely," "sometimes," "often," and "always." We created one variable for smoking on the weekend (defined as Friday and Saturday) and a second for weekday smoking (defined as Sunday through Thursday). Students reporting smoking sometimes, often, or always were contrasted with those reporting smoking never or rarely during these times of the week.

Smoking contexts. Because patterns of smoking are often context specific, we asked participants to report how often during the past month they smoked cigarettes in each of 16 different contexts including the following: your room or apartment, on-campus residence hall, fraternity/sorority house, restaurant, bar, on-campus party, off-campus party, tailgating, hanging out with friends, drinking alcohol, studying, watching TV, before class, after class, playing drinking games, and by yourself. Response options included never, rarely, sometimes, often, and always. Students reporting smoking in each context at least sometimes (i.e., sometimes, often, or always) were compared with those reporting never or rarely smoking in these contexts.

Demographics. Demographic variables included year in school (coded as freshman, sophomore, junior, senior, or fifth-year undergraduate), gender, race (coded as White or non-White), ethnicity (coded as Hispanic or non-Hispanic), and mother's and father's educational level (asked separately; coded as some college education vs. high school degree or less than high school degree). We also assessed participants' membership in Greek organizations, as a member or a pledge (coded as yes or no).

Health risk behaviors. Alcohol use was assessed with three items: past-30-day use (coded as yes or no); past-30-day binge drinking (four or more drinks in a row for females and five or more drinks in a row for males; coded as yes or no); and number of days in a typical week student gets drunk, where drunk was defined as unsteady, dizzy, or sick to your stomach (coded as 0 days vs. 1 or more days). Other health risk behaviors included past-30-day marijuana use (coded as yes or no) and lifetime illegal drug use (cocaine, amphetamines, hallucinogens, Rohypnol, Ecstasy, or prescription drugs without a prescription; coded as yes or no).

Age at smoking initiation. We assessed participants' age at smoking initiation with one item from the Youth Risk Behavior Surveillance System (CDC, 2006): How old were you when you smoked a whole cigarette for the first time? This was treated as a continuous variable.

Time to first cigarette. We assessed nicotine dependence with one item measuring time to first cigarette in a day. Response options included "within 5 min," "within 6–30 min," "within 31–60 min," and "after 60 min." This item is used frequently as a proxy for nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerström, 1991; Moran, Wechsler, & Rigotti, 2004).

Quit efficacy. We assessed participants' self-efficacy for quitting smoking with one item: If you decided to give up smoking altogether, how likely do you think you would be to succeed? Response options were "very unlikely," "somewhat unlikely," "somewhat likely," and "very likely."

Perceived health effects. We assessed participants' perceptions of the health effects of their smoking with one item: "How concerned are you about the possible effects of cigarette smoking on your health?" Response options were "not at all concerned," "only slightly concerned," "fairly concerned," and "very concerned."

Data analyses

LCA was applied to examine the structure underlying the items measuring smoking behaviors and contexts. The basic premise of LCA is that, within classes, items are locally independent

(Lazarsfeld, 1950; McCutcheon, 1987). For our application, this means that the co-occurrence of smoking behaviors and contexts can be explained by an underlying classification of college students into subgroups (classes) with similar patterns of smoking. The goal of LCA is to identify the smallest number of classes that adequately describes the association among smoking behaviors and contexts.

Our model-building strategy involved starting with the most parsimonious one-class model ("all smokers the same") and fitting successive models with an increasing number of latent classes to determine the most parsimonious model that provided an adequate fit to the data. The goodness of fit of various models was first evaluated using the Bayesian information criteria (BICs), a global fit index that combines goodness of fit and parsimony. In a comparison of models with the same set of data, models with lower values are preferred. For latent class models, there are considerations other than global goodness-of-fit indices. Rather than rely solely on the BIC, which tends to favor more complex models, we used residual diagnostics proposed by Magidson and Vermunt (2000) to probe the basic assumption in LCA of local independence, that is, that the specified number of classes is sufficient to explain the associations among the smoking behaviors and contexts. The bivariate residuals (BVRs) of Magidson and Vermunt (2000) provide a direct check of this assumption. They can be interpreted as lower bound estimates for the improvement in fit if the corresponding local independence constraints were relaxed. In general, BVRs larger than 3.84 identify correlations between associated variable pairs that have not been explained adequately by the model.

Because of the large number of smoking context variables (16) relative to the smoking behaviors (4) and concerns that some of the contexts might overlap, we performed a preliminary LCA restricted to the context variables in hopes of reducing the number of contexts. Based on these analyses, we combined smoking contexts with strong local dependencies ($BVR > 3.84$). Since these local dependencies are likely a result of the items' measuring similar contexts, we used the joint item method, whereby a set of items are replaced by a single item that is positive if the response to any of the questions is positive. In particular, we combined the following smoking contexts: (a) restaurant and bar; (b) on-campus and off-campus party; (c) drinking alcohol and playing drinking games; (d) before class and after class; and (e) your room, studying, and watching TV. We also removed the following contexts because of their low prevalence and lack of discriminatory power: (a) on-campus residence hall, (b) fraternity/sorority house, and (c) tailgating.

Next, to clarify the nature of the derived latent classes, students were assigned to their most likely LCA-derived smoking class based on their estimated posterior probabilities of class membership given their observed smoking pattern. When students are assigned to latent classes based on their estimated class membership probabilities (i.e., posterior probabilities), some degree of misclassification error is likely to arise. Therefore, we present both the overall classification error rates and the average posterior probabilities for each class. Individual-level class membership indicators were then treated as dependent variables in multinomial logistic regression models, and bivariate relationships with demographics, other health risk behaviors, nicotine dependence, perceived health effects, and quit efficacy were explored. Because college campuses comprise intact social

groups, students within a school are likely to be more like one another than they are to be like students at other schools (Murray & Short, 1995, 1996). Failure to account for this correlation among students within a school in regression analyses could result in inflated Type I error rates and invalid conclusions (Donner, Birkett, & Buck, 1981). Hence, the bivariate multinomial logistic regression modeling took into account the within-school clustering by the addition of a random effect for school using the Stata Statistical Software version 10 and the GLLAMM package. Overall, four degrees-of-freedom tests for any differences in the classes were performed. Pairwise comparisons of smoking classes were considered if the overall tests were significant. Odds ratios (ORs) and 95% CIs adjusted for clustering within schools were calculated for the independent variables. A two-sided *p* value of less than .05 was considered statistically significant for this paper.

Results

Out of 4,271 total students surveyed in fall 2006, 1,102 (25.8%) reported smoking in the past 30 days and were used in the study analyses. Student characteristics and behaviors of the sample are given in Table 1. Overall, the sample contained slightly more female smokers (56%). More than three-fourths of smokers were White (86%). Twenty-four percent were freshmen, 26% were sophomores, 26% were juniors, 18% were seniors, and 4% were fifth-year undergraduates. Finally, 13% of smokers were members or pledges of a Greek organization.

Based on the reduced set of seven smoking contexts and the four smoking behaviors, latent class models were fit to the data starting with the most parsimonious one-class model (all smokers the same) with progression to less parsimonious models. The BIC suggested a best-fitting model based on seven classes of college smokers. However, diagnostic information based on BVRs indicated that the local independence assumption between some item pairs was violated for the seven-class model, in particular, (a) smoking at a party and smoking while drinking (BVR = 7.8) and (b) smoking on a weekend and smoking on a weekday (BVR = 7.4).

Although violations of the local independence assumption were reduced significantly by going from a four- to five-class model (i.e., 14 local dependencies compared with 9), the addition of a sixth and then seventh class still did not remove all local dependencies (four and two local dependencies remained, respectively). Since increasing the complexity of the model by adding classes did not remove all local dependencies, we began by refitting the more parsimonious five-class model and relaxing the local independence assumption. This was done by allowing for a residual dependence between a pair of items; that is, the association between a pair of items is not assumed to be explained completely by the latent class structure. In situations where there is only one large BVR (BVR > 3.84), a new model can be estimated by allowing for this residual dependence within the item pair. However, if there are several significant BVRs, a common strategy is to relax the local independence assumptions one at a time, starting with the largest BVR, reestimating the model, and checking the updated BVRs after each new model is estimated before allowing for local dependence between additional items. This strategy is used because, once you have allowed for a local dependence in a model, all the BVRs in the

new model may no longer be significant (Magidson & Vermunt, 2000).

By allowing local dependencies between items with significant BVRs and using this step-by-step process until all BVRs were no longer significant, we ended up with a five-class model allowing for local dependencies between (a) smoking while drinking alcohol and smoking at a party (BVR = 9.9), (b) smoking on a weekend and smoking on a weekday (BVR = 16.9), (c) smoking while drinking alcohol and smoking at a restaurant or bar (BVR = 9.3), and (d) smoking at a party and smoking hanging out with friends (BVR = 8.4). The fit index for this five-class model with local dependence was improved compared with the six- and seven-class models (BICs = 12,793, 12,897, and 12,892, respectively, for the five-, six-, and seven-class models). The item pairs for which we relaxed the local independence assumption will likely always be highly correlated. For example, if you are smoking at a party, you are also likely to be hanging out with friends. The addition of classes to explain such correlations is unlikely to produce meaningful subgroups, resulting in unnecessary model complexity. Hence, we chose to accept the more parsimonious five-class model of college smoking.

The estimated probabilities of reporting smoking behaviors and smoking in different contexts in each class are displayed graphically in Figure 1. College smokers in class 1, which comprised an estimated 28% of our sample, are likely to be daily smokers who smoke 6–10 cigarettes/day and smoke in all contexts. We refer to this group as the “heavy smokers.” College student smokers in class 2 (prevalence = 22%) represent a class of “moderate smokers,” smoking about 10–19 days/month and on average 2–5 cigarettes on each smoking day. These smokers smoke on both weekends and weekdays. College student smokers in class 3 report smoking only in social contexts (i.e., hanging out with friends, in a restaurant or bar, at a party, and while drinking). These “social smokers” are most likely to smoke on the weekends, smoking only 3–5 days/month and 2–5 cigarettes on each smoking day. The prevalence for this group is 19%. An additional 26% of college student smokers are in class 4 and report smoking only 1 or 2 days in the past month and smoking one or fewer cigarettes on those days. They are unlikely to report smoking on either the weekend or the weekdays. We refer to this group of college smokers as the “puffers.” The final class of smokers report moderate levels of smoking but do not report smoking in any context or on any day of the week. The prevalence for this group is only 4%. Similar to the puffers, this group does not report smoking at least sometimes in any context; however, in contrast to the puffers, their levels of smoking are more consistent with those of the moderates. Either members of this group are failing to report where and when they smoke or the survey is failing to ask about contexts in which they smoke. We refer to this group as the “no-context” group. Student characteristics and behaviors of the participants within each subgroup are given in Table 1.

To learn more about our LCA-derived subtypes of college student smokers, individuals were assigned to classes based on estimated modal posterior probabilities of class membership given their observed patterns of smoking. The estimated classification error rates were 2%, 3%, 6%, 7%, 7%, and 9% for the two-, three-, four-, five-, six-, and seven-class models, respectively. For the final five-class model with local dependence, the estimated classification error rate was 7%. The average posterior

Figure 1. Patterns of smoking among past-30-day college smokers. *Class-specific means are rescaled to lie within the 0–1 range. The lowest observed value is subtracted from the class-specific mean and then divided by the range, which is the difference between the highest and lowest observed values.

probabilities under this final model were a respectable 0.95, 0.95, 0.89, 0.91, and 0.87 among those assigned to classes 1 through 5, respectively. Class assignments were then treated as nominal outcomes and analyzed using baseline-category logistic regression modeling.

Table 2 gives the bivariate logistic regression results for looking at differences between classes. On demographics and activities, the five classes were different in year in school ($p = .01$), residence location ($p < .01$), and proportion of Greek members or pledges ($p < .01$). For class year, students in a higher class year were associated with lower likelihood of being a puffer versus a heavy smoker ($OR = 0.84$, 95% $CI = 0.72$ – 0.97) or a social smoker ($OR = 0.76$, 95% $CI = 0.65$ – 0.89). Puffers also were more likely to live on-campus compared with heavy smokers ($OR = 2.30$, 95% $CI = 1.62$ – 3.27), moderate smokers ($OR = 2.14$, 95% $CI = 1.50$ – 3.04), or social smokers ($OR = 1.83$, 95% $CI = 1.26$ – 2.65). Greek members or pledges were more likely to be social smokers than heavy smokers ($OR = 2.59$, 95% $CI = 1.44$ – 4.65) or moderate smokers ($OR = 2.58$, 95% $CI = 1.44$ – 4.61). Greek members or pledges also were more likely to be puffers than heavy smokers ($OR = 2.41$, 95% $CI = 1.38$ – 4.22) or moderate smokers ($OR = 2.41$, 95% $CI = 1.38$ – 4.19).

For health risk and other drug use, we found differences among classes in past-30-day drinking (any and binge), past-30-day marijuana use, lifetime illegal drug use, age at first cigarette, and time to first cigarette ($p < .05$ for all; Table 3). The difference among classes for getting drunk in a typical week was marginally significant ($p = .05$). Moderate and social smokers were more likely to report drinking in the past 30 days compared with heavy smokers (moderate vs. heavy $OR = 2.56$, 95% $CI = 1.23$ – 5.34 ; social vs. heavy $OR = 3.73$, 95% $CI = 1.53$ – 9.10). These same two groups of smokers also reported an increased prevalence of binge drinking in the past 30 days

(moderate vs. heavy $OR = 1.95$, 95% $CI = 1.28$ – 2.96 ; social vs. heavy $OR = 2.46$, 95% $CI = 2.55$ – 3.90). Puffers were less likely to report any drinking in the past 30 days compared with moderate smokers ($OR = 0.43$, 95% $CI = 0.20$ – 0.91) and social smokers ($OR = 0.29$, 95% $CI = 0.12$ – 0.73). No-context smokers were less likely to report any drinking in the past 30 days compared with social smokers ($OR = 0.23$, 95% $CI = 0.06$ – 0.86). No-context smokers also were less likely to report binge drinking in the past 30 days compared with moderate smokers ($OR = 0.39$, 95% $CI = 0.18$ – 0.83) and social smokers ($OR = 0.31$, 95% $CI = 0.14$ – 0.68). Puffers also had lower odds of reporting binge drinking compared with social smokers ($OR = 0.54$, 95% $CI = 0.34$ – 0.86).

Puffers were less likely to report past-month marijuana use than moderate smokers ($OR = 0.64$, 95% $CI = 0.45$ – 0.91), social smokers ($OR = 0.68$, 95% $CI = 0.47$ – 0.98), and no-context smokers ($OR = 2.11$, 95% $CI = 1.04$ – 4.31). Except for moderate smokers, all classes were associated with decreased likelihood of lifetime drug use compared with heavy smokers ($p = .22$). Compared with moderate smokers, puffers ($OR = 0.37$, 95% $CI = 0.26$ – 0.54) and no-context smokers ($OR = 0.40$, 95% $CI = 0.18$ – 0.90) were less likely to report lifetime drug use. Puffers also were less likely to report drug use compared with social smokers ($OR = 0.51$, 95% $CI = 0.34$ – 0.74).

Older age at first cigarette was associated with being a social smoker compared with a heavy smoker ($OR = 1.14$, 95% $CI = 1.06$ – 1.22) or with being a puffer compared with a heavy smoker ($OR = 1.22$, 95% $CI = 1.14$ – 1.30). Puffers also were older at their first cigarette than were moderate smokers ($OR = 1.15$, 95% $CI = 1.07$ – 1.23). No-context smokers were younger at their first cigarette than were moderate smokers ($OR = 0.84$, 95% $CI = 0.74$ – 0.96), social smokers ($OR = 0.79$, 95% $CI = 0.69$ – 0.90), or puffers ($OR = 0.74$, 95% $CI = 0.65$ – 0.85).

Table 1. Means and frequencies of individual characteristics of student smokers by latent class of smoking ($n=1,102$)^a

	All smokers	Heavy smokers	Moderate smokers	Social smokers	Puffers	No-context smokers
Characteristics						
Gender						
Male	43.3	44.8	44.8	37.9	43.8	57.1
Female	56.0	55.2	55.2	62.1	56.2	42.9
School classification						
Freshman	24.3	21.9	24.9	19.6	29.3	34.3
Sophomore	26.4	24.8	27.8	25.8	29.3	20.0
Junior	25.8	30.1	22.9	26.3	24.2	28.6
Senior	18.4	18.6	19.6	23.4	15.7	8.6
Fifth year	3.9	4.6	4.9	4.3	1.7	8.6
Not seeking degree	0.1	0.0	0.0	0.0	0.0	0.0
Hispanic	3.0	1.9	3.7	2.4	3.4	9.1
Race						
White	86.4	87.7	88.8	90.5	85.8	76.5
Non-White	13.3	12.3	11.2	9.5	14.2	23.5
Mother's education						
Less than high school	2.5	1.6	4.5	1.4	2.0	9.1
High school degree	44.6	51.8	40.3	45.9	42.7	36.4
College degree	51.5	46.6	55.1	52.6	55.2	54.5
Father's education						
Less than high school	3.5	5.4	2.5	2.4	2.7	11.8
High school degree	39.2	41.7	37.8	46.6	37.5	32.3
College degree	54.4	52.9	59.8	51.0	59.7	55.9
Member Greek organization	12.7	6.7	8.1	19.0	17.8	17.1
Health risk behaviors						
Past-30-day drinking						
0 days	4.4	7.1	2.9	2.4	4.9	3.1
1–5 days	32.8	35.9	31.8	28.1	37.9	31.2
6–14 days	40.8	33.6	41.3	55.2	41.8	46.9
15–30 days	18.9	23.5	24.0	14.3	15.4	18.7
Binge past 30 days						
0 days	13.3	22.4	11.2	10.8	14.7	21.4
1–5 days	35.8	31.7	43.0	47.4	45.7	35.7
6 or more days	37.4	45.9	45.8	41.7	39.5	42.9
Gets drunk in a typical week	62.6	54.8	67.1	69.2	63.8	51.4
Marijuana use past 30 days	45.5	46.3	49.8	48.1	38.6	57.1
Ever use illicit drugs	39.5	51.3	46.3	38.4	24.2	25.7
Age at smoking initiation	15.5 (2.6)	14.9 (2.5)	15.3 (2.4)	15.8 (2.6)	16.2 (2.6)	14.1 (3.1)
How soon after you wake do you smoke first cigarette?						
Within 5 min	4.1	10.3	0.8	1.5	1.5	11.4
Within 6–30 min	11.3	30.8	6.9	1.5	0.8	17.1
Within 31–60 min	12.1	30.1	13.1	1.0	1.1	5.7
After 60 min	69.2	28.8	79.2	96.1	96.6	65.7
Smoking attitudes						
How likely to succeed in quitting?						
Very unlikely	5.4	13.5	3.3	1.0	1.7	5.7
Somewhat unlikely	8.0	18.0	8.6	1.0	0.7	20.0
Somewhat likely	26.0	49.8	35.1	15.8	2.8	14.3
Very likely	59.3	18.7	53.1	82.3	94.8	60.0
How concerned about health effects?						
Not at all concerned	9.4	3.8	6.9	9.1	16.8	20.0
Only slightly concerned	28.3	19.5	28.2	42.9	28.2	28.6
Fairly concerned	37.2	46.2	44.1	32.4	27.2	31.4
Very concerned	24.3	30.5	20.8	15.7	27.8	20.0

Note. ^aAll values are percentages or means with standard deviations.

Table 2. Multinomial logistic regression modeling for smoking class as a function of demographic characteristics ($n=1,102$)

Covariate	Overall <i>p</i> value	Odds ratio	95% <i>CI</i>	<i>p</i> value
Class year	.014			
Moderate versus heavy		0.97	0.84–1.12	.679
Social versus heavy		1.09	0.93–1.27	.297
Puffers versus heavy		0.84	0.72–0.97	.014
No-context versus heavy		0.87	0.64–1.19	.382
Social versus moderate		1.13	0.96–1.32	.143
Puffers versus moderate		0.86	0.74–1.00	.056
No-context versus moderate		0.90	0.66–1.23	.521
Puffers versus social		0.76	0.65–0.89	.001
No-context versus social		0.80	0.58–1.09	.163
No-context versus puffers		1.02	0.75–1.39	.907
Greek versus non-Greek	<.001			
Moderate versus heavy		0.98	0.51–1.90	.961
Social versus heavy		2.59	1.44–4.65	.001
Puffers versus heavy		2.41	1.38–4.22	.002
No-context versus heavy		2.29	0.84–6.21	.104
Social versus moderate		2.58	1.44–4.61	.001
Puffers versus moderate		2.41	1.38–4.19	.002
No-context versus moderate		2.28	0.84–6.18	.104
Puffers versus social		0.94	0.59–1.51	.805
No-context versus social		0.89	0.35–2.31	.818
No-context versus puffers		1.20	0.47–3.07	.710
Lives on-campus versus off-campus	<.001			
Moderate versus heavy		1.07	0.74–1.54	.730
Social versus heavy		1.26	0.86–1.83	.233
Puffers versus heavy		2.30	1.62–3.27	<.001
No-context versus heavy		1.82	0.89–3.73	.099
Social versus moderate		1.17	0.80–1.71	.427
Puffers versus moderate		2.14	1.50–3.04	<.001
No-context versus moderate		1.69	0.83–3.46	.150
Puffers versus social		1.83	1.26–2.65	.001
No-context versus social		1.45	0.70–2.99	.318
No-context versus puffers		0.87	0.43–1.78	.707
Gender	.126			
White versus non-White	.156			
Hispanic versus non-Hispanic	.259			
Mother's education	.822			
Father's education	.249			

Compared with heavy smokers, all other classes started smoking later after waking, and this was the case especially for social smokers ($OR=8.92$, 95% $CI=5.58-14.3$) and puffers ($OR=10.1$, 95% $CI=6.41-15.8$). Although social smokers and puffers started smoking later after waking compared with moderate smokers (social $OR=2.73$; puffers $OR=3.08$), no-context smokers started smoking earlier after waking compared with moderate smokers ($OR=0.48$). No-context smokers also started smoking earlier than social smokers ($OR=0.18$) or puffers ($OR=0.16$).

Regarding smoking attitudes, we found significant differences between the classes on their perceived success of attempting to quit smoking ($p<.001$) and perceived concern about

Table 3. Multinomial logistic regression modeling of smoking class as a function of health risk behaviors ($n=1,102$)

Covariate	Overall <i>p</i> value	Odds ratio	95% <i>CI</i>	<i>p</i> value
Any past-30-day drinking	.007			
Moderate versus heavy		2.56	1.23–5.34	.012
Social versus heavy		3.73	1.53–9.10	.004
Puffers versus heavy		1.09	0.63–1.87	.765
No-context versus heavy		0.85	0.28–2.55	.766
Social versus moderate		1.48	0.53–4.15	.456
Puffers versus moderate		0.43	0.20–0.91	.028
No-context versus moderate		0.34	0.10–1.14	.080
Puffers versus social		0.29	0.12–0.73	.008
No-context versus social		0.23	0.06–0.86	.029
No-context versus puffers		0.90	0.29–2.75	.847
Any past-30-day binge	<.001			
Moderate versus heavy		1.95	1.28–2.96	.002
Social versus heavy		2.46	1.55–3.90	<.001
Puffers versus heavy		1.30	0.90–1.88	.166
No-context versus heavy		0.75	0.36–1.55	.431
Social versus moderate		1.27	0.77–2.12	.351
Puffers versus moderate		0.67	0.44–1.03	.069
No-context versus moderate		0.39	0.18–0.83	.015
Puffers versus social		0.54	0.34–0.86	.010
No-context versus social		0.31	0.14–0.68	.003
No-context versus puffers		0.64	0.30–1.34	.235
Gets drunk in a typical week	.051			
Marijuana use past 30 days	.049			
Moderate versus heavy		1.17	0.83–1.66	.368
Social versus heavy		1.09	0.76–1.56	.653
Puffers versus heavy		0.75	0.53–1.04	.087
No-context versus heavy		1.56	0.76–3.16	.218
Social versus moderate		0.93	0.64–1.35	.705
Puffers versus moderate		0.64	0.45–0.91	.012
No-context versus moderate		1.34	0.65–2.74	.424
Puffers versus social		0.68	0.47–0.98	.036
No-context versus social		1.42	0.69–2.93	.342
No-context versus puffers		2.11	1.04–4.31	.040
Illegal drug use, ever use	<.001			
Moderate versus heavy		0.81	0.57–1.14	.221
Social versus heavy		0.59	0.41–0.85	.004
Puffers versus heavy		0.30	0.21–0.43	<.001
No-context versus heavy		0.33	0.15–0.72	.006
Social versus moderate		0.73	0.50–1.06	.098
Puffers versus moderate		0.37	0.26–0.54	<.001
No-context versus moderate		0.40	0.18–0.90	.026
Puffers versus social		0.51	0.34–0.74	.001
No-context versus social		0.55	0.25–1.24	.150
No-context versus puffers		1.12	0.50–2.50	.789

health effects ($p<.001$). Both social smokers ($OR=6.98$, 95% $CI=4.88-9.99$) and puffers ($OR=15.6$, 95% $CI=10.1-24.1$) perceived they would be more likely to be successful in quitting smoking compared with heavy smokers. Compared with moderate smokers, social smokers ($OR=3.16$) and puffers ($OR=7.08$) perceived they would be more likely to be successful in quitting as well. No-context smokers perceived they would be

less likely to be successful in quitting smoking compared with social smokers ($OR=0.27$) or puffers ($OR=0.12$). Heavy smokers were more concerned about health effects than were any of the other classes. Social smokers were less concerned about health effects than were moderate smokers ($OR=0.76$, 95% $CI=0.62-0.93$; Table 4).

Discussion

The results of our study suggest that college student smokers are a heterogeneous group, comprising five distinct subclasses of smokers, based on discrepant patterns and contexts of tobacco use. Heavy smokers (28%) are daily smokers who smoke equally on weekends and weekdays and smoke 6–10 cigarettes/day. They also report smoking in all types of contexts. Moderate smokers (22%) reported smoking about 2–5 cigarettes/day on 10–19 smoking days/month. They smoke on both weekends and weekdays and smoke slightly more in social than nonsocial contexts. Social smokers (19%) reported smoking 2–5 cigarettes on smoking days but smoke only 3–5 days/month. Social smokers report smoking only in social contexts and are more likely to smoke on weekends. Puffers (26%) report smoking one or fewer cigarettes on 1 or 2 days out of the past month. The context in which puffers were most likely to report smoking was while drinking alcohol. These students likely had a puff or two of someone else's cigarette while they were drinking. The final group is the no-context smokers (4%). They report frequencies and quantities of smoking similar to those in the moderate group; however, they did not report smoking in the contexts we measured.

The demographic characteristics that separated these groups were year in school, residence location (on- or off-campus), and participation in Greek organizations. Younger students were more likely to be puffers than heavy or social smokers. This finding suggests that early experimentation could lead to more regular use over a student's college career and highlights the need for targeted interventions that focus on young college students. The extent to which the subclasses of smokers described in this study represent a transitional process from experimentation to daily smokers is an important question to be considered in future studies. Some research suggests that nondaily smoking (smoking on some, but not all, and days of the month) remains relatively stable over the course of 4 years in college (Colder et al., 2006). However, in our study, nondaily smoking was a pattern of use characterized by four out of the five subclasses. The extent to which transitions among these four subclasses represent transitions to more regular smoking behavior is still unknown.

These distinct groups also showed variation in their participation in Greek organizations. Members of Greek organizations were more likely to be social smokers or puffers than heavy or moderate smokers. This finding likely represents the association of smoking and alcohol use related to the socially oriented lifestyle frequently endorsed by such organizations (Moran et al., 2004; Sutfin et al., manuscript under review). Finally, puffers were more likely to live on-campus than were heavy, moderate, and social smokers. This finding could reflect the tendency for puffers to be younger students, who are more likely to live in dorm settings on campus than are older students.

Subclasses of smokers also differed in their reports of alcohol use. Moderate and social smokers were more likely than

Table 4. Multinomial logistic regression modeling of smoking class as a function of smoking behaviors and attitudes ($n=1,102$)

Covariate	Overall <i>p</i> value	Odds ratio	95% <i>CI</i>	<i>p</i> value
Age at first cigarette	<.001			
Moderate versus heavy		1.06	0.99–1.13	.097
Social versus heavy		1.14	1.06–1.22	<.001
Puffers versus heavy		1.22	1.14–1.30	<.001
No-context versus heavy		0.90	0.79–1.20	.088
Social versus moderate		1.07	1.00–1.15	.063
Puffers versus moderate		1.15	1.07–1.23	<.001
No-context versus moderate		0.84	0.74–0.96	.011
Puffers versus social		1.07	1.00–1.15	.062
No-context versus social		0.79	0.69–0.90	<.001
No-context versus puffers		0.74	0.65–0.85	<.001
Time to first cigarette	<.001			
Moderate versus heavy		3.26	2.56–4.16	<.001
Social versus heavy		8.92	5.58–14.3	<.001
Puffers versus heavy		10.1	6.41–15.8	<.001
No-context versus heavy		1.59	1.09–2.30	.015
Social versus moderate		2.73	1.68–4.43	<.001
Puffers versus moderate		3.08	1.93–4.92	<.001
No-context versus moderate		0.48	0.32–0.73	<.001
Puffers versus social		1.14	0.62–2.07	.677
No-context versus social		0.18	0.10–0.31	<.001
No-context versus puffers		0.16	0.09–0.28	<.001
Perceived success of attempting to quit smoking	<.001			
Moderate versus heavy		2.24	1.81–2.78	<.001
Social versus heavy		6.98	4.88–9.99	<.001
Puffers versus heavy		15.6	10.1–24.1	<.001
No-context versus heavy		1.90	1.24–2.91	.003
Social versus moderate		3.16	2.21–4.51	<.001
Puffers versus moderate		7.08	4.60–10.9	<.001
No-context versus moderate		0.85	0.55–1.32	.461
Puffers versus social		2.23	1.36–3.65	.001
No-context versus social		0.27	0.16–0.45	<.001
No-context versus puffers		0.12	0.07–0.22	<.001
Perceived concern about health effects	<.001			
Moderate versus heavy		0.75	0.62–0.91	.004
Social versus heavy		0.57	0.47–0.70	<.001
Puffers versus heavy		0.65	0.54–0.78	<.001
No-context versus heavy		0.55	0.37–0.80	.002
Social versus moderate		0.76	0.62–0.93	.009
Puffers versus moderate		0.87	0.72–1.05	.146
No-context versus moderate		0.73	0.50–1.08	.114
Puffers versus social		1.13	0.93–1.37	.231
No-context versus social		0.95	0.64–1.40	.792
No-context versus puffers		0.82	0.56–1.20	.305

heavy smokers or puffers to be past-30-day drinkers. Social smokers also were more likely to report past-30-day drinking than were the no-context smokers. Additionally, moderate smokers reported having engaged in past-30-day binge drinking more often than did heavy or no-context smokers. Social smokers reported more binge drinking than did heavy smokers, no-context smokers, and puffers. This finding suggests that, for

moderate and social smokers, the relationship between alcohol and tobacco use is strong, indicating a need for targeted interventions that focus specifically on curbing this association.

Not surprisingly, subclasses of smokers differed in their age at initiation, time to first cigarette, perceived quit efficacy, and perceptions of health risks. Heavy smokers began smoking at an earlier age than puffers and social smokers. The no-context group began smoking at an earlier age than puffers, social, and moderate smokers. However, the average age at initiation for all classes of smokers in the present study was prior to college entry. In fact, post-hoc analyses revealed that the proportions of students reporting their initiation at age 18 or later for each class were as follows: heavy = 14.1%, puffers = 38.9%, moderate = 19.5%, social = 27.5%, and no-context = 5.7%. So although the majority of all smokers initiated use prior to the age of 18, puffers were the most likely to have initiated smoking after 18 years. Again, this finding suggests the need for early intervention prior to entry into college, as well as early in the college career. All groups reported differences in their time to first cigarette, except puffers and social smokers. Compared with all other groups, heavy smokers had the shortest time to first cigarette.

Heavy smokers were more concerned about the health effects of their smoking and perceived lower success in a quit attempt. This finding suggests that heavy smokers are addicted smokers who are legitimately concerned about the health effects of their habit. They perceive more difficulty in quitting, compared with any of the other smoking groups, and are likely to require individual interventions such as pharmacotherapy and behavioral interventions. Similarly, social smokers reported lower levels of perceived health effects than moderate smokers and reported higher perceived self-efficacy for quit attempts. This finding may reflect their lower level of addiction than moderate smokers, but more research is necessary to test this hypothesis.

The results of the present study highlight the heterogeneity of college student smokers and underscore the need for targeted interventions. As suggested by our data, the connection between alcohol and tobacco use is strongest for social and moderate smokers. Interventions targeted at increasing smoke-free policies in venues that serve alcohol may reduce smoking rates among these groups. For social smokers in particular, this is a promising strategy. These smokers smoked only in social situations, many of which involved drinking alcohol. The effectiveness of smoke-free policy interventions with this group may depend on the extent to which these drinking and smoking occasions occurred in public rather than private venues. However, colleges could prohibit smoking in any college-owned buildings, as recommended by the American College Health Association (2005). For some schools, this would include dorms, Greek houses, and university-owned off-campus housing. This policy change could affect a substantial number of college student smokers, reducing the overall smoking rate among this population.

An additional policy avenue that could be pursued is having landlords designate their residences smoke-free. Although enforcement would need to be monitored continually, coupling campus policy changes with policy changes to private residences and with smoke-free policies in public arenas that serve alcohol could reduce smoking rates substantially among social smokers and potentially other smoking groups as well. Given that subgroups of smokers likely require different intervention strate-

gies, the ideal approach may be a comprehensive method that would include policy changes to increase smoke-free environments, individual treatments, and preventive education, such as that recommended by the American College Health Association (2005).

The present study was limited to college students from a particular state, and at least one study has shown regional variation in tobacco use among college students (Wechsler et al., 1998). Therefore, our ability to generalize the results of the present study may be limited. However, the schools selected to be part of the larger study are representative of schools in North Carolina. Furthermore, the demographic profile of this sample generally reflects that of undergraduate students in the United States (U.S. Department of Education, 2006). Although the demographic profiles may be similar, important cultural differences may exist between states that have a long history of tobacco growth and production, such as North Carolina, and other regions of the country that may have longstanding tobacco prevention programs, such as California. Future research should consider regional differences based on state-level variables such as tobacco control and tobacco production.

The response rate for the Web survey was relatively low; however, it was similar to rates found in other studies of college students' health risk behaviors (McCabe, Diez, Boyd, Nelson, & Weitzman, 2006; Reed et al., 2006). Nevertheless, nonresponders may have had different behaviors. Future studies with better response rates are needed to help validate these findings.

The present study also was limited by the measurement of context used. As described earlier, smoking was measured in 16 different contexts. However, for the no-context smokers, results suggested that the 16 contexts did not capture the environments in which those smokers typically smoke. One context not included in this measurement was smoking while in a car. It is possible that this context, along with others, may help explain the situations in which this group typically smokes. Future studies should investigate further the possible contexts in which these and all college student smokers smoke. Qualitative studies may be particularly useful to elucidate contexts.

In conclusion, the present study revealed distinct patterns and contexts of tobacco use among a sample of college students who smoke cigarettes. The five distinct subgroups that emerged in the analyses highlight the heterogeneity of college student smokers and underscore the need for targeted interventions. Future research should examine the stability of these patterns among college students over time to determine whether these latent classes represent increasing stages of tobacco dependence. Additionally, future research should evaluate the efficacy of different types of interventions, including environmental- and individual-level interventions, among the different subclasses of smokers.

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Declaration of Interests

None declared.

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