



Original Contribution

Determinants of First Puff and Daily Cigarette Smoking in Adolescents

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Few prospective studies of smoking initiation have investigated a wide range of time-varying and invariant predictor variables at the individual and contextual levels concurrently. In this study (1999–2005), 877 Canadian students (mean age = 12.7 years) who had never smoked at baseline completed self-report questionnaires on cigarette smoking and 32 predictor variables in 20 survey cycles during secondary school. Height and weight were measured in survey cycles 1, 12, and 19. School administrators completed questionnaires on school tobacco control policies/activities, and trained observers collected data on access to tobacco products in commercial establishments near schools. Younger age, single-parent family status, smoking by parents, siblings, friends, and school staff, stress, impulsivity, lower self-esteem, feeling a need to smoke, not doing well at school, susceptibility to tobacco advertising, alcohol use, use of other tobacco products, and attending a smoking-tolerant school were independent determinants of smoking initiation. Independent determinants of daily smoking onset among initiators of nondaily smoking included smoking by siblings and friends, feeling a need to smoke, susceptibility to tobacco advertising, use of other tobacco products, and self-perceived mental and physical addiction. Adolescent tobacco control programs should address multiple individual and contextual-level risk factors. Strategies that address nicotine dependence symptoms are also needed for adolescents who have already initiated smoking.

adolescent; epidemiologic factors; incidence; longitudinal studies; risk factors; smoking

Over the last 30 years, smoking prevention research has largely focused on testing interventions that teach adolescents skills to resist peer pressure to smoke (1), an approach that may be too limited to result in strong and sustained impact. By investigating relatively restricted sets of time-bound determinants, epidemiologists conducting risk factor research have contributed to the development of narrowly focused prevention interventions, and there are now concerns that smoking-related intervention research may have reached a plateau (2). It has become increasingly clear that the determinants of youth smoking range from individual-level factors to broad societal influences. In addition, researchers have begun to adopt the perspective that the determinants of smoking may change according to stage of onset, from the development of attitudes about smoking and the intention to smoke (3) to “full-blown” nicotine or tobacco dependence (4). Further, the set of determinants underlying cigarette use in early adolescence may differ from the set that is important in mid- or late adolescence or early adulthood. Finally, tobacco as a public health and

research issue is a moving target across countries in terms of legislation, bans, policies, social norms, and other factors that contribute to constant evolution of the problem and in turn, its solutions. Therefore, the determinants of smoking will not necessarily be the same in different countries over time.

Adding to the complexity of understanding youth smoking and designing relevant interventions based on risk factor research is the fact that many previous studies have used cross-sectional designs, which often cannot distinguish the temporality of exposure and outcome. Over the past decade, however, an increasing number of well-designed longitudinal studies have investigated a remarkable range of risk factors for cigarette smoking in adolescents. In addition to frequently studied risk factors, including sociodemographic characteristics (sex, age, race, single-parent family status, household income, parental education, socioeconomic status), social influences (parental, sibling, and peer smoking), use of alcohol and illicit drugs, and psychosocial determinants (knowledge, attitudes, beliefs, intention to smoke,

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academic performance, sensation-seeking, rebelliousness, self-esteem, impulsivity, novelty-seeking, perceived stress, negative life events, perceived benefits of smoking), investigators have studied a wide range of “new” factors. At the individual level, these include, among others, genetically impaired nicotine metabolism (5, 6), genetic variation of dopamine receptor genes (7), depression (7–13), curiosity (14), weight concerns (8, 15–17), parental R-rated movie restriction (18), depiction of smoking in movies (19, 20), use of smokeless tobacco (21), asthma (22), unplanned smoking initiation (23), and symptoms of nicotine dependence (24, 25). At the contextual level, tobacco control policy and legislation initiatives (26, 27), tobacco advertising and marketing (9, 28–33), and cigarette pricing (15, 27) are increasingly being recognized as important in youth smoking. Incorporating a life-course perspective (34), these newer studies sometimes differentiate determinants of initial cigarette use from determinants of persistent, sustained, or heavy smoking (24, 26, 33, 35–38) and nicotine or tobacco dependence (4, 39).

However, researchers in many longitudinal studies have investigated relatively small subsets of determinants. Few have incorporated a wide array of both individual- and contextual-level factors concurrently, while taking variability in factors that change over time into account. Our objective in this study was to identify time-varying and time-invariant determinants of cigarette-smoking initiation from a broad range of sociodemographic, psychosocial, health-related, lifestyle-related, and contextual factors. While many adolescents initiate cigarette smoking, only a subset escalates and/or sustains smoking (35, 40) and is therefore at higher risk of developing nicotine dependence. On the premise that the set of determinants associated with smoking onset may differ from the set of determinants associated with escalating or sustained smoking, we also investigated the determinants of daily smoking onset among adolescents who had initiated nondaily smoking.

MATERIALS AND METHODS

The Nicotine Dependence in Teens Study is a prospective investigation of 1,293 students, initially aged 12–13 years, recruited from grade 7 classes in a convenience sample of 10 secondary schools in Montreal, Quebec, Canada. The study objectives were to measure the onset of nicotine dependence symptoms in relation to cigarette smoking and to investigate the importance of a wide range of sociodemographic, psychosocial, health- and lifestyle-related, and contextual factors in the initiation of smoking and nicotine dependence. Over half (55.4%) of eligible students participated; the low response related, in part, to a labor dispute that resulted in some teachers' refusing to collect consent forms. Parents/guardians provided signed consent. The study received ethics approval from the Montreal Department of Public Health Ethics Review Committee and the McGill University Faculty of Medicine Institutional Review Board.

Baseline data collected in fall 1999 comprised anthropometric measurements (i.e., height, weight) taken by trained technicians (41) and self-report questionnaires. Follow-up questionnaire data were collected every 3 months during the

10-month school year for the next 5 years until participants completed secondary school, for a total of 20 survey cycles. Follow-up anthropometric data were collected in survey cycles 12 and 19.

In spring 2003, we collected school-specific data on tobacco control policies and within-school activities promoting nonsmoking by means of self-report questionnaires completed by school administrators. In addition, during spring 2003, students and teachers were asked to identify commercial establishments (i.e., convenience stores, gas stations, pharmacies, restaurants, fast food chains, grocery stores, dollar stores) within a 1-mile (1.6-km) radius of schools where students “hung out” before school, during recess and lunch, and after school. Each establishment was visited by 2 trained observers who collected data through direct observation on availability of and access to tobacco products, visibility of no-smoking signs, and cigarette promotions, using an assessment tool adapted from previous work (42, 43).

Study variables

Data on cigarette smoking were collected by means of 3 indicators. First, “lifetime smoking history” was measured using 1 questionnaire item: “Have you ever IN YOUR LIFE smoked a cigarette, even just a puff (drag, hit, haul)?” (44). Response choices included no; yes, 1 or 2 times; yes, 3 or 4 times; yes, 5–10 times; and yes, more than 10 times. Second, “current smoking status” was measured using 1 item (44): “Check the 1 box that describes you best: I have never smoked a cigarette, even just a puff; I have smoked cigarettes, even just a puff, but not at all in the past 12 months; I smoked cigarettes once or a couple of times in the past 12 months; I smoke cigarettes once or a couple of times each month; I smoke cigarettes once or a couple of times each week; I smoke cigarettes every day.” Third, for collection of data on “recent cigarette use,” participants completed a past-3-month recall (45) in each survey cycle that collected data on cigarette smoking in each of the 3 months preceding each questionnaire. The recall included 1 item for each month, which measured the number of days on which the participant had smoked during that month, and 1 item for each month that measured the number of cigarettes smoked per day on average during that month. Three-month test-retest reliability for these 2 items was very good ($\kappa = 0.78$ and $\kappa = 0.75$, respectively) (46). The total number of cigarettes smoked for each of the previous 3 months was calculated by multiplying the number of days on which the respondent had smoked during the month by the average number of cigarettes smoked per day on the days on which he/she had smoked. Three-month test-retest reliability was lower for total number of cigarettes smoked per month (intraclass correlation coefficient = 0.64) (46).

We collected data on a wide variety of predictor variables selected on the basis of the strength of the evidence in a review of recent longitudinal studies on adolescent smoking, on the feasibility of obtaining valid and reliable data, and on the potential utility of the variable in terms of designing preventive interventions. Predictor variables included socio-demographic characteristics (age, sex, language spoken at

home, single-parent family status, parental education); indicators of smoking in the social environment (smoking by parents, siblings, friends, and teachers/school staff); psychological exposures (stress symptoms (47), worry about one's weight, worry about one's relationship with one's parents, depression symptoms (48–51), impulsivity (52, 53), novelty-seeking (53), self-esteem (54)); psychosocial exposures (susceptibility to smoking, academic performance, susceptibility to tobacco advertising); overweight status (41); lifestyle-related factors (alcohol use, use of other tobacco products, level of physical activity (55), participation in team sports, television-viewing); asthma; self-reports of physical and mental addiction (37); and school and community tolerance of smoking.

Data on each variable were collected once, 2–3 times, or 20 times during the 5 years of data collection, depending on whether we expected the variable to be time-invariant, more or less time-invariant, or time-varying during secondary school. The Web Appendix, which is posted on the *Journal's* Web site (<http://aje.oxfordjournals.org/>), describes predictor variables in detail, including the survey cycle(s) in which data were collected, the specific measurement items, response choices, and how response choices were recoded for analysis.

Data analysis

The analytic database for analysis of the initiation of smoking was created in 6 steps. First, the same value of each predictor variable measured only once (i.e., self-esteem, susceptibility to tobacco advertising, asthma, school tolerance of smoking, community tolerance of smoking) was assigned to all 20 survey cycles for each participant. Second, for predictor variables measured 2–3 times during follow-up (parental education, smoking by teachers/school staff, impulsivity, novelty-seeking, academic performance, overweight), we used a “first observation carried backward” in combination with a “last observation carried forward” strategy to impute values for the other 17–18 survey cycles. Specifically, the “first observation carried backward” strategy involved carrying the first available value of the variable for each participant backwards to all previous survey cycles. Similarly, in the “last observation carried forward” strategy, the value of the variable was carried forward until new data on the same variable were available. This new value was then carried forward to subsequent survey cycles. Third, predictor variables thought to be time-varying (i.e., smoking by parents, siblings, and friends, stress symptoms, depression symptoms, susceptibility to smoking (feeling like one really needed a cigarette), worry about one's weight, worry about one's relationship with one's parents, alcohol use, use of other tobacco products, level of physical activity, participation in team sports, hours of television-watching per week, and nicotine dependence symptoms (mental addiction, physical addiction)) were measured in all 20 survey cycles. Missing values for time-varying factors for any given participant were imputed using the “first observation carried backward” and “last observation carried forward” strategies as described above. Fourth, a “missing” value

was assigned to categorical variables for participants for whom no data were available over the entire study for that variable. Fifth, to assure that values of the predictor variables preceded the outcome, data on the outcomes were drawn from the survey cycle immediately subsequent to those from which predictor variable data were drawn. Finally, data for all participants for all survey cycles up to and including the survey cycle in which either the study outcome was attained or follow-up ended were pooled across participants and survey cycles. Thus, each participant contributed 1 observation for each 3-month period reached without experiencing the event or being lost to follow-up. In general, a participant who experiences an event or is lost to follow-up at the k th follow-up will contribute, at most, k observations to the database. The pooled logistic regression analyses fitted to the data this way emulate the Cox proportional hazards regression approach (56–58).

A second database, which included data for participants who initiated smoking during follow-up, was used for analysis of the onset of daily smoking. Observation began at the survey cycle in which the participant initiated cigarette smoking and terminated either at the end of follow-up or at the survey cycle in which the participant initiated daily smoking. Of the 421 participants who initiated smoking during follow-up, 10 who initiated smoking and daily smoking in the same survey cycle were removed from the analysis.

Initiation of cigarette smoking was defined to have occurred during the survey cycle in which participants reported smoking 1 or more cigarettes for the first time in the 3-month recall of cigarette use. We conducted univariable logistic regression analyses to examine the association between each of 29 predictor variables and smoking initiation.

We then conducted separate multivariable regression analyses to test each predictor variable separately in a model with its own distinct set of covariates. Potential confounders of the association under investigation in each model were identified in a correlation matrix of all predictor variables, as those variables that were correlated with the predictor variable of interest at $r \geq 0.20$. At a minimum, results from all multivariable models were adjusted for sex and age, regardless of their correlation with the predictor variable of interest. Multivariable logistic regression analyses were conducted within a generalized estimating equations framework, with an autoregressive working correlation structure for the residuals, to correct for individual-level clustering due to repeated measurements on the same participant.

Initiation of daily smoking was defined to have occurred during the survey in which participants reported smoking every day in at least 1 of the preceding 3 months. The analytic approach for this outcome was the same as that used for smoking initiation. Because numerous reports indicate that nicotine dependence symptoms can emerge well before daily smoking (24, 25, 59), we included self-reports of mental and physical dependence as predictor variables, in addition to all other predictor variables included in the earlier analysis. At a minimum, each multivariable analysis included sex, current age, and time since smoking initiation as predictor variables.

All statistical analyses were conducted using the R System for Windows, version 2.8.0 (60). Statistical significance testing was conducted at the level of $\alpha = 0.05$. All tests were 2-sided.

RESULTS

Of 1,293 students at baseline, 416 (32%) reported smoking at or prior to baseline and were therefore excluded from the analysis. Table 1 describes the predictor variables in the 877 participants who had never smoked (not even a puff) at baseline and compares these variables in the 421 participants (48% of 877) who initiated cigarette smoking during follow-up with those in the 456 (52% of 877) participants who did not initiate smoking. Eighty-seven participants (10% of 877; 21% of 421) initiated daily cigarette smoking during follow-up.

With several exceptions (i.e., language, parental education, overweight, asthma, physical activity, television-viewing, community tolerance of smoking), all predictor variables were statistically significantly associated with smoking initiation in univariable analyses (Table 2). Among sociodemographic variables, only single-parent family status, younger age, and poor academic performance were associated with a higher rate of smoking initiation in the multivariable models. All 4 indicators of smoking in the social environment (i.e., smoking by parents, siblings, friends, and teachers/staff) were statistically significant determinants of smoking initiation. Psychosocial predictor variables associated with a higher rate of smoking initiation included stress, impulsivity, feeling a need to smoke, and both items related to tobacco advertising susceptibility. Among lifestyle-related indicators, alcohol use and use of other tobacco products were both statistically significantly associated with smoking initiation. Finally, of the 2 measures of context, only school tolerance of smoking was statistically significantly associated with smoking initiation. Predictor variables not statistically significantly related to smoking initiation included sex, language spoken at home, parental education, depression, novelty-seeking, worry about one's weight, worry about one's relationship with one's parents, overweight status, participation in team sports, asthma, physical activity, television-viewing, and community tolerance of smoking.

Nine of 32 predictor variables were statistically significantly related to initiation of daily smoking in univariable analyses (Table 3). Multivariately, none of the sociodemographic or psychological predictor variables were statistically significant. Two of 4 indicators of smoking in the social environment (i.e., smoking by friends and siblings) were statistically significant determinants. Among psychosocial predictor variables, feeling a need to smoke and both indicators of susceptibility to tobacco advertising were significant multivariately. High depression symptom scores were associated with a lower rate of daily smoking initiation. Among lifestyle-related variables, only use of other tobacco products predicted daily smoking. Finally, self-perceived mental and physical addiction were both strong independent determinants of the onset of daily smoking.

To assess whether secular changes in levels of risk factors or rates of smoking posed a threat to the validity of the analyses, we carried out sensitivity analyses wherein we reran all of the analyses adjusting for calendar year. This adjustment did not affect the findings or conclusions.

DISCUSSION

There are approximately 200 longitudinal studies that have collectively identified a wide range of predictors of youth smoking. However, many researchers have investigated only a limited number of predictors and, in addition, have not distinguished between initiation of smoking and sustained smoking. There is, in fact, little longitudinal evidence for most predictor variables. With the possible exceptions of parental smoking, smoking by friends, and susceptibility to smoking, the evidence that does exist for single risk factors is usually inconsistent across studies. This is probably related to differing definitions and methods of measuring exposure and outcome, differing study designs, and differing analytic approaches across studies.

In the current analysis, we quantified the effects of individual- and contextual-level predictors on initiation of any adolescent smoking, as well as of daily smoking. We refined previous work by examining a wide range of time-varying and invariant predictor variables. In addition, the 3-month time interval between data collection periods was substantially shorter than in many reports published to date, allowing for increased precision in the measurement of time of outcome onset, as well as the collection of updated data on time-varying predictor variables. Finally, we studied both smoking initiation and the onset of daily smoking as separate, distinct outcomes. Daily smoking was used as the indicator of sustained smoking because our previous work identified this as a key milestone in the smoking onset process (61, 62), because its definition is less open to interpretation than the definitions of other possible outcomes such as "regular" or "nicotine-dependent" smoking (3), and because it is a common surveillance indicator.

Our findings support the notion that there are multiple diverse determinants of initiation of adolescent smoking and conversion to daily smoking at both the individual and contextual levels, so that studies of adolescent smoking truly warrant perspectives captured in broad socioecologic models of health determinants. The Ecological Systems Theory (63), for example, posits that complex contextual layers of the environment, such as family, peers, school, neighborhood, and society, interact with individual-level determinants to shape the development of lifestyle behaviors. Several specific findings from the current analysis are noteworthy.

First, the range of risk factors for initiation was wider than that for daily smoking. Fifteen of 29 predictor variables were identified in the analysis of initiation, while only 9 of 32 predicted daily smoking. While reduced power may be an issue in the second analysis, the predictors of daily smoking were a subset of those for initiation (with the exception of depression symptoms, which protected against daily smoking). It is notable that some parameter estimates (i.e., for smoking by friends, cigarette advertisements' making

Table 1. Baseline Characteristics of Participants Who Initiated and Did Not Initiate Cigarette Smoking During Follow-up, Nicotine Dependence in Teens Study, 1999–2005^a

	Initiated Smoking (n = 421)		Did Not Initiate Smoking (n = 456)		Total (n = 877)	
	% or Mean (SD)	Median (IQR)	% or Mean (SD)	Median (IQR)	% or Mean (SD)	Median (IQR)
Sociodemographic indicators						
Male sex	43.7		56.4		50.3	
Age at baseline, years	12.7 (0.4)		12.7 (0.5)		12.7 (0.5)	
French spoken at home	29.0		25.6		22.0	
Single-parent family	9.5		7.0		7.2	
Parent(s) completed college	69.1		66.6		67.8	
Not doing well at school	15.1		6.4		10.8	
Indicators of smoking in the social environment						
Smoking by parent(s)	32.9		26.5		29.6	
Smoking by sibling(s)	11.6		8.8		10.1	
Smoking by a few or more friends	29.6		14.9		22.0	
Smoking by teachers/school staff (a bit/very true)	78.2		63.7		71.0	
Psychosocial indicators						
Stress symptoms		1.3 (0.9–1.7)		1.2 (0.8–1.6)		1.2 (0.8–1.6)
Depression symptoms		2.0 (1.3–2.7)		2.0 (1.2–2.8)		2.0 (1.2–2.8)
Impulsivity score		2.2 (0.9–3.5)		1.9 (0.8–3.0)		2.0 (0.9–3.1)
Novelty-seeking score		3.0 (1.9–4.1)		2.7 (1.6–3.8)		2.8 (1.7–3.9)
Self-esteem score		2.6 (1.8–3.4)		2.8 (2.4–3.2)		2.7 (2.1–3.3)
Worrying about one's weight	35.6		28.2		31.8	
Worrying about one's relationship with one's parents	34.5		25.6		29.9	
Feeling like one really needed a cigarette (rarely/sometimes/often)	7.1		2.2		4.6	
Cigarette package warnings not making one afraid to smoke	47.3		37.9		42.6	
Cigarette advertisements making one want to smoke (a bit/very true)	9.0		1.5		5.2	
Overweight	21.8		24.5		23.2	
Asthma	13.8		12.1		13.0	
Lifestyle-related indicators						
Alcohol use	44.6		23.3		33.5	
Use of other tobacco products	1.9		0.0		0.9	
Physical activities in past week		15.0 (1.2–28.2)		13.0 (0.0–28.0)		14.0 (0.0–28.0)
Participation in team sports	74.8		72.4		73.5	
Hours of television-watching per week		16.0 (1.4–30.6)		16.0 (0.0–32.0)		16.0 (1.0–31.0)
Indicators of nicotine dependence						
Mental addiction (a little/quite/very)	4.1		2.0		3.0	
Physical addiction (a little/quite/very)	1.7		1.5		1.6	
Indicators of context						
School tolerance of smoking		6.0 (0.0–12.0)		6.0 (0.0–12.0)		6.0 (0.0–12.0)
Community tolerance of smoking		37.0 (22.0–52.0)		37.0 (25.0–49.0)		37.0 (25.0–49.0)

Abbreviations: IQR, interquartile range; SD, standard deviation.

^a All percentages and means were computed after excluding missing data.

Table 2. Results From Logistic Regression Models of the Association Between Predictor Variables and Initiation of Cigarette Smoking in Adolescents ($n = 877^a$), Nicotine Dependence in Teens Study, 1999–2005

Predictor Variable	Crude OR	95% CI	Adjusted OR	95% CI	Covariates Included in Model
Sociodemographic indicators					
Sex					Age, stress symptoms, depression symptoms, worry about weight, worry about relationship with parents
Male ^b	1.0		1.0		
Female	1.48	1.20, 1.82	1.19	0.96, 1.47	
Age, years ^c	0.73	0.68, 0.80	0.67	0.61, 0.73	Sex, smoking by friends
Language spoken at home					Sex, age, school tolerance of smoking
English ^b	1.0		1.0		
French	1.28	0.98, 1.68	0.69	0.40, 1.20	
Single-parent family					Sex, age
No ^b	1.0		1.0		
Yes	1.41	0.99, 2.01	1.48	1.05, 2.09	
Parent(s) completed college					Sex, age, smoking by parent(s), school tolerance of smoking, community tolerance of smoking
No ^b	1.0		1.0		
Yes	1.08	0.84, 1.39	1.22	0.94, 1.58	
Doing well at school					Sex, age, self-esteem score
A bit/very true ^b	1.0		1.0		
Not at all true	1.93	1.39, 2.67	1.51	1.09, 2.08	
Indicators of smoking in the social environment					
Smoking by parent(s)					Sex, age, completion of college by parent(s)
No ^b	1.0		1.0		
Yes	1.54	1.22, 1.95	1.49	1.18, 1.87	
Smoking by sibling(s)					Sex, age
No ^b	1.0		1.0		
Yes	1.82	1.37, 2.42	1.91	1.45, 2.51	
Smoking by friends					Sex, age
None ^b	1.0		1.0		
A few or more	2.44	1.97, 3.04	3.29	2.62, 4.13	
Smoking by teachers/school staff					Sex, age, school tolerance of smoking
Not at all true ^b	1.0		1.0		
A bit/very true	1.78	1.37, 2.31	1.64	1.26, 2.14	
Psychosocial indicators					
Stress symptoms ^c	2.13	1.71, 2.66	1.53	1.04, 2.23	Sex, age, depression symptoms, self-esteem score, worry about weight, worry about relationship with parents
Depression symptoms ^c	1.45	1.28, 1.66	1.08	0.89, 1.32	Sex, age, stress symptoms, self-esteem score, worry about weight, worry about relationship with parents
Impulsivity score ^c	1.41	1.25, 1.59	1.21	1.02, 1.44	Sex, age, novelty-seeking score
Novelty-seeking score ^c	1.46	1.27, 1.69	1.22	0.99, 1.50	Sex, age, impulsivity score
Self-esteem score ^c	0.42	0.32, 0.56	0.61	0.46, 0.81	Sex, age, doing well at school, stress symptoms, depression symptoms
Feeling like one really needed a cigarette					Sex, age
Never ^b	1.0		1.0		
Rarely/sometimes/often	6.71	4.73, 9.53	6.04	4.28, 8.52	

Table continues

Table 2. Continued

Predictor Variable	Crude OR	95% CI	Adjusted OR	95% CI	Covariates Included in Model
Worry about weight					Sex, age, stress symptoms, depression symptoms, worry about relationship with parents, overweight
No ^b	1.0		1.0		
Yes	1.60	1.30, 1.98	1.25	0.99, 1.58	
Worry about relationship with parents					Sex, age, stress symptoms, depression symptoms, worry about weight
No ^b	1.0		1.0		
Yes	1.75	1.41, 2.17	1.22	0.96, 1.56	
Cigarette package warnings making one afraid to smoke					Sex, age
A bit/very true ^b	1.0		1.0		
Not at all true	1.43	1.14, 1.79	1.47	1.18, 1.83	
Cigarette advertisements making one want to smoke					Sex, age
Not at all true ^b	1.0		1.0		
A bit/very true	4.08	2.37, 7.02	3.80	2.32, 6.21	
Overweight					Sex, age, worry about weight
No ^b	1.0		1.0		
Yes	0.89	0.68, 1.17	0.78	0.59, 1.02	
Asthma					Sex, age
No ^b	1.0		1.0		
Yes	1.05	0.76, 1.44	1.00	0.74, 1.36	
Lifestyle-related indicators					
Alcohol use					Sex, age
No ^b	1.0		1.0		
Yes	2.55	2.07, 3.15	2.81	2.28, 3.47	
Use of other tobacco products					Sex, age
No ^b	1.0		1.0		
Yes	3.73	2.12, 6.58	4.90	2.73, 8.80	
Physical activities in past week ^c	1.01	1.00, 1.02	1.01	1.00, 1.02	Sex, age, school tolerance of smoking
Participation in team sports					
No ^b	1.0		1.0		Sex, age
Yes	1.27	1.01, 1.59	1.19	0.95, 1.49	
Hours of television-watching per week ^c	1.00	0.99, 1.01	1.00	0.99, 1.01	Sex, age
Indicators of context					
School tolerance of smoking ^c					Sex, age, language spoken at home, completion of college by parent(s), smoking by teachers/school staff, physical activities in past week
Low/moderate ^b	1.0		1.0		
High	1.41	1.12, 1.78	1.79	1.09, 2.95	
Community tolerance of smoking ^c					Sex, age, completion of college by parent(s)
Low/moderate ^b	1.0		1.0		
High	0.95	0.75, 1.20	0.98	0.78, 1.25	

Abbreviations: CI, confidence interval; OR, odds ratio.

^a There were 10,035 person-surveys contributed by 877 participants. After exclusion of observations with missing data, there were at least 8,362 person-surveys contributed by 691 participants.

^b Reference category.

^c OR indicates the increase in risk of smoking initiation per 1-unit change in the predictor variable.

Table 3. Results From Logistic Regression Models of the Association Between Predictor Variables and Initiation of Daily Cigarette Smoking Among Adolescents Who Had Initiated Nondaily Cigarette Smoking ($n = 411^a$), Nicotine Dependence in Teens Study, 1999–2005

Predictor Variable	Crude OR	95% CI	Adjusted OR	95% CI	Covariates Included in Model
Sociodemographic indicators					
Sex					Current age, stress symptoms, depression symptoms, self-esteem score, feeling like one really needed a cigarette, worry about weight, worry about relationship with parents, years since smoking initiation
Male ^b	1.0		1.0		
Female	1.24	0.77, 1.99	1.14	0.62, 2.11	
Current age, years ^c	0.77	0.60, 0.99	0.77	0.58, 1.01	Sex, years since smoking initiation
Language spoken at home					Sex, current age, years since smoking initiation, school tolerance of smoking
English ^b	1.0		1.0		
French	1.16	0.68, 1.99	0.97	0.32, 2.93	
Single-parent family					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	1.49	0.83, 2.70	1.51	0.83, 2.74	
Completion of college by parent(s)					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	1.14	0.66, 1.97	1.16	0.66, 2.02	
Doing well at school					Sex, current age, self-esteem score, years since smoking initiation
A bit/very true ^b	1.0		1.0		
Not at all true	1.72	0.95, 3.11	1.50	0.77, 2.94	
Indicators of smoking in the social environment					
Smoking by parent(s)					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	1.37	0.84, 2.25	1.32	0.80, 2.16	
Smoking by sibling(s)					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	2.31	1.44, 3.72	2.32	1.42, 3.77	
Smoking by friends					Sex, current age, years since smoking initiation
None ^b	1.0		1.0		
A few or more	7.18	1.77, 29.15	7.38	1.81, 30.11	
Smoking by teachers/school staff					Sex, current age, years since smoking initiation, school tolerance of smoking
Not at all true ^b	1.0		1.0		
A bit/very true	1.20	0.66, 2.20	1.18	0.63, 2.19	
Psychosocial indicators					
Stress symptoms ^c	1.37	0.91, 2.04	0.98	0.44, 2.22	Sex, current age, depression symptoms, self-esteem score, feeling like one really needed a cigarette, worry about weight, worry about relationship with parents, mental addiction, physical addiction, years since smoking initiation
Depression symptoms ^c	1.13	0.85, 1.51	0.60	0.38, 0.94	Sex, current age, stress symptoms, self-esteem score, feeling like one really needed a cigarette, worry about weight, worry about relationship with parents, years since smoking initiation
Impulsivity score ^c	1.01	0.77, 1.33	0.85	0.58, 1.25	Sex, current age, novelty-seeking score, years since smoking initiation
Novelty-seeking score ^c	1.17	0.85, 1.60	1.31	0.84, 2.03	Sex, current age, impulsivity score, years since smoking initiation
Self-esteem score ^c	0.74	0.44, 1.23	0.97	0.55, 1.70	Sex, current age, doing well at school, stress symptoms, depression symptoms, worry about weight, years since smoking initiation

Table continues

Table 3. Continued

Predictor Variable	Crude OR	95% CI	Adjusted OR	95% CI	Covariates Included in Model
Feeling like one really needed a cigarette					Sex, current age, stress symptoms, depression symptoms, mental addiction, physical addiction, years since smoking initiation
Never ^b	1.0		1.0		
Rarely/sometimes/often	8.50	4.86, 14.86	2.81	1.29, 6.13	
Worry about weight					Sex, current age, stress symptoms, depression symptoms, self-esteem score, worry about relationship with parents, years since smoking initiation
No ^b	1.0		1.0		
Yes	1.42	0.90, 2.26	1.36	0.76, 2.42	
Worry about relationship with parents					Sex, current age, stress symptoms, depression symptoms, worry about weight, years since smoking initiation
No ^b	1.0		1.0		
Yes	0.98	0.61, 1.56	0.69	0.39, 1.24	
Cigarette package warnings making one afraid to smoke					Sex, current age, years since smoking initiation
A bit/very true ^b	1.0		1.0		
Not at all true	2.69	1.57, 4.59	2.72	1.58, 4.66	
Cigarette advertisements making one want to smoke					Sex, current age, years since smoking initiation
Not at all true ^b	1.0		1.0		
A bit/very true	7.29	4.03, 13.17	8.16	4.43, 15.03	
Overweight					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	1.28	0.75, 2.19	1.22	0.71, 2.11	
Asthma					Sex, current age, years since smoking initiation
No ^b	1.0		1.0		
Yes	0.91	0.44, 1.87	0.94	0.46, 1.93	
Lifestyle-related indicators					
Alcohol use					Sex, current age, use of other tobacco products, years since smoking initiation
No ^b	1.0		1.0		
Yes	2.42	1.27, 4.59	1.80	0.91, 3.55	
Use of other tobacco products					Sex, current age, alcohol use, years since smoking initiation
No ^b	1.0		1.0		
Yes	3.87	2.45, 6.11	3.78	2.29, 6.23	
Physical activities in past week ^c	1.01	0.99, 1.02	1.01	0.99, 1.03	Sex, current age, team sports, years since smoking initiation, school tolerance of smoking
Team sports					Sex, current age, physical activities in past week, years since smoking initiation
No ^b	1.0		1.0		
Yes	0.93	0.58, 1.51	0.83	0.51, 1.35	
Hours of television-watching per week ^c	1.00	0.99, 1.02	1.00	0.98, 1.02	Sex, current age, years since smoking initiation
Indicators of nicotine dependence					
Mental addiction					Sex, current age, stress symptoms, feeling like one really needed a cigarette, physical addiction, years since smoking initiation
Not at all ^b	1.0		1.0		
A little/quite/very	9.69	5.84, 16.07	2.53	1.19, 5.39	
Physical addiction					Sex, current age, stress symptoms, feeling like one really needed a cigarette, mental addiction, years since smoking initiation
Not at all ^b	1.0		1.0		
A little/quite/very	13.30	8.24, 21.65	4.49	2.49, 8.12	
Years since smoking initiation					Sex, current age
0–1 ^b	1.0		1.0		
2–3	0.96	0.60, 1.55	0.89	0.55, 1.43	
4–5	0.71	0.30, 1.71	0.58	0.24, 1.44	

Table continues

Table 3. Continued

Predictor Variable	Crude OR	95% CI	Adjusted OR	95% CI	Covariates Included in Model
Indicators of context					
School tolerance of smoking ^c					Sex, current age, language spoken at home, smoking by teachers/school staff, participation in team sports, years since smoking initiation
Low/moderate ^b	1.0		1.0		
High	1.17	0.71, 1.91	1.22	0.43, 3.44	
Community tolerance of smoking ^c					Sex, current age, years since smoking initiation
Low/moderate ^b	1.0		1.0		
High	0.96	0.57, 1.60	0.98	0.57, 1.67	

Abbreviations: CI, confidence interval; OR, odds ratio.

^a There were 3,843 person-surveys contributed by 411 participants. After exclusion of observations with missing data, there were at least 3,148 person-surveys contributed by 336 participants.

^b Reference category.

^c OR indicates the increase in risk of smoking initiation per 1-unit change in the predictor variable.

one want to smoke, use of other tobacco products, and self-perceived physical addiction) indicated markedly strong effects on daily smoking.

Second, older age was associated with a lower risk of smoking initiation. The most likely explanation for this observation is the phenomenon of “depletion of susceptibles” (4). Specifically, in a fixed cohort of adolescent never smokers followed over time, those who initiate smoking are removed from the pool of adolescents at risk (because each individual can initiate smoking only once, at which time follow-up is terminated). Accordingly, a 15-year-old who has not initiated smoking is less likely to be susceptible than a 12-year-old.

Third, the visibility of smoking among adult role models and peers was an important predictor of initiation across social environments at home and at school. While smoking among adult role models did not predict conversion to daily smoking, peer smoking continued to be influential. Recent legislation will enable control of the visibility of smoking at school in many jurisdictions, but smoking at home remains a difficult issue. Programs that reinforce parental and sibling awareness that their own smoking behavior may have an important influence on the smoking behavior of young adolescents are needed. In addition, research is needed to investigate whether parental smoking potentiates youth smoking through role modeling or through biologic processes primed by exposure to secondhand smoke.

Fourth, “feeling like you really need a cigarette,” probably an indicator of susceptibility to smoking, increased the risk of initiation 6-fold and the risk of daily smoking almost 3-fold. Because it has face validity, this indicator may be a helpful screening question for use in clinical practice to identify adolescents in whom there may be a critical need for preventive intervention.

Fifth, both indicators of susceptibility to tobacco advertising were strong determinants of both initiation and daily smoking. The few longitudinal studies on the effects of tobacco advertising to date concur that pro-tobacco messages may increase smoking initiation (26, 64). Our results support these findings and suggest that even though many jurisdictions already have relevant legislation, banning to-

bacco advertising should continue to be a high public policy priority.

Sixth, use of alcohol and use of other tobacco products were important determinants of smoking. Co-occurrence of cigarette, alcohol, and cannabis use in adolescence is well-recognized (65), and it has been hypothesized that common risk factors underpin co-occurrence. In contrast, our results suggest that alcohol use and use of other tobacco products such as cigars, cigarillos, chewing tobacco, and snuff lead to cigarette smoking. Alcohol use may promote participation in social situations in which access to and availability of cigarettes is increased.

Finally, self-perceived mental and physical addiction predicted sustained smoking. While in early conceptualizations of the smoking-onset process (3) investigators argued that nicotine dependence does not emerge until late in the onset process, these results suggest that nicotine dependence symptoms may in fact lead to increased smoking, if adolescents smoke to lessen nicotine dependence symptoms.

Limitations

The response proportion at baseline was relatively low, but nonresponse was unlikely to have biased the association between the outcomes and predictor variables investigated. With the exception of height, weight, school tolerance of smoking, and community tolerance of smoking, data were based on participant self-reports. Although this may have resulted in reporting bias, any misclassification was probably nondifferential and would therefore have been expected to bias parameter estimates toward the null. Imputation of missing data may have resulted in misclassification. In the analysis of daily smoking initiation, follow-up after initiation of cigarette use was relatively short.

Conclusion

A wide range of diverse risk factors predict initiation of smoking and daily smoking. Prevention programs that target single risk factors, such as those that teach youth skills to resist peer pressure to smoke (66), may well be too focused,

thereby contributing to ineffectiveness. Prevention programs targeted toward reducing smoking in the social environment at home and at school and banning tobacco advertising may well have a substantial positive impact on smoking initiation and sustained smoking. The mechanisms underpinning how use of substances such as alcohol lead to smoking in adolescence need clarification. Finally, youth tobacco control programs will need to include strategies to address nicotine dependence to prevent sustained cigarette use, as soon as adolescents begin to smoke.

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