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Pathways Through Adolescent Smoking: A 7-Year Longitudinal Grouping Analysis

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This study examined longitudinal patterns of smoking among students ($N = 852$) followed from 6th through 12th grades using longitudinal grouping analysis. Six patterns (clusters) were identified: nonsmokers, quitters, experimenters, early escalators, late escalators, and continuous smokers. Baseline (6th-grade) differences in associated risk factors were examined. Growth curve modeling revealed meaningful intercluster differences in risk factor trends over the study period. In general, nonsmokers had the fewest baseline risk factors and slowest increase in risk factors, whereas continuous smokers had higher baseline and more rapidly increasing trends in risk factors. Results suggest that some clusters may respond to population-based antismoking interventions, whereas others (early escalators and continuous smokers) will probably require more focused interventions.

Key words: adolescents, youth, smoking, longitudinal, cluster analysis, growth curve

Attempts to reduce adult smoking rates over the past few decades have experienced some success (Garfinkel, 1997; Gilpin, Lee, Evans, & Pierce, 1994; Siegel et al., 2000), but steady or rising adolescent smoking rates in the mid-1990s (Briton, Clark, Soldz, & Krakow, 1997; Everett, Husten, Warren, Crossett, & Sharp, 1998; Johnston, O'Malley, & Bachman, 1996; Soldz, Kreiner, Clark, & Krakow, 2000) raised concerns that this progress could be undermined as new generations take up smoking and eventually become addicted. Although there has been a modest decline in youth smoking in the past few years, the rates are still high enough to be of serious concern (Johnston, O'Malley, & Bachman, 2000; Soldz, Clark, Stewart, Celebucki, & Walker, 2002). To combat this threat, efforts to prevent youth smoking have taken on increased urgency (U.S. Department of Health and Human Services, 1994). These antismoking efforts include a range of programs, from media campaigns (Goodman & Glantz, 1998; Siegel, 1998; Siegel & Biener, 2000) aimed at the universal population of potential smokers to targeted prevention efforts aimed at high-risk youths and smoking cessation programs aimed at those already addicted to cigarettes.

To target these efforts effectively, it is important to understand the characteristics of subgroups of youths who are likely to respond to different types of prevention programming. One approach to distinguishing subgroups of youths who might differ in their response to distinct tobacco control efforts is to identify young people with different longitudinal patterns of smoking over the crucial adolescent years. For example, some youths presumably permanently abstain from smoking, some experiment briefly with smoking, some may smoke for a while and then quit, and yet others may smoke continuously after initiation and are thus at high risk of becoming addicted adult smokers. The first two groups would seem more likely to be responsive to population-based antismoking campaigns, whereas the third group may require more targeted interventions to prevent progression to adult addicted smoking and the final group may require more active smoking cessation efforts.

In the only attempt so far to identify subgroups with distinct longitudinal smoking patterns, Chassin, Presson, Pitts, and Sherman (2000) examined smoking trajectories from adolescence to adulthood. They identified six subgroups with distinct longitudinal patterns of smoking, or trajectories (abstainers, erratics, early stable smokers, late stable smokers, experimenters, and quitters), and examined subgroup differences in adolescent and young adult psychosocial variables. Subgroup differences in these associated psychosocial factors were examined independently once in adolescence and once in young adulthood.

The abstainers were the largest and most conventional group and had, in most cases, the fewest negative social, psychological, and attitudinal risk factors in adolescence. In contrast, the early stable and erratic groups were, in general, the least conventional and tended to be among the groups exhibiting the most adolescent risk factors. The groups similarly differed in their psychological and social functioning in young adulthood (21–31 years of age), with the abstainers exhibiting less negative affect, less personality risk, and fewer positive beliefs about smoking than most other groups. The erratics and the early and late stable groups tended to be at the higher end on these variables. Interestingly, the abstainers had the highest rates of marriage and college attendance, whereas the early stable group exhibited the highest rates of parenthood. Despite the path-breaking methodological and conceptual strengths of the Chassin et al. (2000) study, these authors did not examine the relations between smoking trajectories and the trajectories of other associated variables.

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In a similar vein, Wills, McNamara, Vaccaro, and Hirky (1996) used developmental trajectories from seventh through ninth grade to identify four subgroups of early adolescent substance users (nonusers, minimal experimenters, late starters, and escalators) and examined group differences at baseline on a variety of psychological, social, and attitudinal variables. In general, escalators exhibited the most deviancy and highest scores on risk factor variables, whereas nonusers exhibited the least deviancy and lowest risk factor scores.

In the current study, we extended the Chassin et al. (2000) and Wills et al. (1996) studies by conducting a more fine-grained yearly examination of the development of smoking over the course of adolescence. We also examined trends in the longitudinal course of psychosocial variables associated with smoking. The goal was to illuminate possible risk and protective factors that can help fuel more effective prevention approaches and intervention strategies. This work built on previous efforts to examine the natural history of smoking over periods of the life course including both adolescence (Ary & Biglan, 1988; Kandel & Faust, 1975; Newcomb & Bentler, 1986) and adulthood (Chen & Kandel, 1995; Soldz & Vaillant, 1999), as well as the transition between these periods (Chassin, Presson, Rose, & Sherman, 1996).

In particular, we used data from a longitudinal study of alcohol, tobacco, and other drug use among a cohort of 6th- through 12th-grade students in Massachusetts (Soldz & Cui, 2001). Smoking patterns over the 7 included years were cluster analyzed to identify subgroups of students who differed in terms of their patterns of smoking over the years of the study. We also refined previous empirical work by comparing resultant smoking subgroups on additional risk factors, many of which have previously been associated with smoking behavior (Conrad, Flay, & Hill, 1992; U.S. Department of Health and Human Services, 1994), including demographic characteristics, parental and peer relationships, school functioning, after-school activities, attitudes toward smoking, and use of other substances such as alcohol and marijuana.

Our analytic strategy resembled that of Morral, Iguchi, Belding, and Lamb (1997), who applied a similar procedure to identify patterns of response to methadone, and that of Wills et al. (1996), who used cluster analysis to distinguish adolescent substance use trajectories.[1] In applying longitudinal grouping analysis to smoking, we extended the technique by examining not only baseline differences between the clusters but intercluster differences in risk factor trends over time. Through examining these trends, we were able to understand the clusters in a broader developmental context. That is, we examined whether different longitudinal patterns of smoking are associated with distinct patterns in the associated life domains of school, social connectedness, smoking attitudes, other substance use, self-esteem, and life satisfaction.

Our analyses can help identify young people who are likely to become experimenters, quitters, abstainers, or regular users. The analyses also can shed light on the processes whereby experimentation with smoking proceeds to regular use for some but not others. Illuminating these issues can help policymakers target antismoking messages and other interventions to audiences who are likely to be responsive to them.

Method

Study Sample

Participants were students at 26 schools in 12 communities included in the Massachusetts Substance Abuse Longitudinal Study (MSALS; Soldz & Cui, 2001), a study of the longitudinal course of alcohol, tobacco, and other drug use and associated attitudes and behaviors conducted by Health and Addictions Research for the Massachusetts Department of Public Health Bureau of Substance Abuse Services. All students in sixth-grade classes in selected schools were asked to participate. Parental and student consent was obtained from 85% of eligible students. All data were collected anonymously by means of self-report, during class periods when possible. Students were linked across years through a unique client identifier derived from their name and birthday. Although they did not constitute a stratified random sample, the communities and schools included in MSALS were chosen to be broadly representative of the public school population in the state, including a cross section of geographic areas, types of schools containing sixth grades (elementary vs. middle), and the four types of communities—urban, suburban, growth (communities undergoing economic growth and sizable expansion in population), and rural—previously identified by the state department of education using cluster analysis of a wide range of demographic variables. Because MSALS participants were not the product of a formal randomized sampling design, no weights were applied to participant data.

The original MSALS study included 1,028 students who were surveyed at Grade 6 and followed up yearly until Grade 12. Although additional students were introduced into the study in the 7th and 8th grades, they were excluded from the current analysis. Students who failed to provide at least 3 years of cigarette data over the study period ($n = 176$) were also excluded from the analysis. As a result, the present analysis included data on 852 students (though missing data reduced the n for many analyses), of whom 55.0% were male and 86.6%, 6.7%, 3.9%, and 2.8%, respectively, were White, Black, Hispanic, and of other racial–ethnic backgrounds (including American Indian and Asian American). The participants were distributed among four types of communities: urban (21.8%), suburban (27.1%), growth (23.5%), and rural (27.6%).

Of the 852 students, 90.8%, 97.3%, 95.0%, 90.5%, 80.4%, and 74.4% were recontacted at Grades 7, 8, 9, 10, 11, and 12, respectively. At baseline in 6th grade, study dropouts did not differ from continuers in terms of gender (46.2% vs. 45.0% female), but they were more likely to be Black (14.6% vs. 6.7%) or Hispanic (20.0% vs. 3.9%) and less likely to be White (60.2% vs. 86.6%). They were also more likely to be residents of urban communities (51.7% vs. 21.8%). In addition, study dropouts were more likely to have been smokers (17.7% vs. 7.3%). Soldz and Cui (2001) also found a negative correlation between a youth's number of risk factors and the number of waves of data collected from that youth.

Survey Instrument

The survey used was a 99-item questionnaire that assessed demographic characteristics; tobacco, alcohol, and other drug use; and associated attitudes and risk factors. The survey was originally designed to assess the role of attitudes toward substance use in initiation of use. Many of the items (sometimes modified) had been used in other cross-sectional and longitudinal surveys, including the Monitoring the Future survey (life satisfaction item; Johnston et al., 1996) and the triennial prevalence study of alcohol, tobacco, and other drug use in Massachusetts (truancy, grade point average [GPA], and marijuana and alcohol use items; Briton et al., 1997; Soldz et

[1] Related approaches to longitudinal grouping were also used by Stice, Myers, and Brown (1998) and Prochaska, Velicer, Gadagnoli, Rossi, and DiClemente (1991).

al., 2000, 2002). Other items, including the smoking attitudes items, were designed for the MSALS.

Although formal psychometric data on the survey items are not available, they are similar to items used in many such prevalence surveys. Many of these items have been demonstrated to predict current and, when combined into a risk factor index, future smoking in this data set (Soldz & Cui, 2001); others have been shown to predict time to smoking initiation (Kreiner et al., 1997). Because detailed documentation is not available, we did not participate in the development of the MSALS, and neither of the two MSALS principal investigators recalled the details, the sources of several individual survey items cannot definitively be identified. Several variables of interest for the current study, such as GPA, self-esteem, marijuana use, and life satisfaction, were not added to the instrument until Wave 3 (eight grade) of data collection.

Variables

The following variables derived from the survey instrument were used in the present analyses.

Demographic variables. Information was obtained on grade (6 to 12), gender, age (in years), race–ethnicity (coded as White non-Hispanic, Black non-Hispanic, Hispanic, or other), and community type (urban, rural, growth, or suburban).

Current smoking. Past-month cigarette use was coded as an ordinal variable (0 = *did not smoke*, 1 = *one cigarette or less*, 2 = *a couple of cigarettes*, 3 = *less than half a pack*, 4 = *half a pack to 1 pack*, 5 = *about 1–3 packs*, 6 = *a pack a week or more*).

Religious involvement. Students reported how often they attended a church, synagogue, or temple for religious services. Responses were scaled at four levels ranging from *at least once a week* (1) to *never or almost never* (4).

Truancy. Students were asked to rate how often they "cut" classes. Responses were scaled at five levels ranging from *more than once a week* (1) to *never or almost never* (5).

GPA. GPA was computed by averaging students' self-reports of their most recent report card grades. Although concerns have been raised regarding the possibility of overestimation affecting the accuracy of self-reported grades (Johnson-Greene et al., 1997), self-reported GPA has been demonstrated in several studies to correlate highly with actual grade reports and other indicators of school performance (Dornbusch, Ritter, Leiderman, Roberts, & Fraleigh, 1987; Furstenberg, Cook, Eccles, Elder, & Sameroff, 1999).

After-school activities (television watching). Students were asked to indicate how much time they spent watching television outside of school. Responses were scaled at five levels ranging from *no time* (0) to *more than 3 hours a day* (4).

Time with mother and time with father. Students were asked separately to estimate the average time they spent with each parent over a typical weekend (0 = *no time*, 4 = *more than 8 hours*).

Life satisfaction. Students were asked to rate their satisfaction with life in general on a 10-point scale ranging from *miserable* (1) to *fantastic* (10).

Self-esteem. This variable was based on participants' responses to the statement "I like myself." Responses were scaled at four levels ranging from *never* (1) to *always* (4).

Marijuana use during the previous 12 months. Students were asked to indicate how many times they had used marijuana or hashish during the past 12 months. Responses were scaled at seven levels ranging from *never* (1) to *40 times or more* (7).

Frequent drinking. Students were asked to indicate how often they had consumed alcohol (i.e., beer, wine, wine cooler, or liquor) during the previous month. Responses were scaled at seven levels ranging from *never* (1) to *every day* (7). Frequent drinking was defined as drinking two or more times a week.

Smoking attitudes. Six attitudes regarding smoking were assessed: (a) Smoking a cigarette is fun; (b) I'll feel good if I smoke a cigarette; (c) It's OK for me to smoke a cigarette; (d) I'll feel high if I smoke a cigarette; (e) If I smoke a cigarette, I'll feel sick; and (f) I'll feel relaxed if I smoke a cigarette. Agreement with individual statements was scaled from 0 (*never*) to 3 (*always*). A smoking attitude index was formed as the mean of the ratings on the five attitudes (with the fifth item reverse coded) other than "I'll feel high if I smoke a cigarette," which was analyzed separately at baseline only. The mean Cronbach alpha coefficient for this composite across grades was .66.

Data-Analytic Strategy

Cluster analysis. One of the goals of this study was to examine discrete longitudinal patterns of smoking. To determine these patterns, we clustered youths on the basis of their seven current smoking scores from Grades 6–12. In cluster analysis, cases are grouped according to their similarity on the clustering variable (in this case, current smoking). To conduct the cluster analysis, we used SAS PROC FASTCLUS, an implementation of *k*-means clustering, a partitioning clustering procedure in which the number of clusters is specified a priori (SAS Institute, 1989). In the case of students who were missing data for some of the study years, the missing current smoking data were imputed by PROC FASTCLUS. In the presence of missing data, this procedure assesses an observation's distance from a cluster seed by computing the squared Euclidian distance between the observation and the seed, multiplying by the inverse of the proportion of nonmissing data points of the observation, and taking the square root.

In *k*-means clustering, after an initial estimate of cluster seeds, participants are assigned to a cluster based on the Euclidean distance from the seeds. An iterative procedure follows in which cluster seeds are replaced by cluster means, cases are reassigned, and the process is repeated until changes in the cluster means become smaller than a specified tolerance.

Cluster differences at baseline. To understand the nature of the clusters, we examined baseline (sixth-grade) differences between clusters. For categorical variables, we used Pearson chi-square analyses to examine intercluster differences. For continuous variables, we used analyses of variance (ANOVAs) to examine differences between the clusters, followed by post hoc Tukey comparisons of pairwise differences.

Cluster differences over time. To further understand the nature of the different clusters, we conducted a series of repeated measures growth curve analyses. These analyses examined intercluster differences in the time trends of variables hypothesized to differ among the six clusters. For the purpose of these analyses, cluster was treated as an independent variable, and an individual's scores on a given variable over the seven grades were the dependent variables. We examined both differences in mean level between clusters (cluster main effect) and differences in the rate of change over time on the dependent variables (interaction of cluster with grade). To allow for curvilinear patterns that could have emerged, we examined possible quadratic effects by entering the square of grade as an independent variable. Also entered was the interaction of that square with cluster, which assessed whether the degree of curvature over time varied between clusters. In cases in which quadratic or interaction terms were not significant, they were dropped from the model, and the model was reestimated.

Because our interest was in cluster differences in trajectory rather than intracluster variance, we treated slopes as a fixed within-cluster effect; intercepts were modeled as a random factor. In the case of several variables, we explored whether treating slopes as a random factor affected the results and found that these more complex models led to virtually the same results as the simpler models reported here, although in some instances the random coefficient models had convergence problems. Because the MSALS data set did not include a variable assessing what classroom a given participant was in, no adjustment was made for a possible design effect arising from clustering of students within classrooms. Therefore, the resultant *p* values may be too liberal and should be interpreted with caution.

The models adopted thus represented a multilevel modeling approach to repeated measures rather than a more traditional repeated measures ANOVA (or multivariate analysis of variance; Tabachnick & Fidell, 1989).

We used this approach because multilevel modeling techniques can handle observations with missing data in the repeated measure (Snijders & Bosker, 1999; Snijders & Maas, 1996) and because they allow for greater flexibility in specifying the covariance structure of the time-varying variable (Littell, Milliken, Stroup, & Wolfinger, 1996). After examination of several potential covariance structures (e.g., compound symmetry and autoregressive), we decided to use an unstructured covariance matrix along with the empirical variance estimator (also known as the "sandwich estimator") because it has the advantage of being able to obtain consistent standard error estimates even in cases in which the covariance–variance matrix is misspecified (Albert, 1999; Diggle, Liang, & Zeger, 1994; Littell et al., 1996). In general, consistent with the statistical literature (Diggle et al., 1994), the models derived from the different covariance structures were very similar and led to virtually identical interpretations. The growth curve of means predicted by the final version of each model (after nonsignificant terms had been removed) was plotted for each cluster, facilitating intercluster comparisons.

Results

Cluster Analysis

We examined all cluster solutions between 2 and 10 clusters. In choosing the best solution, we used several criteria, including examination of the cubic clustering criteria, (Sarle, 1983), interpretability, a desire to avoid extremely small cluster sizes, and a desire to obtain at least one cluster containing youths who initiated and then reduced or stopped smoking. Given these criteria, the best solution contained 6 clusters, no solution with fewer clusters produced a group that reduced smoking. There was also a maximum in the cubic clustering criteria with 6 clusters.

The resultant clusters (1–6, respectively) were labeled *nonsmokers* ($n = 557$), *quitters* ($n = 37$), *experimenters* ($n = 54$), *early escalators* ($n = 76$), *late escalators* ($n = 77$), and *continuous smokers* ($n = 51$). The percentages of participants in each cluster who smoked at least a half pack a month (a current smoking score of 4 or more) are presented in Table 1. This level of use was chosen as a result of the greater specificity of its definition than that of lower levels (e.g., a couple of cigarettes).

Nonsmokers evidenced virtually no consumption throughout the 7 study years. Quitters, in contrast, exhibited no consumption at 6th grade, but their rates climbed to 43.2% at Grade 9 and then dropped to 13.3% by 12th grade. Experimenters exhibited no consumption for the initial 3 years, a steady increase over the next 3 years; and a sharp rise to 63.0% in 12th grade. Consumption by late escalators showed minor fluctuations over the first 4 years and then a sharp increase to 84.2% at Grade 11. Early escalators exhibited a sharp increase at Grade 8 and reached a rate of 97.4% by Grade 12. In contrast, smoking rates in the continuous smokers cluster began at a comparatively high level at Grade 6 (13.0%) and quickly increased to and remained above 90%. These results indicate that the cluster analysis distinguished meaningful and potentially important behavioral discriminations among the students over the 7-year follow-up period.

Cluster Differences at Baseline

Demographic differences. Baseline intercluster differences are presented in Table 2. There was no significant age difference across clusters, $F(1, 795) = 0.40$, $p > .05$. Male students accounted for 51.5% of nonsmokers, whereas 75.7% of quitters were male. Despite a significant chi-square value, there was no clear pattern in the gender distribution across the six clusters, $\chi^2(5, N = 846) = 12.73$, $p < .05$. There were also significant differences in race–ethnicity across clusters, with Whites ranging from a low of 82.3% of nonsmokers to a high of 100% of quitters, $\chi^2(15, N = 798) = 42.75$, $p < .001$. Community type also showed a significant difference, with only 10.8% of quitters living in urban communities, as compared with 37.3% of continuous smokers, $\chi^2(5, N = 793) = 14.31$, $p = .01$.

Psychosocial variables. At Grade 6, quitters and experimenters were more likely to be living with both parents, whereas late escalators and continuous smokers were more likely to be living with a single parent or an extended family; differences were of marginal significance, however, $\chi^2(5, N = 794) = 10.80$, $p = .05$. In addition, we found that most early escalators were living with both parents.

Also at grade 6, the smoking clusters exhibited no difference in truancy rates, $F(5, 786) = 1.95$, $p > .05$, or amount of time spent with mothers, $F(5, 784) = 1.25$, $p > .05$. Continuous smokers, however, spent less time with their fathers than nonsmokers, quitters, or early escalators, $F(5, 786) = 3.08$, $p < .01$ (Tukey pairwise test: Cluster 6 < clusters 1, 2, and 5). A significant disparity was also noted in regard to religious involvement, with continuous smokers exhibiting noticeably less involvement than nonsmokers or quitters, $F(5, 788) = 4.12$, $p = .001$ (Tukey pairwise test: Cluster 6 > Clusters 1 and 3). Furthermore, continuous smokers reported spending relatively more time watching television, $F(5, 789) = 3.56$, $p < .01$ (Tukey pairwise test: Cluster 6 > Clusters 1 and 2).

Table 1
Cluster Size and Smoking Status of Cluster Members Over the Study Period

		Percentage smoking at least half a pack per month, by grade						
Cluster	Cluster size	6	7	8	9	10	11	12
Nonsmokers	557	0.0	1.2	0.6	0.2	0.2	0.6	0.0
Quitters	37	0.0	12.1	30.6	43.2	30.6	8.8	13.3
Experimenters	54	0.0	0.0	0.0	2.0	15.7	6.3	63.0
Late escalators	77	0.0	2.9	1.3	0.0	12.5	84.2	75.0
Early escalators	76	0.0	0.0	21.3	68.5	95.4	98.0	97.4
Continuous smokers	51	13.0	60.9	97.9	97.9	94.9	96.2	92.6

Note. The numbers in a cluster differed somewhat from grade to grade owing to inclusion of all participants with at least three waves of usable data.

Table 2
Association of Smoking Clusters With Grade 6 Baseline Variables

Variable type	Smoking cluster					
	Nonsmokers (n = 557)	Quitters (n = 37)	Experimenters (n = 54)	Late escalators (n = 77)	Early escalators (n = 76)	Continuous smokers (n = 51)
Demographic						
Gender (%)						
Female	48.5	24.3	42.6	35.1	43.2	41.2
Male	51.5	75.7	57.4	64.9	56.6	58.8
Age in years						
M	12.6	12.5	12.7	12.6	12.5	12.8
SD	0.6	0.6	0.5	0.5	0.6	0.7
Race–ethnicity (%)						
White	82.3	100.0	92.6	96.1	90.8	98.0
Black	8.8	0.0	0.0	7.4	1.3	2.0
Hispanic	4.9	0.0	7.4	0.0	7.9	0.0
Other	4.1	0.0	0.0	1.3	0.0	0.0
Community type						
Urban	22.4	10.8	12.9	24.7	15.8	37.3
Nonurban	77.6	89.2	87.1	75.3	84.2	62.7
Psychosocial						
Living situation						
Lives with both parents	74.3	80.0	79.2	62.2	77.3	60.8
Lives with single parent or other	25.7	20.0	20.8	37.8	22.7	39.2
After-school activities: Television (range: 0–4)						
M	2.3	2.3	2.2	2.6	2.6	2.7
SD	1.0	0.9	0.9	1.1	0.9	1.2
Truancy (range: 1–5)						
M	4.9	4.9	4.9	4.9	4.9	4.8
SD	0.4	0.2	0.2	0.3	0.4	0.5
Religious involvement (range: 1–4)						
M	1.9	2.2	1.9	2.3	1.9	2.6
SD	1.2	1.3	1.1	1.3	1.2	1.3
Time with father (range: 1–4)						
M	1.9	2.2	1.8	1.8	2.2	1.5
SD	1.3	1.4	1.1	1.4	1.2	1.3
Time with mother (range: 1–4)						
M	2.4	2.4	2.2	2.5	2.6	2.2
SD	1.2	1.3	1.1	1.3	1.2	1.2
Smoking attitude index (range: 0–3)						
M	0.4	0.6	0.5	0.5	0.6	1.2
SD	0.4	0.7	0.5	0.6	0.7	0.9
Smoking makes me high (range: 0–3)						
M	0.9	0.7	1.0	0.8	0.9	0.3
SD	1.1	1.0	1.1	1.1	1.1	0.6

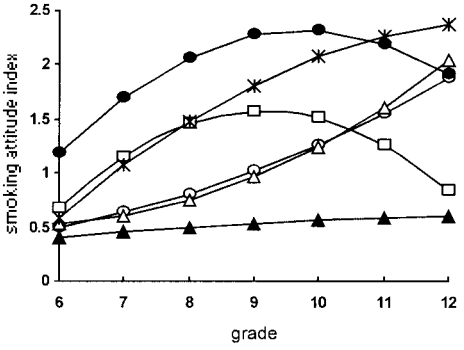
Note. Percentages are presented for all categorical variables; means are presented for all continuous variables.

Attitudes. Continuous smokers were significantly higher on the smoking attitude index than members of the other five clusters, indicating that they had more positive attitudes toward smoking. Also, early escalators scored significantly higher than nonsmokers on the index, $F(5, 789) = 24.40$, $p < .001$ (Tukey pairwise test: Cluster 6 > Clusters 1–5, Cluster 5 > Cluster 1). In contrast, continuous smokers were less likely to report that smoking made them high than members of the other clusters, $F(5, 788) = 3.54$, $p < .01$ (Tukey pairwise test: Cluster 6 < Clusters 1, 3, and 5).

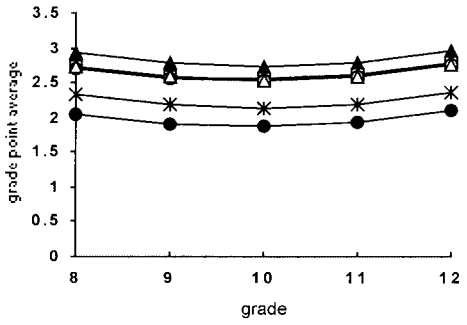
Intercluster Trends Over Time

In addition to baseline analyses, we examined differences between the clusters in trends over the 7 study years in terms of a range of variables representing risk factors for smoking. We used both the statistical significance tests and the graphs of the fitted growth curves from the final model (after removing nonsignificant terms) to interpret the findings. Figure 1 presents plots of the fitted growth curves for selected variables.

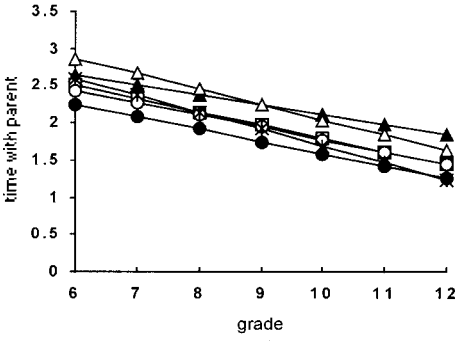
Smoking attitudes. The smoking attitude index showed significant differences between clusters, $F(5, 834) = 2.80$, $p < .05$. There were also intercluster differences over time in slope: interaction between grade and cluster, $F(5, 834) = 25.09$, $p < .001$, and main effect for slope, $F(1, 834) = 125.91$, $p < .001$. Finally, there were differences in curvature over time: Square of Grade × Cluster interaction, $F(5, 834) = 25.37$, $p < .001$. Nonsmokers were consistently lowest on the smoking attitude index; continuous



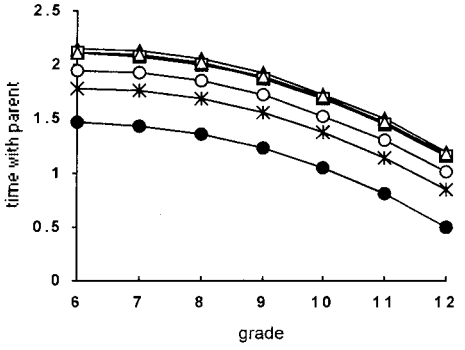
Smoking Attitude



GPA



Time with Parent (Mother)



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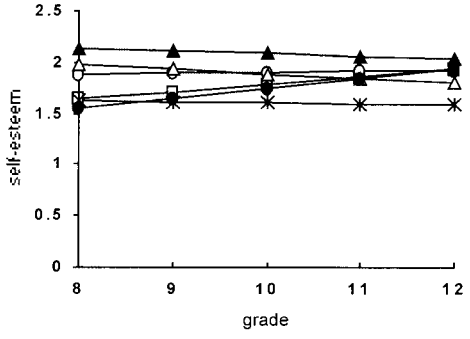
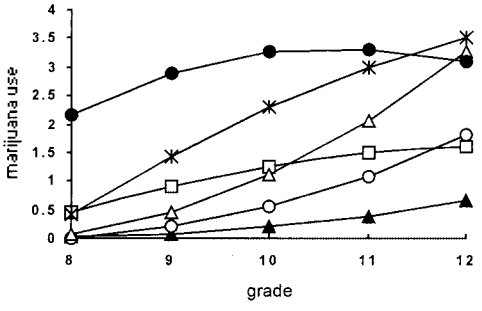


Self-Esteem



Marijuana Use During Last 12 Months

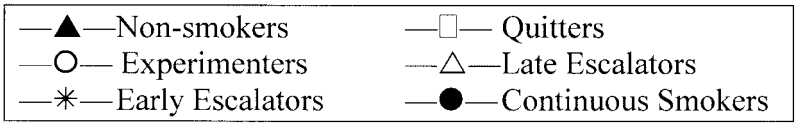


Figure 1. Growth curve models of intercluster differences in smoking attitudes, grade point average (GPA), time with parents, self-esteem, and marijuana use.

smokers had the highest pro-smoking attitudes at most time points, though early escalators ended up slightly higher at Grade 12. Although exhibiting somewhat less positive attitudes toward smoking than the continuous smokers and escalators at most grades, both experimenters and late escalators ended up with attitudes essentially indistinguishable from those of the heavier smoking groups by Grade 12. Interestingly, quitters exhibited a sharp rise in the index from Grade 6 to Grade 9, at which index scores peaked and then declined to near baseline levels by 12th grade.

Time with parents. Time spent with mothers declined among all clusters over the study period, $F(1, 840) = 198.23$, $p < .001$, although the rate of decline differed between groups, $F(5, 840) = 2.87$, $p < .05$; main effect for cluster, $F(5, 840) = 2.28$, $p < .05$. Declines were highest for early escalators and lowest for nonsmokers. Time with fathers exhibited a significant quadratic effect that did not differ between clusters, $F(1, 844) = 47.32$, $p < .001$; linear slope effect, $F(1, 844) = 2.72$, $p > .05$. There were, however, consistent differences in level between the clusters that were maintained throughout the study period, $F(5, 844) = 7.78$, $p < .001$. Continuous smokers spent the least time with their fathers throughout the study period, followed by early escalators.

School performance. GPA showed significant curvature, $F(1, 844) = 96.90$, $p < .001$, and intercluster differences, $F(5, 844) = 27.23$, $p < .001$, but neither slope nor curvature differed between clusters. Continuous smokers consistently had the lowest grades, followed by early escalators. Nonsmokers consistently had the highest grades.

Truancy exhibited significant intercluster differences in level, $F(5, 839) = 4.33$, $p < .001$, and slope, $F(5, 839) = 10.31$, $p < .001$; main effect for slope, $F(1, 839) = 3.81$, $p > .05$. The quadratic effect was significant, $F(1, 839) = 42.35$, $p < .001$, but did not differ across clusters. Nonsmokers had the lowest rates of truancy from Grade 8 on, whereas continuous smokers consistently exhibited the highest rates.

Religious involvement. There were significant intercluster differences in religious involvement, $F(5, 844) = 9.49$, $p < .001$, but the clusters did not differ significantly in either slope or curvature. Religious involvement did decline with grade, $F(1, 844) = 4.27$, $p < .05$, and exhibit some curvature, $F(1, 844) = 5.50$, $p < .05$. Continuous smokers consistently exhibited the lowest levels, followed by early escalators; nonsmokers exhibited the highest levels.

Alcohol and marijuana use. For frequent drinking, there were significant intercluster differences in both curvature, $F(5, 834) = 5.90$, $p < .001$, and slope, $F(5, 834) = 6.48$, $p < .001$; main effect for slope, $F(1, 834) = 14.85$, $p < .001$. There were also main effects for cluster, $F(5, 834) = 4.42$, $p < .001$. Nonsmokers exhibited consistently lower rates of frequent drinking than did any of the other groups, whereas continuous smokers had the highest rates until 12th grade, at which they leveled off. Quitters had the second highest initial rate but then quickly peaked and showed a modest decline. In contrast, experimenters and late escalators began with rates close to those of nonsmokers but escalated to rates equal to or greater than those of continuous smokers by 12th grade. Frequent drinking among early escalators started at an intermediate level but quickly rose to the second highest level in most grades. Marijuana use patterns were relatively similar to those for frequent drinking: intercluster difference in curvature, $F(5, 834) = 4.22$, $p < .001$; difference in slope, $F(5, 834) = 4.67$, $p < .001$; main effect for cluster, $F(5, 834) = 3.20$, $p < .01$; and main effect for grade, $F(1, 834) = 6.67$, $p < .01$. A difference, however, was the greater discrepancy between initial levels for continuous smokers and all other clusters. Also, there was a relatively lower rate of increase for experimenters, along with a more modest increase for quitters.

Self-esteem. Self-esteem did not exhibit a curvilinear pattern of change from the 8th through the 12th grade, although there was a significant interaction between cluster and slope, $F(5, 840) = 3.50$, $p < .01$; main effect for cluster, $F(5, 840) = 7.04$, $p < .001$. Nonsmokers consistently had the highest self-esteem, whereas early escalators had the lowest from Grade 9 on. Interestingly, both continuous smokers and quitters exhibited sharply rising self-esteem, ending up essentially equal with the nonsmokers by 12th grade.

Life satisfaction. Life satisfaction exhibited significant interactions between cluster and slope, $F(5, 839) = 2.70$, $p < .05$; main effect for slope, $F(1, 839) = 4.56$, $p < .05$. There were also intercluster differences, $F(5, 839) = 6.44$, $p < .001$, as well as significant curvature, $F(1, 839) = 6.02$, $p < .05$. Two clusters, quitters and continuous smokers, increased somewhat in life satisfaction from the 8th through the 12th grade, whereas the others either declined (late escalators) or ended up essentially where they started.

Television viewing. There was no intercluster difference in television viewing, $F(5, 845) = 1.51$, $p > .05$, although viewing increased with grade, $F(1, 845) = 158.84$, $p < .001$.

Discussion

In this study, we used longitudinal grouping analysis to discern subgroups of adolescent smokers with distinct trajectories of cigarette consumption between the 6th and 12th grades. Analyses identified six distinct clusters of smokers: nonsmokers, quitters, experimenters, early escalators, late escalators, and continuous smokers. Analyses of both baseline (6th-grade) and longitudinal data provided strong evidence of the existence of distinct longitudinal patterns of smoking over the middle and high school years.

Baseline data analyses demonstrated that traditional protective factors, such as attending church or other religious institutions and spending time with fathers, are more closely associated with nonsmokers than continuous smokers. In contrast, factors such as the amount of time students are truant from school and the amount of time they spend watching television are more closely associated with continuous smokers and escalators. In addition, continuous cigarette use was found to be associated with favorable attitudes toward smoking at baseline. Taken as a whole, these results indicate that the clusters did, indeed, differ as expected on these variables.

A second set of analyses examined cluster differences in risk factor trends over time. Across the various risk factors, students in clusters associated with more severe smoking patterns exhibited the greatest increases over time. Similarly, nonsmokers tended to have the least increase in risk factors, and quitters had intermediate risk factor trends that sometimes paralleled their curvilinear smoking patterns.

One important variable examined was attitudes toward smoking. Changes in these attitudes paralleled rather closely the changing smoking rates among students in a given cluster (see Table 1).

Nonsmokers consistently had less favorable attitudes toward smoking on the smoking attitude index than members of the other clusters, whereas continuous smokers had the most favorable attitudes throughout most of their school careers. Quitters' attitude change closely reflected their trajectory of cigarette use, whereby their attitudes rose to a maximum in 9th grade and then declined. By 12th grade, those in the four clusters who exhibited high smoking rates were virtually indistinguishable on the smoking attitude index, whereas nonsmokers and quitters were similar to each other in terms of their unfavorable attitudes.

Change trajectories for other protective and risk factors were largely reflective of the changes in smoking rates throughout the study period. Nonsmokers were uniformly less likely to skip classes, use marijuana, or drink alcohol. They also spent less time watching television after school. Furthermore, nonsmokers consistently reported having higher life satisfaction, GPAs, and self-esteem. They also attended church more often and spent more time with their parents. Nonsmokers' patterns of change in regard to most protective and risk factors were in sharp contrast to those of continuous smokers, who tended to maintain or increase their already high baseline levels of risk factors. These results paralleled those of Chassin et al. (2000) and Wills et al. (1996): A large abstaining group had the most healthy attitudes and behaviors and the fewest risk factors, and groups of early escalating users exhibited the most problematic attitudes, behaviors, and risk factors.

Understanding the Clusters and Their Implications for Intervention

The distinct trends in risk factors for the different longitudinal smoking clusters aid in understanding the differences among the six clusters. Here we provide a brief synopsis of the most salient points regarding each cluster, along with speculations on potential implications for successful interventions with each group.

Nonsmokers. Nonsmokers constituted the largest group and were distinct from the other clusters on most variables. Their attitudes remained the most negative toward smoking throughout the study period. Interestingly, this cluster included the greatest proportion of minorities of any cluster. The picture that emerges is of a group of well-integrated, socially connected, and successful adolescents. They are perhaps a testament to the repeated findings of longitudinal researchers that not all youths experience a stormy adolescence characterized by social alienation and experimentation with risky behaviors (Block, 1971; Feldman & Elliott, 1990; Offer, 1984; Offer & Offer, 1975). As far as can be seen from our data, these young people are developing satisfactorily, and society and their parents need not worry about them. They are likely to respond very well to broad population-based prevention efforts aimed at maintaining their early anti-tobacco attitudes.

Quitters. Using our analytic techniques, we were able to identify a group of students who initiated and then stopped or reduced their smoking: the quitters. The quitters' attitudes toward smoking roughly paralleled their patterns of smoking over the study years. In terms of their use of other substances (alcohol and marijuana), they exhibited usage rates greater than those of nonsmokers; however, these rates were either declining (alcohol) or negatively accelerating (marijuana), in contradistinction to the rates for most of the other clusters. Thus, the evidence suggests that their experimenting with cigarettes was part of a larger pattern of experimenting with risky behaviors in early adolescence before settling down toward the end of their school careers. An important topic for future research would be to determine whether prevention messages played a role in reducing smoking among these youths (Sly, Hopkins, Trapido, & Ray, 2001; Soldz et al., 2000, 2002). Possibly, population-based prevention efforts (e.g., Centers for Disease Control and Prevention, 1999a, 1999b; Robbins & Krakow, 2000), together with maturation, gradually weaned these youths from smoking and other risky behaviors.

Experimenters and late escalators. These groups were very similar on virtually all variables; thus, we discuss them together.[2] Youths in these clusters exhibited virtually no cigarette use at all until 9th grade, but the percentage who smoked at least half a pack per month increased rapidly after that, until 63.0% of experimenters and 75.0% of late escalators were smoking at that level in 12th grade. They also tended to exhibit escalating use of marijuana and alcohol toward the end of their school careers. Their attitudes toward smoking paralleled their smoking patterns, becoming more pro-smoking in the later grades. They were intermediate on most other variables. These youths are clearly at some risk, in that their experimentation with risky behaviors could lead to more serious problems such as addiction to tobacco. Yet, their later initiation and their intermediate status in terms of most psychosocial variables suggest that these youths have some positive resources that can be drawn on in encouraging more positive behaviors. They are thus probably the main focus of many primary prevention efforts. Efforts to better understand these groups may help improve the crafting of prevention messages targeted at groups that are both at risk and likely to respond to low-intensity population-based messages.

Early escalators. This cluster of students exhibited no smoking until 8th grade; by Grade 9, 68.5% were already smoking at least half a pack per month, and more than 95% were doing so in Grades 11 and 12. Similar to this smoking pattern, these young people tended to start at low to moderate levels for other problematic behaviors, such as truancy and marijuana and alcohol use, but rapidly escalated to end up having among the highest rates of these behaviors. Interestingly, by 12th grade, they were lowest in terms of both self-esteem and life satisfaction. Also, they tended to be the second lowest group in regard to measures of social connectedness (religious involvement and time with mother and father). The pattern that emerges is of a group with problems in some domains in Grades 6 and 7 that rapidly escalate to more global problems across a variety of domains. Prevention efforts with these youths would probably need to begin early and integrate a variety of domains: cigarette and other substance use, social connectedness, and attitudes toward risky behaviors. As is true for continuous smokers, in many cases interventions aimed at early escalators would need to address or compensate for problematic family situations. These youths are not likely to respond strongly to population-based prevention messages, especially by the time they are in high school. It is possible, although not very likely, that they

[2] In fact, as was suggested by one reviewer, the label *experimenters* may be inaccurate given the findings. This reviewer recommended changing the name to *very late escalators.* We did not follow this suggestion, because it was post hoc. Nonetheless, readers should be careful in interpreting the name for this group.

might exhibit some response to such messages in 6th grade, especially if the messages are combined with other efforts to increase their social connectedness. More likely, however, would be a response to interventions targeted at their multiple problem domains.

Continuous smokers. This cluster was the only one to have members smoking half a pack per month in the sixth grade. By the eighth grade, virtually all of them were smoking at that level. They were among the highest groups in all problem domains, having the lowest GPAs, the highest truancy rates, the highest rates of marijuana and alcohol use, the most pro-smoking attitudes, and the least religious involvement and time spent with parents at most grades examined. This group could already be distinguished at Grade 6; on many variables, they exhibited significantly more problematic behavior than one or more of the other clusters at that early point. They also were less likely to report that smoking made them high than were members of the other clusters. This finding may be an indication that they had already developed tolerance at this early age.

Given the multiplicity of problems exhibited by these youths by Grade 6, the early and rapidly escalating nature of their cigarette and other substance use, their probable nicotine addiction, and the escalating nature of these problems over succeeding years, these young people are not good targets for most forms of primary prevention but may need treatment instead. Single-issue efforts are not likely to succeed with them. For example, a significant number of them may need smoking cessation programs integrated as a part of a broader intervention package addressing their multiple risk factors, rather than population-based anti-tobacco messages.

Longitudinal Grouping Analysis

The present study is the first to combine longitudinal grouping analysis and growth curve modeling to examine cluster differences in trends involving correlated variables. The study thus constitutes a "proof of concept" of this approach to longitudinal data and suggests that longitudinal grouping analysis, combined with growth curve modeling, deserves to be added to the toolbox available to longitudinal researchers (Collins & Horn, 1991; Diggle et al., 1994; Gottman, 1995; Mednick, Harway, & Finello, 1984; Rovine & von Eye, 1991; von Eye, 1990).

Limitations of the Study

As with all research, the present study has limitations. Although loss of participants was modest, the study was not attrition free. Furthermore, the participants lost tended to be those with larger numbers of risk factors demonstrated to be associated with smoking. Data from participants were all self-report and were thus subject to a variety of reporting biases. Finally, many of the constructs were assessed by single items of unknown reliability and validity rather than by standard scales with demonstrated psychometric properties. Although the validity of any single finding is uncertain, the overall pattern of differences between clusters is unlikely to be seriously distorted by these limitations.

Conclusion

This study helps fill in a piece of the puzzle of adolescent cigarette smoking by demonstrating that students can be divided into discrete subgroups on the basis of their patterns of smoking during their middle and high school years. Examination of differences between these subgroups on a wide range of variables indicates that they exhibit consistent, meaningful, and important intercluster differences. These differences were used as a guide to suggest different types of prevention, early intervention, and treatment efforts targeted at the distinct groups. If these targeting efforts are to succeed, the ability to distinguish these subgroups at an early stage would be necessary. The data presented here suggest that continuous smokers may be identifiable by Grade 6 and early escalators by Grade 9. It is possible that the inclusion of other variables would have allowed for better early differentiation of these subgroups. The value of these suggestions needs to be addressed in future research efforts.

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