

RESEARCH PAPER

Short term patterns of early smoking acquisition

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Objective: To describe short term patterns of smoking acquisition exhibited by adolescent smokers.

Design: Interview records from the prospective development and assessment of nicotine dependence in youth study were examined retrospectively. Interviews were conducted three times per year over 30 months.

Subjects: 164 students in grades 7–9 (ages 12–15 years, 86 girls, 78 boys) who had used cigarettes at least twice.

Main outcome measures: A continuous timeline of smoking activity, beginning with the subject's first use of tobacco and continuing through follow up, was translated into six patterns—abstinent, sporadic, occasional, daily, escalating, and intermittent. Outcome measures were the proportion of subjects starting/ending in each pattern, and the number of transitions per subject between patterns.

Results: There was a general but discontinuous progression from infrequent to more frequent use, with many interspersed periods of not smoking. Escalation to daily smoking was common after the development of dependence symptoms, but was rare among those who did not have symptoms. After the appearance of symptoms, both transitions to heavier daily smoking and attempts at cessation increased.

Conclusions: Movement to heavier, more frequent smoking is generally unidirectional, although many youths attempt to quit one or more times. The appearance of any symptom of dependence altered the subsequent pattern of smoking behaviour. Future investigators might consider using more frequent data points and a continuous timeline to track smoking behaviour.

Efforts to characterise the onset and development of smoking behaviour in adolescence have typically focused on the smoker's progression through a sequence of stages from first tobacco use to regular, heavy smoking. In a seminal paper, Leventhal and Cleary¹ reviewed many studies conducted in the 1960s and 1970s and concluded: "the data seem to support the hypothesis that it takes upwards of two years and possibly longer from initial tries and occasional experimentation to arrive at heavy, consistent smoking" (p 385). They note further that both the percentage of youths who smoke and the number of cigarettes smoked increase gradually between grades 7 and 11, with big increases apparent around grade 10. However, they called for longitudinal studies to clarify whether these findings truly reflected increases among individual smokers or whether they resulted simply from average data that did not reflect individual patterns.

Since the Leventhal and Cleary paper, a number of investigators have completed longitudinal studies focusing on demographic predictors of smoking,² on risk factors to predict smoking,³ or on grouping smokers according to their patterns of use over time. Investigations of smoking patterns approach the issue by one of two strategies. One strategy emphasises grouping adolescents according to the trans-theoretical model of change developed by Prochaska and DiClemente,⁴ so that youths would be classified as being in one of four stages of smoking acquisition or cessation: precontemplation, contemplation, action, or maintenance.^{5,6} These studies tend to be cross sectional, surveying different cohorts of adolescents at a single point in time. An excellent review of the literature detailing this approach is available.⁷

The alternative strategy emphasises identification of trajectories of adolescent smoking, typically by grouping youths according to changes in their smoking behaviour over the course of a longitudinal study.^{8–11} In these studies, adolescents were interviewed repeatedly at intervals ranging from annually to biennially. Various clusters of youths have

been identified, some of whom progress rapidly from initiation to frequent, moderate or heavy smoking, others of whom progress more slowly to heavy smoking, and still others of whom remain in a stable pattern of light or occasional smoking. The frequent or heavy smoking categories have been variously defined, ranging from "regular weekly smoking" (for example, ≥ 1 cigarette per week),¹⁰ to "heavy smoking" at widely divergent rates of consumption: > 40 cigarettes per month¹¹ to > 10 cigarettes per day.⁸

The stages and trajectories described in the currently available literature provide valuable insights into where interventions might be most effectively made to prevent smoking initially or prevent escalation when a youth experiments with cigarettes. But the cross sectional designs of the stage model studies and the typically long interval between data points in the longitudinal studies may obscure important short term patterns in adolescents' acquisition of smoking. Recent findings that many adolescent smokers begin to experience symptoms of nicotine dependence early in their smoking careers and when they are smoking only sporadically or occasionally^{12–15} suggest that it might be important to examine patterns of smoking more frequently than annually.

Our goal in this paper is to describe patterns of smoking exhibited by a sample of youths who were participating in the prospective development and assessment of nicotine dependence in youth (DANDY) study.^{12–13} As these youths were interviewed three times during each academic year over a 30 month period, and as a continuous record of smoking was established from the first cigarette until the end of follow up, we are able to examine smoking activity in finer detail than the previously cited literature.

Abbreviations: DANDY, development and assessment of nicotine dependence in youth; HONC, hooked on nicotine checklist; tps, transitions per subject

METHODS

Participants

The sample for the present study was drawn from participants in the DANDY study.¹² The original DANDY sample was comprised of a cohort of 679 grade 7 students from two small cities in central Massachusetts. At entry in January 1998, subjects' ages ranged from 11–15 years (mean age 12.6 years). Males represented 52% of the study cohort and 49% of the student body. The racial and ethnic makeup of the original study population (67% white, 20% Hispanic, 5% African America, 5% Asian, and 3% other) was similar to that of the entire student body (63% white, 25% Hispanic, 3% African America, and 3% Asian).

The current report concerns the 164 subjects—86 girls, 78 boys—(of the 237 DANDY participants who had ever inhaled cigarette smoke) who had used cigarettes at least twice in their lifetime (so that a pattern of use might have developed).

Procedures

Interviews

Subjects were interviewed privately in school, three times annually, approximately every three months (excluding summer). Original analyses of the DANDY data revealed that repeated interviews did not result in prompting, and that recall bias did not affect the findings.¹³ To facilitate the accurate recall of dates and events, “personal landmarks”, “bounded recall”, “decomposition”, and a visual aid in the form of a personalised calendar were incorporated into the interviews.^{16, 17} At the first interview, subjects were asked whether either parent was a current smoker, because parental smoking has been found to be a strong predictor of continued smoking among youths.² At each interview, participants were asked about how many days per month and how many cigarettes per day they had smoked in each month since the previous interview. Because reactions such as nausea, dizziness and feeling relaxed on first inhalation of tobacco smoke were found to be a predictor of continued smoking,¹⁸ subjects who reported having inhaled were asked whether their experience of the first inhalation felt good or bad. This was followed by a list of sensations commonly reported on first inhalation, such as coughing, irritation, nausea, dizziness, relaxation, etc. Full details of the interview protocols are described elsewhere.^{13, 18}

Measurement of symptoms of nicotine dependence (loss of autonomy)

Loss of autonomy has been defined as the point at which the sequelae of tobacco use, either physical or psychological, present a barrier to quitting.¹⁴ This is marked by the appearance of any symptom of dependence. At each interview, subjects were asked if they had experienced any of the 10 symptoms of nicotine dependence assessed by the hooked on nicotine checklist (HONC).¹⁴ These include loss of control over the amount or duration of use, an admission of feeling addicted to tobacco, craving or needing tobacco, difficulty controlling the behaviour in situations where smoking is not allowed, or self report of any of the symptoms of nicotine withdrawal when abstinent from tobacco: difficulty concentrating, strong need or urge, irritability, or nervousness, restlessness or anxiety. The date at which the first HONC symptom was experienced was recorded.

Delineation of patterns of smoking

Defining the smoking patterns presented a challenge. When transitions between smoking and not smoking and the frequency and amount of smoking are considered, the number of possible combinations is almost infinite. Lacking any guidelines from the literature as to definitions of short term smoking patterns, our definitions are somewhat

arbitrary. The first four patterns, which parallel those used by other investigators, were defined as follows: abstinent—no smoking for a duration of at least 60 days; sporadic—smoking less than one day per month, but at least once per year; occasional—smoking 1–29 days per month; daily—smoking every day for at least 30 days; and escalating—daily smoking with an increase over time in the number of cigarettes smoked per day. A sixth pattern, intermittent, was created to classify youths who interspersed their smoking with periods during which they tried actively to quit, but whose cessation attempts did not last long enough to qualify as abstinence. Intermittent was defined as two or more quit attempts, each lasting less than 60 days. A single smoking cessation attempt lasting less than 60 days did not change the classification of the subject's pattern, because a single event does not establish a pattern. A subject who smoked daily before and after a single one week quit attempt would be classified as daily throughout that period.

Interviewers recorded smoking activity as reported retrospectively and contemporaneously on a timeline. The timeline began with each subject's first use of tobacco and was divided into periods of varying duration, continuing throughout the youth's participation in the study. Whenever there was a change in smoking frequency or amount, the interviewer marked a boundary between periods. Because the length of time a particular frequency or amount of smoking would last was difficult to determine while it was happening, patterns were coded retrospectively (that is, by looking back at previous changes in smoking behaviour), and the number of times each person moved from one pattern to another was recorded.

Some examples may illustrate the coding scheme. A student who smoked an average of one to two cigarettes per week for three weeks, then moved to smoking one to two cigarettes per day for six weeks, and finally increased to three or more cigarettes per day, would be coded as starting in occasional, moving to daily, and ending in escalating. Another student who smoked an average of one to two cigarettes per week for three weeks, went on vacation with his parents and did not smoke for a month, then returned to smoking an average of one to two cigarettes per week, would be classified as starting and ending in occasional. Finally, a student who smoked one cigarette daily and quit twice for a month each, but started again at an average of five cigarettes per day, would be classified starting in daily, moving to intermittent, and ending in escalating.

Data analysis

The percentage of youths who started or ended in each pattern was calculated, and differences in proportions between subgroups were analysed by a z score test.¹⁹

To facilitate accurate comparisons of transitions between patterns for subsamples of different sizes, we calculated the number of transitions per subject (tps). The transitions data were not appropriate for any statistical analysis because subjects differed notably in the length of follow up, length of smoking career, time spent in various patterns of smoking, and in the number patterns reported.

Four findings from previous research guided our comparisons of subgroups. Regression analyses of the DANDY data set revealed: (1) the loss of autonomy, as measured by the HONC, predicts far greater difficulty in quitting smoking¹³; (2) girls develop symptoms much more quickly than boys¹⁴; and (3) youths who experience nausea, dizziness or relaxation when they initially inhale on a cigarette face a far greater risk of developing a HONC symptom than do those who did not have such reactions.¹⁸ Also, Chassin *et al* report that parental smoking is associated with increased risk of adolescents continuing to smoke into adulthood.²

RESULTS

Subjects

We first compared our sample of 164 subjects to the complete DANDY sample. There were no demographic differences, and all 10 interviews were completed by 61.6% of the sample for this study compared to 67% of all DANDY subjects.

Transitions per subject

The number of tps was fairly evenly distributed between 1 and 6 transitions, with a mean (SD) of 4.15 (2.22), (range 0–9, median 4.00). To assess the potential effect of attrition, we compared the mean number of transitions reported by subjects who completed all 10 interviews (3.88 (2.32), n = 101) with those who did not (4.55 (2.02); *t* (161) = 1.87, *p* = 0.06). Subjects who left the study before completing all 10 interviews tended to make somewhat more transitions between patterns than did those who completed the study.

Figure 1 shows the transitions between patterns for all 164 subjects, who engaged in a total of 480 transitions between patterns, or 2.93 transitions per subject overall. The initial pattern of smoking for each subject is indicated by Start. The last pattern of smoking recorded for each subject is indicated by End. The number of transitions per subject between patterns is represented by both the weight of the arrows and the numbers on them. An analogy may help the reader interpret the figures. Imagine an aerial view of a college campus with the ovals representing buildings and the arrows representing paths worn in the lawn by individuals moving between buildings. One can get a general idea of the volume of traffic between buildings but we do not know how long individuals spent in each building or how many individuals contributed to the development of each path.

Eighty seven per cent of subjects started in either sporadic or occasional patterns. By contrast, only 21% ended in these

patterns, while 38% of subjects end in abstinent and 34% in daily (including escalating). More than half of the daily smokers were escalating their consumption (not illustrated). Figure 1 illustrates that, over time, there was a progression from less frequent to more frequent use, and that movement among the various patterns is dynamic. Transitions back and forth between tobacco use and non-use were quite common. Much of the movement into abstinence came from sporadic and occasional smokers. Also, a small number of retrograde transitions to less frequent use were observed.

Comparisons between subgroups

Subjects without versus with symptoms of nicotine dependence

Figure 2 presents the transitions exhibited by subjects with no HONC symptoms (panel A, n = 57) compared to transitions reported by subjects with at least one HONC symptom (panel B, n = 107). Overall, the no-HONC group made 1.96 tps versus 3.44 tps for the HONC group, suggesting one might expect approximately 1.75 more tps between patterns for subjects who had lost autonomy. A comparable proportion of both groups started in sporadic or occasional (no-HONC: 90%, HONC: 86%). However, several striking differences emerge in the subsequent course of smoking. First, transitions into and through daily are 7.3 times less frequent in the no-HONC group (0.24 tps *v* 1.75 tps), and transitions from occasional to daily were 9.2 times less frequent for the no-HONC group (0.05 tps *v* 0.23 tps). Although the proportion of smokers in daily (including escalating) was comparable at the start (14% HONC *v* 9% no-HONC), almost 10 times as many of the HONC subjects ended follow up as daily smokers (49% HONC *v* 5% no-HONC; *z* = 2.96, *p* < 0.005). These differences far exceed the expected difference between non-symptomatic and symptomatic subjects, and suggest a much greater risk for

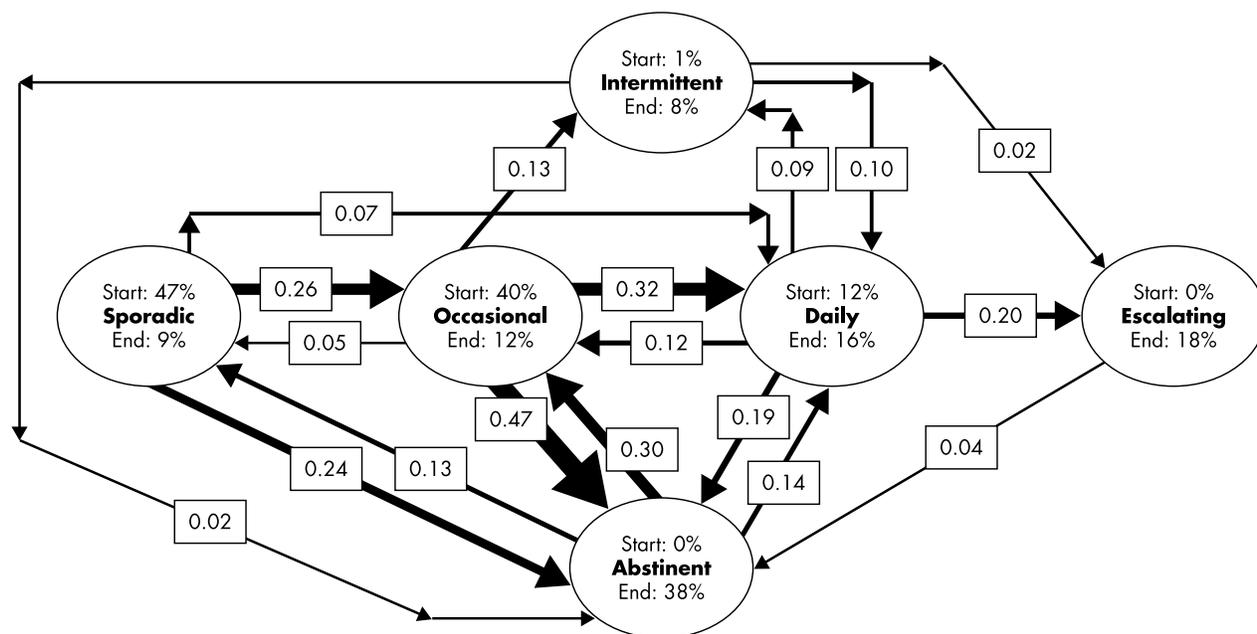
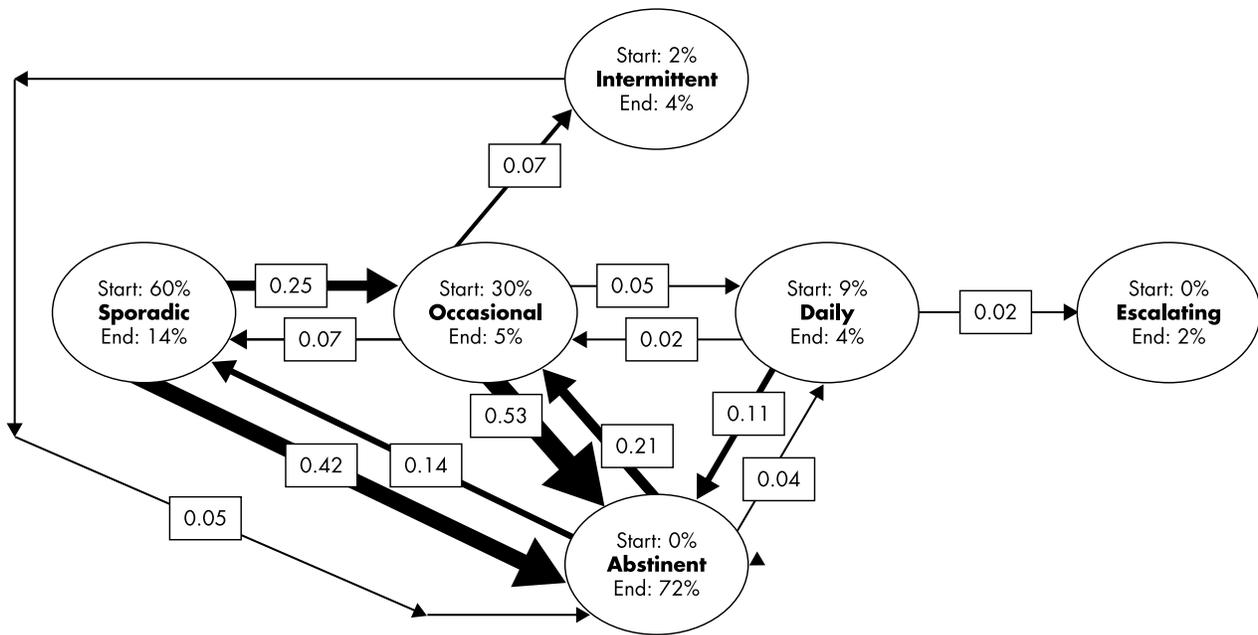


Figure 1 Short term smoking patterns for all subjects (n = 164). Patterns were defined as follows: Abstinent—no smoking for 60 days or more; Sporadic—smoking less than one day per month, but at least once per year; Occasional—smoking 1–29 days per month; Daily—smoking every day for at least 30 days; Escalating—daily smoking with an increase over time in the number of cigarettes smoked per day; Intermittent—2 or more quit attempts, each lasting less than 60 days. A single smoking cessation attempt lasting less than 60 days did not change the classification of the subject’s pattern. The percentage of subjects starting their smoking careers and ending follow up are represented in each pattern by the numbers following Start and End, respectively. The total number of transitions between patterns was 480, yielding 2.93 transitions per subject (tps) between patterns overall. The numbers on the arrows and the weight of each arrow represent the number of tps between patterns. Transitions representing 0.01 or fewer tps are not illustrated.

Panel A (no HONC group) The total number of transitions between patterns was 112, and the overall tps = 1.96.



Panel B (HONC group) The total number of transitions between patterns was 368, and the overall tps = 3.44.

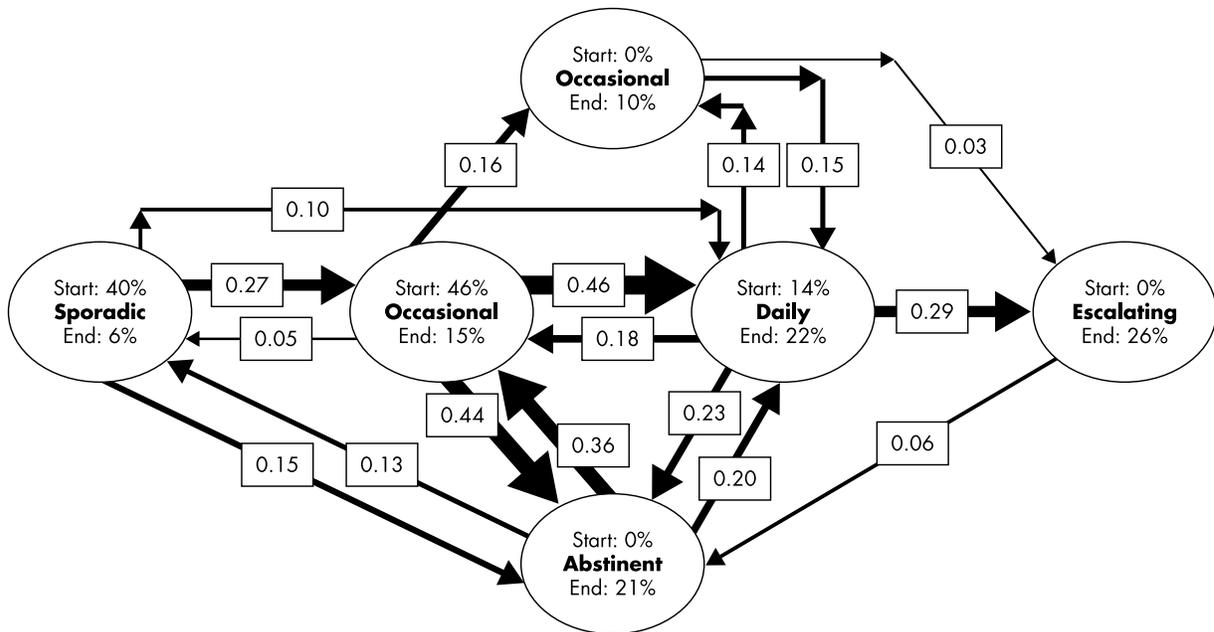


Figure 2 A comparison of smoking patterns for subjects without HONC symptoms (n = 57; panel A) and subjects with HONC symptoms: (n = 107; panel B). The percentage of subjects starting their smoking careers and ending follow up are represented in each pattern by the numbers following Start and End, respectively. The numbers on the arrows and the weight of each arrow represent the number of transitions per subject (tps) between patterns. Transitions representing 0.01 or fewer tps are not illustrated.

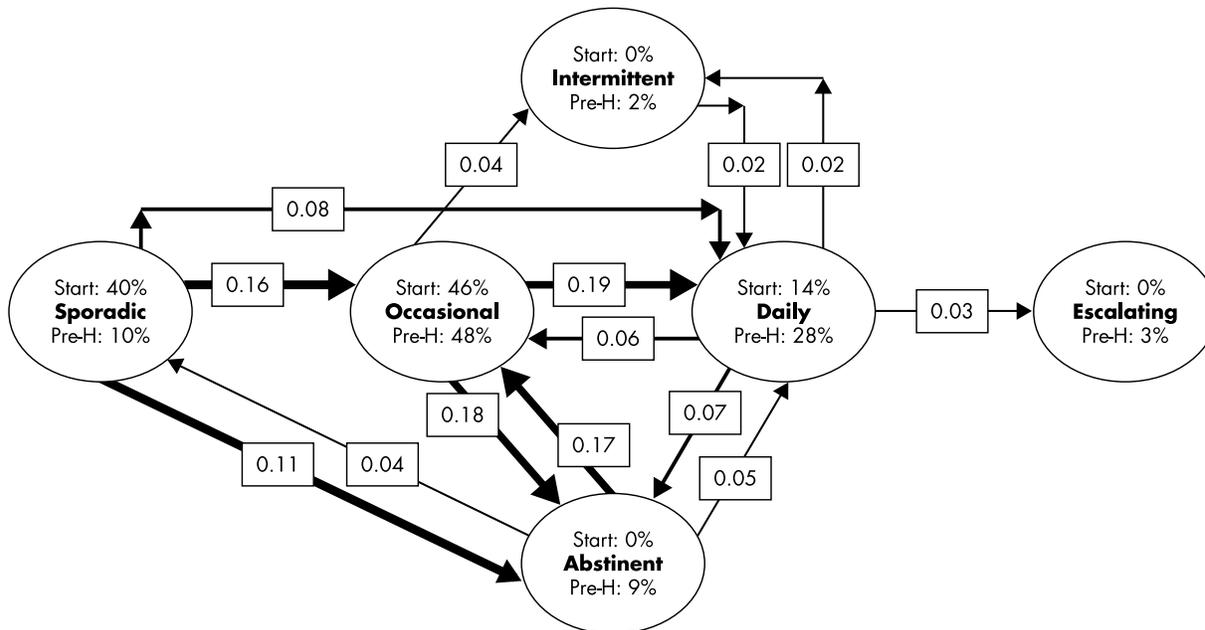
transition to daily smoking among symptomatic subjects. Second, only 2% of the no-HONC group ended the study in escalating, compared to 26% of the HONC group ($z = -1.57$, $p < 0.06$). Finally, more than three times as many of the no-HONC subjects became abstinent by the end of the study (72% v 21%). Thus, the progression to heavier smoking was far greater among subjects who lost autonomy than among those who did not, and once autonomy was lost it became less likely that a subject would achieve abstinence.

A natural question prompted by these findings is whether increased smoking leads to the loss of autonomy, or whether the loss of autonomy leads to increased smoking. Figure 3 illustrates, for subjects who developed HONC symptoms, the comparison between their patterns before (panel A) and after (panel B) the first symptom appeared. In the figure, Pre-H refers to the pattern reported immediately before the first HONC symptom, and Post-H to the pattern reported immediately after the first symptom. These numbers are

not identical because a few subjects changed their pattern of smoking on the day the first HONC symptom appeared. For example, 28% of subjects were daily smokers Pre-H (when symptoms first appeared), but 33% were smoking daily Post-H (immediately after the first symptom), indicating that 5% of subjects transitioned to daily smoking simultaneously with the report of symptoms.

Fifty eight per cent of subjects were sporadic or occasional smokers when HONC symptoms first appeared; 31% were daily (including escalating), and 9% were abstinent. There is a clear increase in activity involving the more serious patterns after the first HONC symptom appears. There were 0.63 tps into and out of daily, intermittent, and escalating before HONC symptoms appeared and 1.99 tps afterward,

Panel A (Before HONC symptoms) The total number of transitions was 116, and the overall tps = 1.08.



Panel B (after HONC symptoms) The total number of transitions was 237, and the overall tps = 2.21.

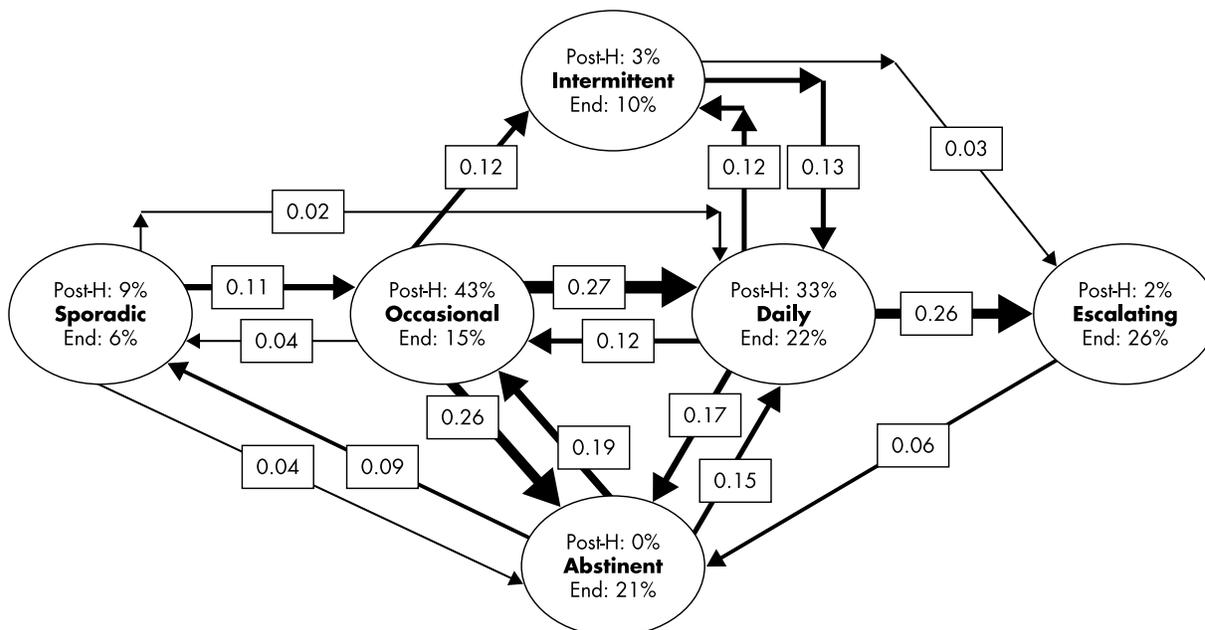


Figure 3 Smoking patterns for subjects with HONC symptoms (n = 107). Panel A represents patterns from the beginning of subjects' smoking career to immediately before the appearance of the first symptom of dependence, while panel B represents patterns from immediately after the appearance of the first symptom to the end of follow up. In panel A, the percentage of subjects starting their smoking careers in each pattern is represented by Start, while the percentage who were in that pattern at the time their first symptom appeared is represented by Pre-H. Similarly, in panel B, the percentage of subjects in each pattern at the time they first experienced HONC symptoms is represented by Post-H, while the percentage who were in that pattern at the end of follow up is represented by End. The numbers Pre-H and Post-H are not identical because a few subjects changed their pattern of smoking on the day the first HONC symptom appeared. The numbers on the arrows and the weight of each arrow represent the number of transitions per subject (tps) between patterns. Transitions representing 0.01 or fewer tps are not illustrated.

suggesting that the development of any symptom of dependence changes the way in which youths smoke. The percentage of daily smokers, including those who were escalating their consumption, also increased significantly, from 31% before the first symptom to 49% at the end of follow up ($z = -1.67$, $p < 0.05$). Additionally, while only 0.03 tps were into escalating before the report of the first symptom, this increased to 0.29 tps after the first symptom was reported. This resulted in a significant increase in the percentage of subjects in escalating, from 3% before the first symptom to 26% by the end of follow up ($z = -1.85$, $p < 0.04$). Cessation activity also increased after HONC symptoms appeared. Before HONC symptoms there were 0.42 tps into abstinent and intermittent, which increased to 0.77 tps after HONC symptoms.

Did the HONC group wind up differently than the no-HONC group because they were intrinsically different, or because their smoking patterns put them at increased risk of losing autonomy? Comparing panel A in fig 2 with panel A in fig 3, we can see that a comparable proportion of both groups started in sporadic and occasional. However, even before losing autonomy, subjects in the HONC group had more of a tendency to progress to daily. There were 0.34 tps into daily in the HONC group compared to 0.09 tps in the no-HONC group. While 14% of the subjects in the HONC group started as daily smokers (including those who were escalating), 35% were in daily/escalating at the point at which their first symptom appeared ($z = -1.73$, $p < 0.05$). Concurrently, before losing autonomy, the HONC group made far fewer transitions into abstinent (0.36 tps) than did the no-HONC group (1.11 tps).

Analyses of the impact of sex, parental smoking, and initial reactions to smoking revealed no differences, perhaps because of our restricted sample size. Whether these factors influence patterns of smoking acquisition remains an open question. Tables and figures representing those comparisons are available from the authors.

DISCUSSION

Our data reveal that the progression from less frequent to more frequent smoking involves a complex, dynamic relationship among different patterns of use. Periods of abstinence lasting 60 days or more were common, as was the resumption of tobacco use. Our investigation focused on "the stage of becoming a smoker", the period between initiation and consistent heavy smoking.¹ As the figures reveal, much occurs during that phase of a smoker's journey, yet overall our results support the notion that the progression from initial cigarette use to heavier patterns of smoking is largely unidirectional.¹⁰ Youths who move on from sporadic and occasional smoking rarely return to those patterns, and those who escalate their daily use almost never de-escalate unless they quit.

Because one must smoke five cigarettes per day to maintain a minimum serum concentration of nicotine, it has been reasoned that smoking less than this poses minimal risk for dependence.²⁰ However, most of our subjects who lost autonomy did so before smoking even one cigarette per day. Also, the transition to escalating daily use tended to follow the loss of autonomy, suggesting that the maintenance of a minimum serum concentration of nicotine is not as important to becoming dependent as once thought. Losing autonomy is a clear milestone in the progression of smoking, as the patterns of smoking are notably different before and after.

National survey data suggest that about half of all youths who have tried tobacco have discontinued use,²¹ but it is difficult from survey data to determine their pattern of smoking when they quit. Our data demonstrate that most of

What this paper adds

Traditionally, tobacco use among youth has been described as a continuous, unidirectional progression over several years, from precontemplation to heavy daily use.

This paper appears to be the first attempt to characterise short term smoking patterns during the acquisition phase among adolescents in a longitudinal study. Our data confirm that while smoking acquisition is characterised by an overall progression from infrequent to frequent use, the process involves a complex, dynamic relationship among different patterns of use. Youths make many unsuccessful attempts at cessation before the progression to daily use. This suggests that cessation interventions should be tailored to include intermittent smokers.

the movement into abstinent is from the sporadic and occasional patterns which come early in the smoker's career. There seems to be a natural tendency to abandon smoking at this level of use. This suggests that before the loss of autonomy many youths successfully give up smoking without intervention. We suggest that attempts be made to enhance the natural tendency to abandon smoking at this stage. An approach that has not been tested is to share with youths the information that the loss of autonomy over nicotine typically occurs soon after the onset of intermittent smoking.¹²⁻¹³ Youths may believe that there is no danger of addiction if they are not smoking every day.

A different picture, and a different challenge, emerges after the loss of autonomy. Our data suggest that the appearance of symptoms of nicotine dependence sparks a struggle between wanting to be a non-smoker and feeling compelled to continue to smoke. There is a sharp increase in attempts to quit smoking after experiencing the first dependence symptom as indicated by an increase in tps into abstinent and intermittent. This parallels the behaviour of neophyte heroin users, who experienced fear and surprise upon realising that they were "hooked", which prompted them to quit before their use got out of control.²² We believe that a promising intervention would be to use the HONC to help novice smokers recognise their symptoms of lost autonomy as quickly as possible in order to spur the natural tendency to attempt cessation.

Intervention efforts at this point might also focus on helping young smokers overcome their loss of autonomy by strengthening their skills in quitting. Adolescent smoking cessation programmes often target those who smoke at least a half pack per day. Our data reveal for the first time the magnitude of relapse to sporadic and occasional smoking. This indicates that cessation intervention efforts need to target occasional and sporadic smokers as well. The HONC might be used as a tool to recruit these intermittent smokers into cessation programmes.

Several limitations may affect how the data from this study are interpreted. First, we do not know the reliability of our subjects' retrospective reports of their smoking. However, because bioassay measures are not sufficiently sensitive to differentiate between non-smokers and intermittent smokers,²³ self report is the current gold standard in research with adolescent beginning smokers. Self reports have repeatedly been found to correlate with biological measures in adolescent daily smokers.²⁴⁻²⁶ Second, individual youths' trajectories through the patterns will have continued after their last interview. Subjects who dropped out of the study had made marginally more transitions before their exit. This suggests that our data may underestimate the true number of transitions per subject. Third, since some subjects who had

not lost autonomy were still smoking at the end of follow up, we cannot know how many eventually developed symptoms. Finally, because of the limited length of follow up, we cannot compare these short term patterns of smoking with the longer trajectories uncovered by others.⁸⁻¹¹

One implication of our study is that investigators conducting longitudinal research might consider using more frequent data collection and a continuous timeline of smoking behaviour. A consequence of examining patterns as snapshots of current smoking behaviour at infrequent intervals is that many intermediate data points are likely lost during the most active phase of smoking acquisition. Concerns that frequent interviewing would produce reactive effects seem unwarranted. The original analyses of the DANDY data revealed no evidence of such effects as prompting or the report of false symptoms. Similarly, there was no evidence of recall bias.¹³ As the interviews were well spaced (about three months apart), it is highly unlikely that subjects could have remembered specific answers they had given in preceding interviews.

Leventhal and Cleary describe the end of the stage of becoming a smoker as the point when a person self identifies as a smoker, based upon a reasoned decision that the advantages of smoking outweigh the disadvantages.¹ In their stage model, the progression toward heavier daily use of tobacco before the development of dependence is attributed to social and psychological rewards. In contrast, our data indicate that those who progress to heavier daily smoking do so after they have developed symptoms of dependence, and often after several unsuccessful attempts to quit. The increase in cessation attempts after the loss of autonomy suggests that many novice smokers progress to heavier smoking despite having decided that the rewards do not outweigh the disadvantages. Stage models of smoking acquisition need to be re-examined in light of the evidence that the early phases of use are marked by frequent attempts to quit.

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