Smoking in college freshmen: University Project of the Tobacco Etiology Research Network (UpTERN)

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Smoking in college freshmen: University Project of the Tobacco Etiology Research Network (UpTERN)

Stephen T. Tiffany, Christopher R. Agnew, Nancy K. Maylath, Lisa Dierker, Brian Flaherty, Elizabeth Richardson, Robert Balster, Missy Hurst Segress, Richard Clayton, and the Tobacco Etiology Research Network (TERN)1

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UpTERN, a study conducted by the Tobacco Etiology Research Network (TERN), was designed to examine trajectories of change in smoking behavior and the emergence of dependence over the course of the freshman year from a large sample of college students. The project included extensive quantitative and qualitative assessments of participants. In the first phase, screener data were collected from 4,690 freshmen entering Purdue University in the fall of 2002. In the second phase, 912 students were enrolled from the 2,001 who reported some prior exposure to smoking cigarettes in the first phase. These students provided extensive baseline information on a web-based assessment protocol administered in the week prior to the beginning of classes in the fall semester. In the third phase, these students participated in a web-based assessment administered for 35 consecutive weeks. Approximately 88% of the sample completed the web-based assessment each week. This report describes the rationale for the project and provides an overview of the constructs targeted across the research. In addition, the research methods, procedures, and assessments are discussed. Findings are reported for day-to-day patterns of smoking as well as alcohol and marijuana use across the 35 weeks of assessment. Finally, selected results from reports using data generated from this project are summarized, including analyses of patterns of smoking over time, associations between daily cigarette smoking and alcohol use, evaluations of the nature of nicotine dependence in low-level smokers, an exploration of early cigarette-use episodes in novice smokers, and a consideration of the role of descriptive and injunctive norms from romantic partners and friends in predicting cigarette smoking over time.

Introduction

The natural history of cigarette smoking has often been characterized as progressing through a series of stages or phases of use. Each stage is presumed to be influenced by biological, psychological, social–cultural, and economic variables that, in combination, contribute to either the escalation or the cessation of smoking (Mayhew, Flay, & Mott, 2000). Researchers have described the critical stages as comprising preparation (prior to the first cigarette), initiation (first cigarette), experimentation (occasional, irregular smoking), regular use (smoking monthly but not daily), and established use (daily smoking associated with dependence; Flay d’Avernas, Best, Kersell, & Ryan, 1983; Leventhal & Cleary, 1980; Mayhew et al., 2000; Stern, Prochaska, Velicer, & Elder, 1987). Research on smoking has focused primarily on people in the beginning (preparation or initiation) or end (established use) stages of the smoking history continuum.

The few studies that have examined intermediate stages of smoking have relied on longitudinal designs...
Capturing only a few timepoints at relatively long interassessment intervals (typically 12 months or longer; Mayhew et al., 2000). Although these studies have revealed useful information about psychosocial factors associated with progression to higher levels of smoking, their temporal resolution is insufficient to capture changes in smoking over shorter intervals. Nor could this type of study reveal relationships between variations in smoking and contiguous time-variant factors that may influence smoking behavior. Consequently, there has been virtually no investigation of day-to-day changes in smoking and associated variables among people who are in the early phases of their smoking careers. The general goal of the current project was to intensively examine day-to-day variations in smoking and related behaviors in young adults at varying levels of smoking experience. This paper presents an overview of the University Project of the Tobacco Etiology Research Network (UpTERN) with a particular emphasis on the rationale for the study, a description of the special issues confronting intensive longitudinal research of this type, and presentation of selected outcomes illustrating the rich dataset generated by this approach.

**Transdisciplinary approach to emergence of smoking and dependence**

Cigarette smoking is an extraordinarily complex process, one that can be and has been approached from biological, pharmacological, psychological, social-cultural, and economic levels of analyses. The collective efforts of these disciplines have generated a massive amount of research. For example, a search of the Medline database from 2001–2006 for the terms cigarette, nicotine, or tobacco yields over 22,000 publications. Despite this enormous number of studies, the impact of findings from any given project is usually confined to the discipline (or subdiscipline) generating the research. Furthermore, there are substantial gaps in our knowledge about tobacco use, particularly in our understanding of what happens between initial experimentation with cigarettes and subsequent regular use.

In 1996, the Robert Wood Johnson Foundation established the Tobacco Etiology Research Network (TERN) in an attempt to encourage a transdisciplinary approach to the etiology of tobacco use and dependence (see Clayton, 2004, for a complete description of TERN). TERN is an “Institute without Walls” involving 14 senior scientists and 10 faculty scholars from 13 institutions of higher education in the United States. A wide range of academic disciplines is represented within TERN, including adolescent medicine, behavioral pharmacology, clinical psychology, economics, epidemiology, ethnography, public health, social psychology, and statistics. Drawing upon these various perspectives, TERN’s primary focus was to gain a more comprehensive understanding of the etiology of tobacco use and dependence. TERN focused its efforts on the following topics: (a) “trajectories” of tobacco use that may or may not include the emergence of dependence, (b) the potential importance of early episodes of use, (c) the possible multidimensional nature and “emergence” of dependence, (d) the importance of both individual- and contextual-level factors as well as their interaction in trajectories of tobacco use and the emergence of dependence, (e) the potentially important role of stress and affect in explaining tobacco use and nicotine dependence, (f) advancements in the conceptualization, measurement, and investigation of salient constructs in the field, and (g) improving the connections between animal and human research. UpTERN represents one aspect of TERN’s efforts to address these topics. Other TERN projects are described elsewhere (Clayton, 2004).

**Natural history of smoking**

In the United States, smoking often begins during adolescence with an average age at initiation of 15.5 years (Substance Abuse and Mental Health Services Administration [SAMHSA], 2006). The lag between first cigarette and daily smoking averages over 2.8 years (SAMHSA, 2006). Moreover, nicotine dependence (defined with DSM criteria) may not emerge until several years after the onset of daily smoking (Breslau, Johnson, Hiripi, & Kessler, 2001). Some researchers have noted that key features of nicotine dependence can surface relatively early in a smoker’s history of exposure to cigarettes (e.g., DiFranza et al., 2002; O’Loughlin et al., 2003), though the exact patterning of cigarette use and nicotine exposure required for the full expression of nicotine dependence is unknown. The temporal focus of the research in UpTERN was on the period between a person’s early episodes of cigarette use and the emergence of regular smoking and dependence.

The conventional depiction of the natural history of chronic smoking is that people first try smoking when they are 15 or 16 and then gradually escalate their frequency of smoking over a 2- or 3-year period to the point where they are smoking daily. Daily smokers continue to escalate their use of cigarettes over the next several years as they develop into chronic, heavily dependent smokers. Though this depiction is consistent with national survey data (e.g., Breslau et al., 2001; SAMHSA, 2006), these data represent averages and do not convey the variety of patterns of use that can occur between a first cigarette and subsequent chronic, dependent smoking. More
broadly, individual smoking patterns vary widely across those who have ever had any involvement with cigarettes. Approximately 70% of all people try a cigarette sometime during their life (SAMHSA, 2006), yet only a third continue smoking to the point of dependence (Breslau et al., 2001). We know little about differences between those who progress to high levels of smoking and those who experiment with smoking but do not transition to chronic use.

Some researchers have questioned whether smoking progression occurs in incremental, categorical stages and have noted that individual change may take place continuously over time (e.g., Mayhew et al., 2000). From this perspective, variations in smoking behavior over the early phases of smoking can be captured by individual growth curves that allow for the assessment of individual change represented in a variety of trajectories (Willet, 1997). Moreover, these trajectories may be grouped into clusters of change curves that share cluster-specific predictors. As an example, Colder and his colleagues (2001) identified distinct patterns of change in adolescent smoking across 4 years of a longitudinal study. These included rapid escalators who were characterized by early escalation of smoking (beginning at age 13) with a rapid increase to heavy levels of smoking. Other patterns showed later onset of smoking (age 15) and escalation to low or moderate levels of smoking. They also identified groups of stable light smokers (1–2 cigarettes/month) and stable puffers (only a few puffs/month). The stable puffer group was the largest of all the trajectory groups (25% of the smokers). Other researchers have identified similar groupings of smokers on the basis of change in their smoking behavior over time (e.g., Andrews & Duncan, 1998; Chassin, Presson, Rose, & Sherman, 1996; Chassin, Presson, Pitts, & Sherman, 2000; White, Pandina, & Chen, 2002).

Rationale for focusing on the early stages of smoking

Although established smokers have fairly stable rates of smoking across days (Shiffman et al., 1994), less experienced smokers are much more likely to display substantial variation in their smoking rates, variation that reflects, presumably, the influence of a wide range of contextual and intraindividual forces (Brandon, Herzog, Irvin, Moffitt, & Gwaltney, 2004; Colby, Tiffany, Shiffman, & Niaura, 2000; Eissenberg, 2004; Glautier, 2004; Tiffany, 1990; Tiffany, Conklin, & Shiffman, 2004). Research on neophyte smokers may reveal that their smoking is a much more dynamic, contextually sensitive behavior than is seen in established smokers or observed in conventional longitudinal studies with relatively low temporal resolution. UpTERN was designed to investigate the dynamic nature of smoking among less experienced smokers at a critical point in time.

There are several compelling reasons to conduct an intensive, high-resolution examination of smoking and related time-variant variables among those who are early in their smoking careers. First, during late adolescence and young adulthood, smokers display considerable variability in their smoking rates across days. During this period, those who smoke are moving onto pathways that may end at chronic, high levels of smoking; sustained low levels of smoking; or smoking cessation. Moreover, the factors promoting adoption of one pathway or another are likely fairly potent and more readily detectable at this period than during later adulthood when smoking and nonsmoking habits are more firmly established. Thus this period offers an excellent opportunity to uncover processes responsible for the adoption of lifelong patterns of smoking and nonsmoking behaviors.

Second, this period should be particularly revealing about the emergence of tobacco dependence. Most of what we know about tobacco dependence comes from studies of adult smokers who smoke at high rates and display all the conventional hallmarks of dependence (Tiffany et al., 2004). Modern theoretical perspectives on dependence concur that the key features of dependence may be evident early in a smoker’s career and well before the development of established smoking (Brandon et al., 2004; Eissenberg, 2004, Glautier, 2004). In addition, modern theories assume that drug dependence reflects temporally dynamic processes that may be best revealed as they emerge during the early phases of smoking (Tiffany et al. 2004).

Third, most smoking interventions target the prevention of the first cigarette (Lantz et al., 2000) or the treatment of heavily dependent, chronic smokers (e.g., Fiore, 2000). Smoking, however, may be highly malleable in the early course of a smoking career before smoking becomes deeply entrenched. Attempts to develop effective interventions at this stage are limited, as very little is known about the factors that promote or inhibit continued smoking in adolescents and young adults. Thus an intensive examination of the development of smoking over late adolescence and young adulthood should reveal new information with implications for the creation of efficacious interventions targeting the early phases of smoking and dependence.

Focusing on young-adult college smokers

UpTERN collected data from young-adult college students for a number of reasons. First, people who are 18–25 years old have the highest rates of smoking of any age group (SAMHSA, 2006). Approximately 45% of this age group has had at least some college education (SAMHSA, 2006). Second, the transition
to college is an important developmental turning point that often alters behavior, affect, cognition, and context—all of which may set the stage for lifelong change (Graber & Brooks-Gunn, 1996). Trend data confirm that college students, especially freshmen, experience continued high rates of binge drinking, declines in physical and emotional self-confidence, and increases in stress and cigarette smoking (Sax, 1997). Third, recent research documents surprisingly high smoking rates among college students, with almost 30% having smoked within the past 30 days, and 43% of these smoking up to 10 cigarettes/day (Rigotti, Lee, & Wechsler, 2000). Furthermore, 11% of college smokers reported having their first cigarette during college, and 28% began smoking regularly at or after age 19, presumably when most were already in college (Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998).

Fourth, although rates of cigarette smoking among non-college-aged peers have been shown to be higher than among college-aged students (e.g., Johnston, Bachman, O’Malley, & Schulenberg, 2007), the goals of UpTERN required intensive data collection from a nonmigrating population over a considerable period of time. College students represent an ideal population in which to collect such data.

Several studies have shown that rates of smoking and tobacco dependence increase steadily over the college years (Bachman et al., 2002; Chassin et al., 1996; Jackson, Sher, & Wood, 2000; Sher, Gotham, Erickson, & Wood, 1996). This trend stands in contrast to alcohol consumption and alcohol-related problems. Unlike tobacco use, alcohol involvement is highest in the freshman year and declines over subsequent college years. For example, Jackson et al. (2000) reported that the vast majority of alcohol-use disorders were diagnosed in the freshman year, whereas the majority of new cases of tobacco dependence occurred after the freshmen year. In sum, many smokers initiate smoking during college, and their rate of smoking and level of dependence increase over their college years.

Fine-grained analysis of smoking behavior

Studies on smoking trajectories and stages of smoking (Mayhew et al., 2000) have used intervals between assessments ranging from several months to years. Such intervals cannot capture fluctuations in smoking rates that may vary at frequencies in the range of months to days. Nor can data derived from conventional longitudinal studies be used to identify specific causal mechanisms or evaluate processes with high temporal specificity (Jackson et al., 2000). Many epidemiological studies of relationships between smoking and other time-variant processes presumed to contribute to variation in smoking (e.g., associations between cigarette smoking and alcohol use) can investigate these relationships only indirectly, as the assessment intervals are too coarse to permit an evaluation of contiguous effects (Jackson et al., 2000; Mayhew et al., 2000). In general, comprehensive investigations of relationships between variables that change over time must use assessment intervals sufficiently brief for capturing short-term change in any of the target variables (Collins & Graham, 2002). Consequently, the present project used a longitudinal design with a high density of assessments (a total of 36) across 38 consecutive weeks.

Smoking initiation

Considerable data suggest that an important early determinant of moving from experimentation to regular smoking is the nature of the initial tobacco-use episode(s) (Eissenberg & Balster, 2000). A person’s first use of cigarettes produces predominantly aversive effects (e.g., nausea, dizziness, sweating), although some people also report positive effects. Aversive effects tend to decrease with repeated use (Friedman, Lichtenstein, & Biglan, 1985; Hahn et al., 1990), and those who report fewer aversive effects from initial cigarettes may be more likely to become regular tobacco users (Eissenberg & Balster, 2000).

Many of the studies of the effects of early cigarettes used retrospective reports that were generally fairly distal from the initial smoking episodes. Thus recall failure and biases complicate interpretation of much of this literature. A longitudinal design that tracks individuals at risk for smoking initiation and examines early instances of smoking relatively close in time to the smoking episode would provide rich data about the relationships between reactions to initial cigarettes and subsequent smoking history. Consequently, unique procedures for assessing smoking initiation in temporal proximity to when it occurred were incorporated into UpTERN.

Behaviors and constructs evaluated in the study

The primary dependent variable tracked in UpTERN was day-to-day variation in smoking levels. The number of factors that might predict or potentially serve as moderators of daily variation in smoking is vast. To reduce these variables to a reasonably manageable set, we focused on proximal behaviors and constructs that, based on our review of the empirical and theoretical literature, were most likely related to the dynamics of smoking. A wide range of smoking-related constructs were assessed at repeated intervals (weekly or every 4 weeks) over the course of the study. A large battery of other variables...
was administered at a baseline session as well as at the end of the first semester and the end of the freshmen year (for more detail regarding these assessments, see Tiffany et al., 2005).

In light of the strong associations reported in the literature between cigarette smoking and alcohol and marijuana use (e.g., Bucholz, Heath, & Madden, 2000; Degenhardt, Hall, & Lysney, 2001; Duncan, Duncan, & Hops, 1998; Flay, Hu, & Richardson, 1998; Griffin, Botvin, Epstein, Doyle, & Diaz, 2000; Jensen et al., 2003; Lewinsohn, Rohde, & Brown, 1999), we also collected information on daily use levels of the latter substances. Further, given that smoking most likely occurs in selected contexts, physical and social, we attempted to determine the locations and social contexts of smoking behavior. In addition, as described in a review commissioned by TERN (Kassel et al., 2003), human and animal studies show strong between-subject associations between stress/negative affect (NA) and the initiation and maintenance of smoking/nicotine self-administration and good evidence for within-person effects of stress/NA cueing on relapse to smoking/nicotine self-administration. Moreover, numerous epidemiological studies have shown smoking to be strongly associated with depression in both adolescent and adult samples (Brown, Lewinsohn, Seeley, & Wagner, 1996; Breslau, Fenn, & Peterson, 1993; Breslau et al., 1998; Kandel et al., 1997). Consequently, weekly assessments of perceived stress, affect, and symptoms of depression were collected.

In contrast to the categorical assumption of nicotine dependence represented by the Diagnostic and Statistical Manual of Mental Disorders (4th edition; DSM-IV; American Psychiatric Association, 1994), modern theories maintain, explicitly or implicitly, that dependence varies on a continuum (see Brandon et al., 2004; Eissenberg, 2004; Glaütier, 2004, for comprehensive TERN-sponsored reviews of theories of dependence and their application to the emergence of tobacco dependence). That continuum is linked to a continuum or trajectory of smoking behavior, with the basic elements of dependence processes evident even in the early episodes of cigarette use. That is, according to nearly all theories, dependence is fundamentally continuous and dimensional, not categorical, in nature (Tiffany et al., 2004). Features of dependence were measured on a weekly basis in the present study to evaluate the dynamics of dependence in relation to smoking.

Changes in other variables with putative associations to smoking dynamics were monitored somewhat less intensively in this research. These included smoking-related constructs such as perceptions of smoking rates, smoker identity, and intentions regarding future smoking. In addition, assessments of sleep, physical activity, major life events, and body image were collected. Finally, the present research included an examination of the associations between changes in friendship and romantic relationship variables with variations in smoking behavior.

Study design and procedures

TERN conducted an intensive longitudinal study on smoking in college freshmen at Purdue University to address three primary aims: First, we wanted to generate detailed assessments of smoking and associated behaviors and contexts over the duration of the freshman year. Second, we wanted to use our mapping of smoking to identify trajectories of smoking behavior and tobacco dependence. Third, we analyzed data to examine dynamic relationships among contexts, intrapersonal variables, and interpersonal variables with a focus on their associations with tobacco and other drug use.

Study site: Purdue University

Purdue is a large public university in the midwestern United States. It had an undergraduate census of approximately 31,000 in 2003. Consistent with other large state universities, two-thirds of students who enter as new freshmen complete their undergraduate degree within 6 years. Some 36% of the student population lives in one of Purdue’s 15 on-campus housing units. All freshmen are required to live on campus. A total of 60% of Purdue undergraduates are Indiana residents; the remainder come from all 50 states and 131 foreign nations. Undergraduates at Purdue report smoking rates that are comparable with those from other major midwestern public universities, and Indiana as a whole has smoking rates that rank fifth among all states (Centers for Disease Control and Prevention, 2003).

Elements of design

The incoming freshmen class was given a screener survey during the summer before the fall semester of 2002. A sample of 912 of these students was enrolled to participate in the intensive campus phase of the study. Prior to the first week of classes, these participants completed a web-based baseline assessment battery. Starting with the third week of classes in the fall semester, students completed a weekly web-based assessment of their smoking behavior and various other variables. (Unfortunately, because of logistical problems launching the web-based weekly assessments, we were unable to track drug-use behavior over the first 3 weeks of the fall semester.) Students were enrolled in this component of the
project for 35 consecutive weeks. Weight measurements and saliva sampling for cotinine levels, which began after the fourth month of data collection (December 2002), were completed monthly.

Ethnography

In addition to the quantitative aspects of our data collection, we incorporated an explicit qualitative/ethnographic component into UpTERN. Our team of ethnographers (headed by Mark Nichter from the University of Arizona) was actively involved in all phases of the project. This team used targeted interviews and focus groups to collect information on the feasibility and content of various assessments and procedures, experiences of smoking initiators, party smoking, rapid transitions in smoking behavior, and fraternity and sorority influences on students. The qualitative aspect of UpTERN dovetailed nicely with the quantitative, as participant responses to the weekly web-based assessments were used to trigger in-depth interviews in temporal proximity to reported events.

Web assessments

All web-based assessments were formatted and maintained online by Wallingford Research & Design of Bothell, Washington (http://wallingford.net). The web site design was based on a standardized template (including an UpTERN logo) to create a consistent look and feel across pages for participants. With respect to survey content, each online survey was organized into sections that served to (a) organize thematic groups of questions, (b) control the order, flow, and paging of a survey, (c) allow some portions of the survey to have their questions randomized while keeping other sections static, (d) dynamically present or hide questions based on prior answers or other criteria, and (e) include nonquestion content such as instructions and other pertinent study information (e.g., where to go for payment).

Participants

Potential participants eligible for the screener survey were restricted to those students who were high school seniors admitted as full-time students at Purdue University for the fall 2002 semester, 18 years old or older, and a U.S. citizen. The size of this sampling frame was 6,560.

Screener survey

The screener, titled “College Freshmen Health Behavior Survey,” consisted of 27 items that assessed the participants’ current and past smoking behavior, current and past use of tobacco products other than cigarettes, and attitudes and expectancies regarding cigarette use. This survey was completed in an average of less than 10 min.

Screener survey procedures

Day on Campus was a 1-day Purdue University orientation program that took place on weekdays between mid-June and early July of 2002. Incoming Purdue freshmen were strongly encouraged to attend this program. A postcard briefly describing the project was mailed in mid-May to all incoming freshmen scheduled to attend Day on Campus activities. The postcard told potential participants that they would have the opportunity to complete a confidential 10-min survey during Day on Campus. The postcard informed students of the locations where they could complete the survey.

At the survey locations, students were directed to a desk where they were greeted by a research assistant who described the project. As part of this description, potential participants were informed that their answers to the survey would remain strictly confidential. They also 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 that would take place on the campus over the fall and spring semester of the upcoming year. After participants completed the screener, they were paid US$5.00 in cash.

Baseline assessment

Baseline assessment battery. This assessment consisted of a variety of single items, scales, and inventories selected to evaluate smoking, alcohol, and marijuana history; use of other tobacco products; attitudes and intentions with regard to smoking; nicotine dependence; cigarette craving; smoking initiation; demographic information; general health status; stress; history of depression, anxiety sensitivity, conduct disorder; attention, and hyperactivity; romantic relationships and friendships; and personality. This battery was administered via the web.

Baseline assessment procedures. Immediately following Day on Campus (in July 2002), a letter from the principal investigator invited selected participants to complete the baseline assessment and weekly questionnaires. A return postcard was included in the mailing. The postcard allowed participants to enter or opt out of the study and to provide phone contact information for scheduling purposes. By the second week of August, approximately 1,200 students had agreed to participate.
The baseline assessment was administered in computer labs located on the Purdue campus in the middle of August. At the beginning of a baseline session, participants read and signed an informed consent document. The entire baseline assessment battery was completed in less than 90 min by each participant.

Weekly assessment phase

In any given week, participants had access to the web-based assessment beginning on Friday at 5:00 p.m. and ending Tuesday at noon (Eastern Standard Time). The first weekly assessment was initiated during the first week of September 2002. Participants could log on to the web system from any computer with access to the Internet. When participants logged on, they were asked to enter their username and personal identification number. They were then presented with a series of pages containing questions for the particular assessment they were completing. Most items were presented in a multiple-choice format. When participants completed a page of questions, the web program checked the data for unanswered questions or errors (obvious inconsistencies or extreme values on open-ended questions). In the case of errors, participants were directed to reconsider their answer. If participants skipped a question, they were given the opportunity to either complete the unanswered question(s) or move on to the next page of questions. (That is, participants were not forced to answer questions they intended to skip.) Less than 0.5% of questions were intentionally skipped. Participants generally completed an assessment in a single session. However, participants could suspend their web session and automatically resume later at the point where they had left off.

In these weekly assessments, some constructs were included only once every 4 weeks; others appeared weekly. Every week, we asked about daily (a) cigarette use, (b) marijuana use, (c) alcohol use, and (d) cigarette combined with alcohol use; we also included detailed questions on smoking, affect, stress, depression, and nicotine dependence using the Nicotine Dependence Syndrome Scale (NDSS; Shiffman, Waters & Hickcox, 2004). Cigarette, alcohol, and marijuana use were tracked on a daily basis with a timeline followback procedure that queried about use of any of those substances on each day since the previous week’s assessment (or a maximum of 10 days if the participant had missed the previous weekly assessment). A participant who reported smoking initiation during the preceding week was presented with detailed questions about each of the first five cigarettes. Other assessments appeared every 4 weeks. In week 1 we asked about physical activity, in week 2 we assessed romantic relationships and friendships, in week 3 we asked about sleep habits and body image, and in week 4 we asked about stressful events. This cycle was repeated every 4 weeks such that each set of questions was administered a total of nine times.

Subject retention

We used a variety of procedures to maintain very high participation and retention rates. First, a student completing all surveys, including the screener and baseline assessments, had the opportunity to earn a total of $420 for participating in the study. Each student was paid $5 for the screener survey, $35 for the baseline assessment, $5 for each weekly assessment, and $5 for each saliva sample. Scheduled payments for the weekly assessments were boosted periodically to enhance participation rates. For example, students were paid $10 extra for the first two weekly assessments. Students also were given bonus payments for completing a series of consecutive assessments. Second, students were sent E-mails alerting them to each upcoming assessment. In addition, if students did not complete an assessment by Sunday evening of their scheduled assessment weekend, they were sent reminder E-mails encouraging them to complete the assessment within the next 24 hr. Additional E-mails and letters were sent to students thanking them for their participation and providing them with general information about the study. Third, each student was assigned a research assistant who served as a contact person for the student and helped the student with any study-related problems. Any students not completing a scheduled assessment by the Monday morning following the assessment weekend were called by their personal contacts, who encouraged participation.

Results

Sample and participation

Of the 6,560 incoming freshmen who were eligible to take the screener, 4,690 completed the screener survey, for a 71% completion rate. We used the screener data to identify participants who would be invited to participate in the next phase. Our primary interest was in finding students who had some exposure to smoking so as not to devote resources tracking students who had a very low probability of smoking once they came to campus. We selected students who had at least one lifetime cigarette or at least one puff within the last year. That gave us a potential sample of 2,001 students. In an attempt to generate a manageable sample size for the longitudinal phase of the project, we limited recruitment
to the first 1,200 students who responded to our invitation to enroll in the study. During the 6 weeks between administration of the screener survey and the beginning of the academic year, we contacted and enrolled 912 students to participate in the weekly study.

Table 1 depicts some notable characteristics of our enrolled participants. Although we did not intend to recruit a sample that was necessarily representative of smokers among the freshmen class at Purdue or 18-year-old college students nationally, we found no significant differences on any of the screener variables between the 912 enrolled and 1,089 none-enrolled participants. Furthermore, we used data from the 2002 National Survey on Drug Use and Health (NSDUH; SAMHSA, 2003) and examined key smoking variables from 18-year-old college students, as well as 18-year-olds not enrolled in college, who reported a lifetime history of at least one smoked cigarette. As seen in Table 2, the UpTERN sample was highly comparable with the NSDUH samples of 18-year-old college students as well as those not enrolled in college on several key smoking variables.

Only 4% of the students withdrew from the project over the 35 weeks of the study, approximating the withdrawal rate for Purdue freshmen. Figure 1 shows the weekly participation rate on the weekly web assessments across 35 weeks of the project. Overall, participation rates were very high, averaging 88% across the 35 weekly assessments. There were three notable dips in the rates: during October break, during the 4-week semester break, and during the week of spring break. The participation rate for these break periods averaged 74%. When students were on campus, the participation rate averaged over 90%.

**Patterns of daily use**

Figure 2 shows the number of people who reported any use of cigarettes, alcohol, or marijuana in a given week. The number of people reporting use of these substances declined steadily across weeks, reaching its lowest point at around day 120, in week 17. After that point, levels of use generally stabilized and, in the case of cigarettes and alcohol, showed a modest increase. Across all three drugs, the number of people reporting use was highest in the early weeks of the first semester. Apparently, at the beginning of the freshmen year, the students had many opportunities to experiment with drugs, but many did not continue use.

If someone reported smoking in a given week, how much did he or she smoke? In this study, we were

**Table 1. Characteristics of enrolled subjects.**

<table>
<thead>
<tr>
<th></th>
<th>Number of subjects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female/male</td>
<td>414/498</td>
<td>46.4/53.6%</td>
</tr>
<tr>
<td>Indiana resident</td>
<td>608</td>
<td>67%</td>
</tr>
<tr>
<td>Lifetime cigarettes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 or more</td>
<td>114</td>
<td>12.5%</td>
</tr>
<tr>
<td>100–499</td>
<td>123</td>
<td>13.4%</td>
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<tr>
<td>16–99</td>
<td>232</td>
<td>25.4%</td>
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<tr>
<td>6–15</td>
<td>133</td>
<td>14.5%</td>
</tr>
<tr>
<td>2–5</td>
<td>192</td>
<td>21.0%</td>
</tr>
<tr>
<td>1 puff–1 cigarette</td>
<td>121</td>
<td>13.3%</td>
</tr>
<tr>
<td>Lifetime daily smoking</td>
<td>186</td>
<td>20%</td>
</tr>
<tr>
<td>Ever used?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigars</td>
<td>534</td>
<td>58%</td>
</tr>
<tr>
<td>Snuff</td>
<td>213</td>
<td>24%</td>
</tr>
<tr>
<td>Clove cigarettes</td>
<td>180</td>
<td>20%</td>
</tr>
<tr>
<td>Chewing tobacco</td>
<td>131</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Figure 1.** UpTERN weekly participation rate.

**Table 2.** Comparison of UpTERN sample with 18-year-old college and noncollege students in 2002 National Survey on Drug Use and Health (NSDUH).

<table>
<thead>
<tr>
<th>Variable</th>
<th>UpTERN</th>
<th>NSDUH 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current age (years)</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Male/female (%)</td>
<td>54/46</td>
<td>48/52</td>
</tr>
<tr>
<td>Median age at first cigarette (years)</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Smoking daily (%)</td>
<td>19.9</td>
<td>18.8</td>
</tr>
<tr>
<td>Median age at daily smoking (years)</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Smoking 100 lifetime cigarettes (%)</td>
<td>37.3</td>
<td>38.0</td>
</tr>
<tr>
<td>Smoked in past 30 days (%)</td>
<td>45.4</td>
<td>45.7</td>
</tr>
<tr>
<td>Median number of cigarettes smoked on smoking daysa</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. aCalculated from those reporting smoking in past 30 days.
able to refine the temporal resolution of smoking behavior, a level of resolution rarely available in longitudinal studies of drug use. We could plot, on a daily basis, how many cigarettes people reported smoking. When we did, we saw a picture of smoking behavior that was much more dynamic and contextually sensitive than was seen with coarser aggregations of data. Figure 3 shows the results across 246 consecutive days of smoking. At first glance, the data appeared somewhat chaotic, but upon closer inspection, a strong 7-day pattern was evident in the daily smoking rates. Figure 4, which shows average smoking for each day of the week, captures this pattern. The levels are slightly above 3 cigarettes/day for Sunday through Wednesday, climb on Thursday, and peak at above 4.5 cigarettes on Friday and Saturday.

It is instructive to consider some of these points in light of the calendar (Figure 3). For example, the Thursday of the ninth week had the second highest Thursday rate overall. This day happened to be Halloween, a traditional party day at Purdue (and at colleges across the United States). Another period of
interest is week 15, which is finals week of the first semester. During finals, weekday smoking was somewhat higher than what we had seen in most other weeks. Moving a bit farther out, we see the 4 weeks of the semester break when students were not on campus. This period contained both the lowest and highest smoking rates across the first 22 weeks of the study. The lowest was Christmas Day. The highest, New Year’s Eve, occurred exactly 1 week later. Finally, classes resumed for the spring semester in the 19th week. Here we observed a resumption of the pattern similar to that seen in the previous semester when students were on campus. These calendar-based smoking findings are consistent with those found by other researchers investigating alcohol use among college students during the academic year (e.g., Del Boca et al., 2004).

Figure 5 shows alcohol drinks per day for any participants who reported drinking in a given week. Not surprisingly, alcohol consumption displayed the same weekly pattern seen with smoking. In fact, the disparity between weekdays and weekends was even more pronounced with alcohol. Relatively little drinking occurred on Sundays through Wednesdays when students were on campus. As seen with smoking, Halloween was associated with a boost in drinking, as was New Year’s Eve. When students left campus during breaks, their drinking was distributed more evenly across days of the week. This was particularly evident during spring break, the 7 days around day 200 in the figure. The overall pattern for daily marijuana use paralleled the overall trends observed for cigarette and alcohol use: a strong day-of-week effect with levels of use peaking on Fridays and Saturdays.

Smoking trajectories

A detailed analysis by Colder and colleagues (2006) of the daily smoking data that combined qualitative analysis of ethnographic data and random effects and marginal models for quantitative data revealed that Friday and Saturday evenings were typically party nights, and those days also were associated with the highest levels of smoking, particularly in the fall semester. The pattern of high levels of weekend smoking relative to weekday smoking was most pronounced during the first 14 weeks of the study. Overall levels of smoking declined over the fall semester, and, during the spring semester, the levels of weekend smoking declined such that the weekend–weekday difference in smoking levels was attenuated. In qualitative interviews, students described the initial weeks of the fall semester as a time of freedom and exploration. As the freshman year progressed, academic demands became more pronounced with a corresponding decline in partying and socializing.

Univariate time-series analyses of daily cigarette smoking, alcohol drinking, and marijuana use by Dierker and colleagues (in press) complemented the findings of Colder et al. (2006), showing that a substantial subset of the sample displayed higher levels of substance use at the beginning or end of the academic year. A large proportion of cigarette smokers (64.7%) showed significant positive correlations between smoking levels on any given day and smoking levels on the day preceding and following that day. Systematic patterns of week-to-week use also appeared in the data from approximately half of the sample, with smoking on any given day predicted by levels of smoking occurring 1, 2, or 3 weeks prior. Similar patterns of autocorrelations for days imme-

![Figure 5. Mean number of daily alcohol drinks.](image-url)
Dierker and colleagues (2006) evaluated associations between daily patterns of smoking and alcohol consumption during the periods that students were on campus (i.e., with winter break and spring break days removed from the analyses). This evaluation used bivariate time-series analyses to examine cross-correlations between smoking and drinking across and within days. These analyses revealed strong cross-correlations between smoking and drinking within any given day and on past and future days for the majority of participants reporting both smoking and drinking. Significant associations were most common within any given day, with 86% of the participants showing significant same-day positive associations between smoking and drinking. In addition, significant positive cross-correlations were seen at time lags of 1, 2, and 3 weeks before or after a given day. This pattern suggested a cyclical, weekly pattern of consumption of cigarettes and alcohol. Finally, the smoking-drinking association within days was stronger for individuals at higher levels of smoking and alcohol use. Considerable literature suggests strong relationships between smoking and alcohol use, but these data are the first to explore the cross-association of these two behaviors using such fine-grained assessments of in vivo use. The results suggest that dynamics of smoking behavior among neophyte smokers can be better understood in light of concurrent use of other drugs, including notably, in the context of university life, alcohol consumption.

**Smoking dependence**

Data from the UpTERN study also have been used to examine the nature and correlates of nicotine dependence among low-level smokers. Costello et al. (2007) tested the viability of the five-factor structure of the NDSS (Shiffman et al., 2004) from the NDSS assessments collected at the 14th weekly assessment. Previously, the factor structure of the NDSS, a multidimensional measure of dependence, had been evaluated only in mature, heavy smokers. Confirmatory factor analysis from the UpTERN sample supported the hypothesized five-factor model.

Sledjeski et al. (2007) examined the predictive validity of four nicotine dependence measures used in the UpTERN study: DSM-IV nicotine dependence criteria (American Psychiatric Association, 1994); Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991), Hooked on Nicotine Checklist (HONC; DiFranza et al., 2002), and the NDSS. Data from these measures administered at the 14th weekly assessment were used to predict smoking behaviors at the end of the first and the second academic years. (Data assessing participants’ smoking during their second year of college were collected with a mail questionnaire at the end of that school year [i.e., May 2004]). Dependence levels as assessed by both the HONC and DSM-IV measures were predictive of smoking at both follow-up points. In addition, the NDSS Total score and some of the NDSS factors were positively associated with subsequent smoking behavior. The FTND was generally less predictive of smoking behaviors than the other measures. Finally, higher scores on each dependence measure predicted shorter periods of abstinence at the follow-up assessments. Although not all assessments performed equally well, the overall pattern of results suggested that the concept of nicotine dependence as indexed by these measures is a relevant and valid construct among light smokers.

Dierker et al. (2007) examined the performance of DSM-IV nicotine dependence criteria among participants who reported any smoking during week 14 of the weekly survey (N=176). Given the interest in the applicability of DSM-IV to low-level smokers, the criterion of daily smoking was not used as one of the required dependence features. Although the highest prevalence of nicotine dependence was associated with those reporting the heaviest and most frequent smoking, a substantial number of participants reporting daily or heavy smoking did not meet diagnostic criteria for nicotine dependence. Moreover, a subgroup of participants smoking at low, nondaily levels did meet diagnostic criteria for nicotine dependence. Collectively, these findings indicate that dependence as defined by DSM-IV criteria can appear among those who are relatively light smokers, and that, in general, the presence of dependence, though related to the level of recent cigarette exposure, is not isomorphic with the number of cigarettes smoked or days smoking per week.

**Smoking initiation**

During UpTERN, participants who had a minimal smoking history (fewer than 15 lifetime cigarettes), as identified from responses to the screener survey and baseline assessment, were given a special set of items to answer if, during the weekly assessments, they reported smoking cigarettes. Data on these early-use episodes (EUEs) were collected on the participants’ first five reported EUEs. The EUEs item set included questions about the amount smoked, the topography of use, subjective experiences, concurrent substance use, and the social context of use. A total of 163 students provided 538 EUEs over the 35 weekly assessments. In addition to the quantitative data collected through the web-based assessment, a
subsample (n=16) of those reporting EUEs were interviewed by the ethnographic team to gather qualitative data about the experiences and contexts of initial cigarette exposure. The data from these EUEs provide a unique window into the experiences of novice smokers as they are exposed to their initial cigarettes. Analyses of these data showed the majority of the initial EUEs occurred within a social or party setting and that over 90% occurred when the person was with other people who were smoking (M. C. Acosta, T. Eissenberg, M. Nichter, R. L. Balster, & the Tobacco Etiology Research Network, manuscript under review). In addition, the majority of the first recorded EUEs occurred while the participant was drinking alcohol (65%). The overall subjective effects reported for these initial cigarettes were mild, and the magnitude of effects did not differ as function of whether or not the person was drinking alcohol. The students who continued on to have five EUEs (n=78) were more likely to smoke more of the initial cigarette, inhale more deeply, and report significantly greater positive and sensory/peripheral subjective effects from their first EUE compared with those who did not continue.

**Interpersonal relationships and smoking**

UpTERN also featured the collection of detailed information concerning the social relationships in which participants were involved throughout the study. Etcheverry and Agnew (in press) assessed associations between romantic partner and friend norms and cigarette smoking over time. They examined how both descriptive and injunctive norms from these two potentially important sources of influence predict smoking. Descriptive norms refer to a standard regarding the perception of what people commonly do in or across situations, whereas injunctive norms refer to approval or disapproval of a given behavior. Several analytic techniques were used in an attempt to eliminate the effects of peer and partner selection as an explanation for the obtained results. Controlling for selection processes, the results from growth curve modeling analyses support the independent influence of both descriptive and injunctive norms in predicting smoking over time. In addition, romantic partner norms were found to be particularly predictive of smoking, above and beyond friend norms.

**Challenges and potential of web-based longitudinal research on smoking**

As noted earlier, we were unable to launch the weekly assessment phase of UpTERN until the fourth week of the first semester. Consequently, we were unable to assess levels of smoking and other drug use during the initial weeks of the college year, a period that may be characterized by considerable experimentation with cigarettes and drugs by large numbers of freshmen students. Future research on smoking patterns during the college years should target these important weeks as students navigate the developmental challenge of making the transition from their home environments to a college setting.

The intensive assessment phase of UpTERN was limited, primarily, to the freshman year of college. Although this is likely a critical period for the development or maintenance of smoking patterns that may persist into later adulthood, a comprehensive assessment of the development of smoking and nicotine dependence will require intensive measurement over the duration of a college career and beyond. By the same token, the assessment approach used in UpTERN should begin at earlier periods in these students’ lives, including, at the least, intensive assessment during high school years.

UpTERN focused on college students in one university. The generalizability of the findings would be enhanced by the inclusion of participants from multiple settings, including additional universities, 4-year colleges, technical training sites, and work settings—in short, a representative sampling of the major contexts 18-year-olds confront when they leave high school. As web access continues to expand throughout the population, it becomes increasingly feasible to conduct intensive web-based assessments of smoking across a wide range of settings and samples.

Although the combined frequency and duration of the smoking assessments in UpTERN is somewhat unprecedented in the cigarette smoking literature, our measurement of daily smoking levels was limited by our use of retrospective recall of smoking over 1-week intervals. The timeline followback procedure we used likely enhanced the validity of self-reported smoking (Brown et al., 1998). Nevertheless, the precise accuracy of these retrospective reports is unknown. Other procedures, such as daily monitoring of smoking through the web or interactive voice recording (Krukowski, Solomon, & Naud, 2005; Toll, 2005) or cigarette-by-cigarette monitoring through handheld computers (e.g., Shiffman et al., 2002), could be used in future studies to estimate the validity of the timeline followback procedure or to serve as more direct measures of daily smoking levels.

The web-based approach used in UpTERN had several features that had clear advantages for the goals of our study. The web was highly accessible for our subjects. They could complete the questionnaires on or off campus. They did not have to come to us to give us data; we came to them. Further, the branching capability of the web-based system allowed us to use extremely flexible programming...
that was highly tailored to the responses of each subject. The programming was developed with extensive error checking, and, as a result, we had very few missing data points from within assessment sessions. Finally, the web assessments appeared to be highly palatable to our participants. Because the students never saw the pile of questionnaires they had yet to complete, the web assessment procedures were not viewed as particularly overwhelming. They were able to take breaks from any of the questionnaires and start again where they had left off with no difficulty, as the web program simply bookmarked their break point. All of the advantages described above are predicated on participants having ready access to the web, circumstances very applicable in university settings and increasingly applicable everywhere.

We believe our results demonstrate the value of intensive, longitudinal data collection. We adopted a frequency of assessment that allowed us to capture dynamics in the data that would be unattainable with less frequent measurement. The utility of this approach was enhanced by the high participation rate across the 35 weeks of assessment. We attribute our success to the confluence of several factors, the most important of which was the monetary compensation for weekly assessments. Beyond money, participants also informed us that the E-mail notices regarding impending assessments, E-mail reminders about late assessments, and phone calls from staff when assessments were missed also were important factors in helping them remember to complete assessments in a timely fashion. We also made efforts to establish a collaborative relationship between the project and the participants through the use of periodic letters, postcards, and E-mails describing the progress of the project and, in general, by attempting to maintain a human face on the project, even though the vast majority of the data were collected through a somewhat impersonal process. All of this required significant financial resources, a potential limitation confronting future data collection efforts that are not backed by similar levels of funding.

Although the data collection process described in this paper may appear overwhelming and, perhaps, unattainable by most, that is simply not true. At times, we were overwhelmed by the magnitude of the project, mostly because so much of what we were attempting was new. Also, we were forced by the press of time to get nearly all of UpTERN up and running with virtually no pilot work. At times we felt as though we were laying track as the train was barreling full steam right behind us. However, we worked out many of the bugs in this approach and are happy to share what we have learned. For instance, we have developed web-based software that will be available in some form for use by others. In many ways, and despite its large scale, we view UpTERN as the pilot study for more focused follow-up research on some of the phenomena we identified.

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Note

References


