

## Predictors of the Occurrence of Smoking Discontinuation in Novice Adolescent Smokers

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### Abstract

**Background:** While long-term cessation is an outcome of interest in adult smokers, little is known about discontinuing smoking in adolescent smokers. The objective was to identify the predictors of the occurrence of smoking discontinuation in novice smokers.

**Methods:** Data were available for 620 adolescent smokers participating in a longitudinal study on the natural course of nicotine dependence. Data on smoking discontinuation (i.e., stopping smoking for  $\geq 12$  consecutive months) were collected in 20 cycles over five years from grade 7 to 11 (1999–2005). Data on 37 potential predictors representing a wide range of demographic, psychosocial, health, lifestyle, smoking-related, and context-related characteristics were collected once, 2 to 3 times, or 20 times. Pooled logistic regression was used to test the association between each potential predictor and smoking discontinuation, adjusting for potential confounders.

**Results:** Forty percent of 620 participants discontinued smoking during follow up. Male sex [OR (95% confidence interval), 1.8 (1.3–2.4)], age [1.3 (1.1–1.5)], cigarette package warnings [0.6 (0.5–0.9)], team sports participation [1.4 (1.1–1.9)], family stress [0.7 (0.6–1.0)], worrying about weight [0.6 (0.5–0.9)], overweight [0.7 (0.5–1.0)], illicit drugs use [0.5 (0.4–0.7)], tolerance [0.6 (0.4–1.0)], and other nicotine dependence symptoms [1.0 (0.9–1.0)] were statistically significantly associated with smoking discontinuation.

**Conclusions:** Both individual and context-level factors were associated with smoking discontinuation.

**Impact:** Programs and policy targeting novice adolescent smokers may be more effective if factors associated with long-term smoking discontinuation are taken into consideration. In particular, young smokers may need help with dependence symptoms, body weight issues, family functioning, and polysubstance use. Cigarette package warnings may be effective in helping adolescents discontinue smoking. *Cancer Epidemiol Biomarkers Prev*; 23(6); 1090–101. ©2014 AACR.

### Introduction

Cigarette smoking in youth remains a critical public health concern because the prevalence remains high (1–4) and because many of those who initiate experience symptoms of nicotine dependence within months of initiation (5–9), leading to years of exposure to the carcinogens and other noxious substances in tobacco smoke. A cornerstone of tobacco control is cessation. However, while 50% to 70% of adolescent smokers try to quit each year (2, 10), most experience difficulty doing so (6), and 90% relapse within one year (2). The rate of relapse is higher among older

adolescents and among those who smoke daily (10). Furthermore, while there are effective cessation interventions for adults (11), few youth cessation interventions have been shown to be effective (12–14).

Implicit in the notion of "trying to quit" is that individuals recognize themselves as being a smoker, that they want to quit, and that they make a conscious effort to quit. While long-term or lifetime cessation is an established outcome of interest for both adolescent and adult smokers, the notion of stopping or discontinuing smoking (15) among novice adolescent smokers (i.e., smokers within a year or two of initiation) has received little attention in the research community. Discontinuing smoking refers to stopping smoking while not necessarily making a conscious effort to quit. It may be a more relevant notion than cessation or "trying to quit" in novice smokers, some of whom may not yet recognize themselves as being a smoker, which would obviate their wanting and making a conscious effort to quit. It may well be that factors associated with discontinuing smoking among novice smokers differ from those associated with making a conscious effort to quit among well-established smokers.

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The objective of this study was to identify predictors of the occurrence of long-term smoking discontinuation in novice adolescent smokers, from among a wide array of individual- and context-level factors selected on the basis of a review of longitudinal studies on adolescent smoking cessation (16). These included sociodemographic, psychologic, health and lifestyle indicators, as well as indicators related to smoking in the social and physical environment.

### Materials and Methods

Data were drawn from the Nicotine Dependence in Teens (NDIT) Study, a prospective cohort investigation of 1,293 students (56% of those eligible) aged 12 to 13 years at baseline, recruited in 1999–2000 from all grade 7 classes in a convenience sample of 10 secondary schools in Montreal, Canada (17). The relatively low baseline response related to unwillingness of some students (or parents) to provide a blood sample for genetic analysis and to a province-wide labor dispute that resulted in some teachers not collecting consent forms. Baseline data collection included self-report questionnaires and anthropometric measurements. Follow-up questionnaire data were collected every 3 months during the 10-month school year for the next 5 years (1999–2005) until participants completed secondary school, for a total of 20 cycles per student. Follow-up anthropometric data were collected in cycles 12 and 19.

School-specific data were collected in spring 2003 in self-report questionnaires completed by school administrators, on tobacco control policies and activities within schools to promote nonsmoking. Students and teachers were also asked to identify convenience stores and restaurants within a 1 mile radius of schools where students "hang out." Two trained observers visited each establishment to collect data through direct observation on tobacco products, no smoking signs, and cigarette promotions, using an assessment tool adapted from previous work (18, 19).

Parents/guardians provided written informed consent at baseline. NDIT received ethics approval from McGill University (Quebec, Canada) and the Centre de recherche du Centre hospitalier de l'Université de Montréal (Quebec, Canada).

For the current analysis, we retained 706 NDIT participants who either (i) reported at baseline that they had smoked cigarettes, or (ii) who entered the study as a never-smoker but initiated smoking during follow-up. Follow-up for this analysis began at baseline for participants who reported smoking at baseline. For participants who began smoking during follow-up, follow-up began at the time of initiation.

### Study variables

Smoking discontinuation (yes, no), was measured using a 3-month recall of cigarette use (20). The recall included one item for each month that measured the number of days on which the participant had smoked during the month, and one item that measured the number of

cigarettes smoked per day on average on the days that the participant smoked during that month. The mean number of cigarettes smoked per month in the 3-month interval preceding each survey cycle was computed by averaging the products of these two variables over the 3 months. Smoking discontinuation was considered to have occurred when a participant reported no cigarettes smoked in the 3-month recall in four consecutive cycles (i.e., over the past 12 months).

Potential predictors investigated included demographic indicators (sex, age, language spoken at home, single-parent family status, and parental education); psychosocial indicators [family stress, non-family-related stress (21, 22), depression symptoms (23), impulsivity (24, 25), novelty-seeking (25), self-esteem (26), worrying about weight, susceptibility to cigarette package warnings, and susceptibility to tobacco advertising]; health-related indicators [overweight (17, 27), history of asthma diagnosed by a health professional]; lifestyle indicators [use of alcohol, tobacco products other than cigarettes, and illicit drugs, number of bouts of participation in light, moderate, and vigorous physical activity (i.e., LPA, MPA, and VPA) in the past week (28), participation in team sports, and weekly amount of TV watching]; cigarette smoking indicators (time since initiation and mean number of cigarettes smoked per month in the past 3 months); nicotine dependence symptom indicators [i.e., tolerance, self-medication, withdrawal symptoms, and other nicotine dependence symptoms (29)]; and finally, indicators pertaining to the social environment [smoking by parent(s), sibling(s), friends, and teachers/school staff] and the school neighborhood [tolerance of smoking in school, local restaurants, and corner stores (30)].

Data on each potential predictor were available once, 2 to 3 times, or 20 times depending on whether the predictor was time-invariant during secondary school. Supplementary Table S1 describes potential predictors, including when data were collected, items comprising multi-item measures, response choices, and how responses were coded for analysis.

### Multiple imputation

The median [interquartile range (IQR)] of the percentage distribution of values missing for each variable in each cycle (excluding cycles when values were missing by design) was 6% (15%); minimum = 0%, maximum = 89%. We imputed missing values using a "partial" last observation carried forward (LOCF) approach followed by multiple imputation (MI) (Supplementary Table S2). LOCF was applied to variables that were time-invariant or approximately time-invariant (so that they were measured in selected cycles only). For example, novelty-seeking was measured in cycles 14 and 18 only. Hence, by design, the novelty-seeking variable had missing values for all participants in the other cycles. Values at cycles before the survey in which novelty-seeking was first measured were left missing. The LOCF strategy was "partial" because a value could only be carried forward

up to the survey in which it was (supposed to be) measured next, but not beyond. Allowing a single value to be carried forward beyond the next cycle might have resulted in underestimation of the variability of the variable.

Bootstrapped-based MI was subsequently performed to impute values that remained missing. The algorithm relied on both cross-sectional and longitudinal features of the data (i.e., the distribution of the variable at the same cycle, as well as the distribution of that variable at previous and subsequent cycles), thereby improving the MI performance for variables the values of which correlate over time (31). Because its distribution was skewed, "mean number of cigarettes smoked per month" was log-transformed before MI (and back-transformed after modeling its association with smoking discontinuation). This ensured that MI would not depend unduly on extreme data points in the original distribution. After MI, continuous variables were truncated so that their distribution ranged between the minimum and maximum values of the observed data (i.e., out-of-range values were replaced with the minimum or maximum value of the observed distributions). Ten imputation sets were generated using data for the 706 participants who reported smoking during follow-up. Fig. 1 depicts further modifications made to each MI set. The sample size of the final MI datasets included 615 to 620 participants and 248 to 257 discontinuation events.

### Data analysis

For each participant, data on repeated observations up to the survey in which smoking discontinuation was observed or the end of follow-up (whichever came first), were pooled. Logistic regression was used to model the association between each potential predictor and discontinuation (32). Simple and multivariable regression models were estimated on each MI set and then combined using Rubin rule (33). Multivariable models regressed discontinuation indicator at a given cycle (i.e., the first of  $\geq 4$  cycles in which the participants did not report smoking any cigarettes) on the value of the potential predictors (one at a time) measured in the preceding cycle, controlling for potential confounders measured in the cycle preceding the cycle in which data on the potential predictor were drawn. In other words, we lagged the potential predictors' values by one cycle and the covariate data by two cycles. Potential confounders adjusted for, for any given predictor, were selected on the basis of their correlation with the predictor. If the absolute value of the correlation exceeded 0.2, then the potential confounder was included in the model for that predictor. Age and sex were included in all multivariable models regardless of their correlations with the predictor. Clustering induced by incorporating multiple cycles per participant was accounted for using generalized estimating equations (GEE) with an exchangeable correlation matrix and robust (sandwich) estimators of standard errors.

Sensitivity analyses were performed to assess the impact of the partial LOCF carried out before MI on variables with values missing completely by design in some cycles. In the first sensitivity analysis, MI was conducted without any previous LOCF imputation. In the second sensitivity analysis, a more liberal LOCF imputation was used before MI (i.e., any measured value observed was carried forward and backward until a new measured value was available). Results of the sensitivity analyses were compared with the main results obtained using the modeling strategies described above.

The analyses were undertaken using R (v2.14.1), the Amelia II (v1.5–5) package for MI and the Zelig (v 3.5.4) package for GEE models (34–36).

### Results

Table 1 describes the potential predictors of smoking discontinuation in smokers retained for analysis. Approximately one-third of the sample was male, the mean age at baseline was 13.4 years, 19% spoke French at home, and 42% had one or both parents who were university educated. Forty-three percent had parents who smoked, 87% had friends who smoked, and 78% reported that they often saw their teachers or other school staff smoking. Table 1 also presents the distributions of these same characteristics in the pooled sample, which includes up to 15 observations per participant. These data necessarily reflect changes over time due either to termination of follow-up related to participants who discontinued smoking or were lost to follow-up, or the time-varying nature of these variables.

Reflecting that the sample comprised novice smokers, the median (IQR) number of cigarettes smoked per month was 0.6 (5.1) at baseline (Table 1). Only 43% to 45% of participants across MI datasets reported smoking 30 or more cigarettes per month on average in at least one cycle.

Of the 620 participants in this study, 40% discontinued smoking during follow-up. Most who discontinued were very light smokers, in the survey before discontinuation, 185 to 189 of those who discontinued smoked 0 to 2 cigarettes per month, 16 to 21 smoked 3 to 4, 18–25 smoked 5–30, and 18–23 smoked more than 30. The mean (SD) and median (IQR) for number of cigarettes smoked per month in the past 3 months ranged respectively from 14.2 to 21.6 (72.0–107.3) for the mean, and 0.4 (1.0–2.2), illustrating the skewness of the distribution. The mean (SD) and median (IQR) cumulative duration of smoking in the cycle before discontinuation ranged respectively from 3.3 to 3.4 (2.7–2.8) for the mean (approximately 10 months) and 2.0 to 3.0 (3.0–4.0; approximately 6–9 months) for the median.

Ten of the 37 potential predictors were statistically significantly associated with discontinuation (Table 2). Specifically, 2 of 5 sociodemographic variables were statistically significantly associated with discontinuation: male sex and age were both positively associated with smoking discontinuation. Three of nine psychosocial variables were associated with discontinuation: family stress

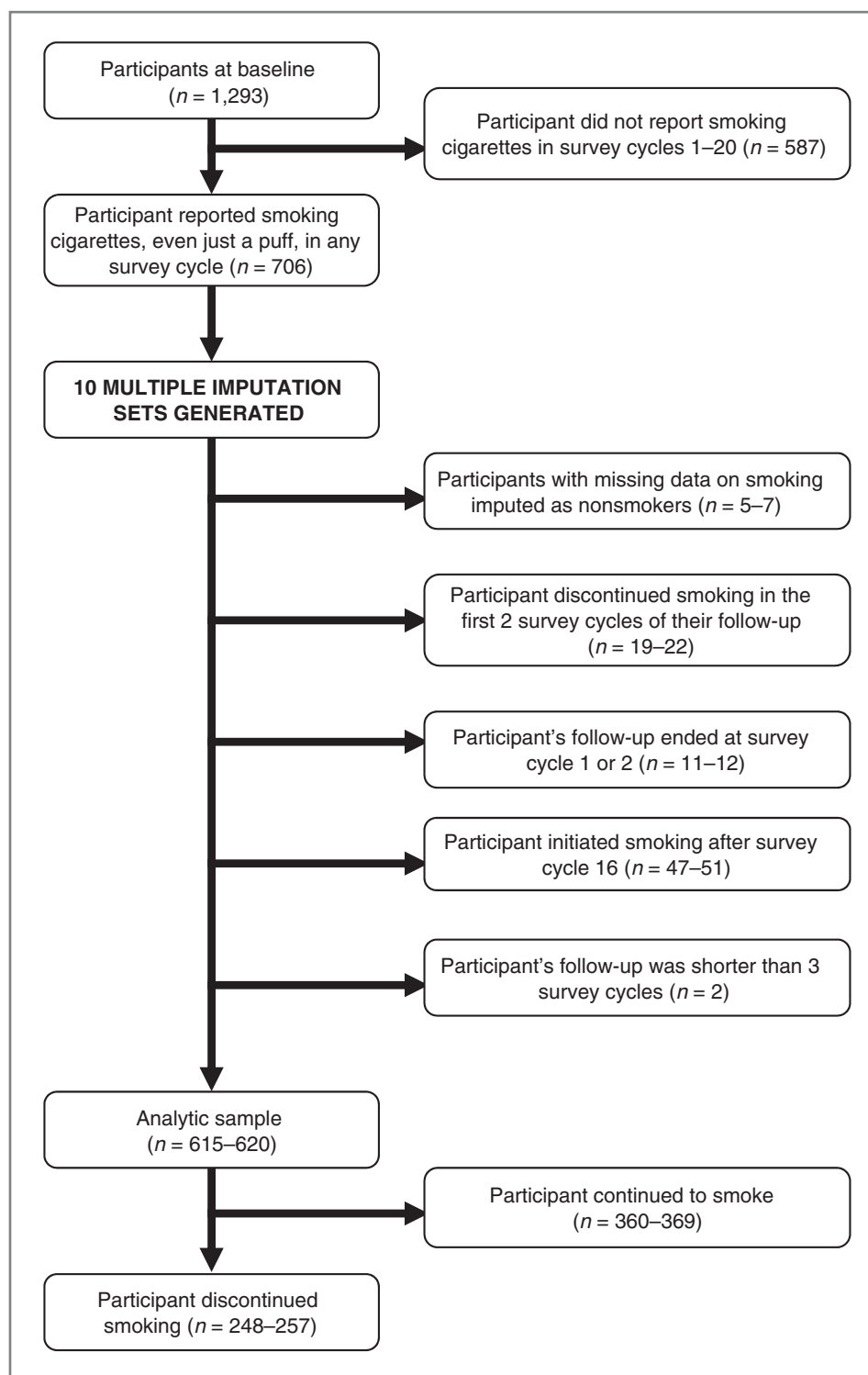


Figure 1. Derivation of the analytic sample including the range of sample sizes and number of outcome events across multiple imputation datasets, NDIT study, 1999–2005.

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and worrying about weight were negatively associated with discontinuation, whereas believing cigarette package warnings was positively associated with the outcome. Being overweight was negatively associated with discontinuation. Among eight lifestyle indicators, two were

statistically significantly associated with discontinuation; not using illicit drugs appeared protective and participation in team sports was positively associated with discontinuation. Two of six indicators of nicotine dependence (tolerance, other nicotine dependence symptoms)

**Table 1.** Characteristics of novice adolescent smokers, NDI study, 1999–2005

	Smokers at baseline, <i>n</i> (range) = 615–620	Pooled sample of smokers <sup>a</sup> , <i>n</i> (range) = 3862–3921
Sociodemographic		
Male (%) <sup>b</sup>	37.2	30.3
Age, y [median (IQR)]	13.4 (1.3)	14.4 (1.7)
French speaking (%) <sup>b</sup>	19.4	23.3
Single-parent family (%) <sup>b</sup>	14.2	16.2
Parent(s) university educated (%) <sup>b</sup>	42.4	46.7
Psychosocial indicators		
Family stress [median (IQR)]	1.2 (0.8)	1.3 (0.6)
Non-family-related stress [median (IQR)]	1.6 (0.7)	1.6 (0.8)
Depression symptoms [median (IQR)]	2.2 (1.1)	2.2 (1.1)
Impulsivity [median (IQR)]	2.6 (1.3)	2.6 (1.4)
Novelty-seeking [median (IQR)]	3.2 (1.1)	3.2 (1.1)
Self-esteem [median (IQR)]	2.5 (0.7)	2.4 (0.7)
Worrying about weight (%) <sup>b</sup>	47.8	49.3
Cigarette package warnings make me afraid to smoke (% no) <sup>b</sup>	43.9	40.6
Cigarette ads make me want to smoke (% yes) <sup>b</sup>	24.0	28.5
Overweight (%)	25.5	28.7
Asthma (%)	19.0	18.4
Lifestyle indicators		
Alcohol use (%) <sup>b</sup>	74.6	80.3
Use tobacco products other than cigarettes (%) <sup>b</sup>	44.5	40.7
Illicit drug use (%) <sup>b</sup>	34.9	58.8
Light physical activity [median (IQR)]	6.3 (7.0)	7.0 (6.0)
Moderate physical activity [median (IQR)]	10.0 (13.0)	8.0 (13.0)
Vigorous physical activity [median (IQR)]	2.0 (7.0)	2.0 (7.0)
Participation in team sports (%) <sup>b</sup>	56.2	49.3
TV watching per week, h [median (IQR)]	6.0 (5.5)	5.5 (5.0)
Smoking and nicotine dependence indicators		
No. cycles since smoking initiation [median (IQR)]	1.0 (1.0)	4.0 (5.0)
No. cigarettes smoked per month in past 3 months [median (IQR)]	0.6 (5.1)	3.0 (99.8)
Tolerance (%) <sup>b</sup>	21.0	30.2
Other nicotine dependence symptoms [median (IQR)]	2.0 (8.0)	7.6 (13.0)
Self-medication [median (IQR)]	0.0 (2.4)	1.0 (5.0)
Withdrawal symptoms [median (IQR)]	0.0 (1.1)	1.0 (3.0)
Context-level indicators		
Social environment		
Parent(s) smoke (%) <sup>b</sup>	43.3	43.9
Sibling(s) smoke (%) <sup>b</sup>	29.9	34.2
Friends smoke (%) <sup>b</sup>	87.4	92.9
Teachers/school staff smoke often (%) <sup>b</sup>	77.8	80.0
Neighborhood indicators		
Tolerance of smoking at school (% high) <sup>b</sup>	37.3	39.2
Tolerance of smoking in local corner stores [median (IQR)]	0.3 (0.2)	0.4 (0.5)
Tolerance of smoking in local restaurants [median (IQR)]	0.3 (0.4)	0.3 (0.4)

<sup>a</sup>Includes up to 15 observations per participant.

<sup>b</sup>Percentages and medians were computed excluding missing data.

were negatively associated with discontinuation. Finally, none of 7 context-level indicators were associated with discontinuation.

In addition to the context-level indicators, other potential predictors not statistically significantly associated

with discontinuation included language spoken at home, single-parent family, parent(s) university educated, other stress symptoms, depression, impulsivity, novelty-seeking, self-esteem, cigarette advertisements make me want to smoke, asthma, alcohol use, use of other tobacco

**Table 2.** Associations between smoking discontinuation and potential predictors in novice adolescent smokers, NIDIT study, 1999–2005<sup>a</sup>

Potential predictor	OR <sub>Crude</sub>	95% CI	OR <sub>adj</sub>	95% CI	Covariates included in multivariable model
<b>Sociodemographic</b>					
Sex					
Female (ref)					
Male	1.83	1.36–2.46	1.76	1.28–2.41	Age, depression symptoms, participate in vigorous physical activity, worrying about weight, use tobacco products other than cigarettes
Age (years) <sup>b</sup>	0.93	0.83–1.04	1.27	1.09–1.49	Sex, other nicotine dependence symptoms, withdrawal symptoms, no. cigarettes smoked per month in past 3 months, illicit drug use, time since smoking initiation
<b>Language spoken at home</b>					
Other (ref)					Age, sex, tolerance of smoking in local corner store, tolerance of smoking in local restaurant
French	0.86	0.62–1.21	0.99	0.67–1.47	
<b>Single-parent family</b>					
No (ref)					Age, sex
Yes	0.73	0.48–1.09	0.76	0.50–1.15	
<b>Parent(s) university-educated</b>					
No (ref)					Age, sex, tolerance of smoking in local corner store
Yes	1.31	0.94–1.83	1.23	0.87–1.75	
<b>Psychosocial indicators</b>					
Family stress <sup>b</sup>	0.65	0.49–0.85	0.73	0.55–0.96	Age, sex, depression symptoms, non-family-related stress
Non-family-related stress <sup>b</sup>	0.78	0.63–0.97	0.90	0.71–1.14	Age, sex, family stress, depression symptoms, worrying about weight
<b>Depression symptoms<sup>b</sup></b>					
No (ref)					Age, sex, family stress, non-family-related stress, worrying about weight, self-esteem, self-medication
Yes	0.92	0.77–1.09	1.15	0.94–1.40	
<b>Impulsivity<sup>b</sup></b>					
No (ref)					Age, sex, tolerance of smoking in local restaurant
Yes	0.99	0.86–1.14	0.97	0.83–1.13	
<b>Novelty-seeking<sup>b</sup></b>					
No (ref)					Age, sex, impulsivity
Yes	0.90	0.74–1.09	0.91	0.74–1.10	
<b>Self-esteem<sup>b</sup></b>					
No (ref)					Age, sex, depression symptoms
Yes	1.38	0.93–2.05	1.28	0.85–1.93	Age, sex, depression symptoms, non-family-related stress
<b>Worrying about weight</b>					
No (ref)					
Yes	0.56	0.43–0.72	0.63	0.47–0.85	Age, sex
<b>Cigarette package warnings make me afraid to smoke</b>					
No (ref)					
Yes	1.37	1.05–1.80	1.44	1.10–1.89	Age, sex, other ND symptoms
<b>Cigarette ads make me want to smoke</b>					
No (ref)					
Yes	0.67	0.46–0.99	0.78	0.50–1.21	Age, sex
<b>Overweight</b>					
No (ref)					
Yes	0.73	0.53–1.01	0.70	0.50–0.97	

(Continued on the following page)

**Table 2.** Associations between smoking discontinuation and potential predictors in novice adolescent smokers, NDIT study, 1999–2005<sup>a</sup> (Cont'd)

Potential predictor	OR <sub>crude</sub>	95% CI	OR <sub>adj</sub>	95% CI	Covariates included in multivariable model
Asthma					Age, sex
No (ref)					
Yes	0.97	0.65–1.46	0.96	0.63–1.47	
Lifestyle indicators					Age, sex
Alcohol use					
No (ref)					
Yes	0.95	0.70–1.29	0.94	0.69–1.29	
Use tobacco products other than cigarettes					Age, sex
No (ref)					
Yes	1.02	0.81–1.28	0.90	0.70–1.15	
Illicit drug use					Age, sex, other nicotine dependence symptoms, time since smoking initiation
No (ref)					
Yes	0.43	0.33–0.57	0.50	0.37–0.68	
Participate in light physical activity (LPA) <sup>b</sup>	1.00	0.96–1.04	1.02	0.98–1.06	Age, sex
Participate in moderate physical activity (MPA) <sup>b</sup>	1.00	1.0–1.02	1.00	0.99–1.01	Age, sex, participate in vigorous physical activity
Participate in vigorous physical activity (VPA) <sup>b</sup>	1.02	1.00–1.04	1.00	0.98–1.03	Age, sex, participate in moderate physical activity, participate in team sports
Participate in team sports					Age, sex, participate in vigorous physical activity
No (ref)					
Yes	1.52	1.16–1.99	1.44	1.07–1.92	
TV per week (hours) <sup>b</sup>	1.02	1.00–1.04	1.01	0.99–1.03	Age, sex
Smoking and nicotine dependence indicators					
Time since smoking initiation <sup>b</sup>	0.83	0.79–0.88	0.95	0.89–1.02	Age, sex, friends smoke, other nicotine dependence symptoms, self-medication, withdrawal symptoms, no. cigarettes smoked per month in past 3 months, illicit drug use
No. cigarettes smoked per month in past 3 months <sup>b</sup>	0.99 <sup>c</sup>	0.99–1.00	1.00	0.99–1.00	Age, sex, other nicotine dependence symptoms, self-medication, withdrawal symptoms, time since smoking initiation
Tolerance <sup>b</sup>	0.54	0.37–0.79	0.64	0.41–0.99	Age, sex, other nicotine dependence symptoms, self-medication
Other nicotine dependence symptoms <sup>b</sup>	0.91	0.88–0.94	0.95	0.91–0.99	Age, sex, tolerance, self-medication, withdrawal symptoms, time since smoking initiation, no. cigarettes smoked per month in past 3 months, cigarette ads make me want to smoke, illicit drug use
Self-medication <sup>b</sup>	0.89	0.84–0.94	0.98	0.91–1.06	Age, sex, depression symptoms, parent(s) smoke, tolerance, other nicotine dependence symptoms, withdrawal symptoms, no. cigarettes smoked per month in past 3 months, time since smoking initiation

*(Continued on the following page)*

**Table 2.** Associations between smoking discontinuation and potential predictors in novice adolescent smokers, NDIT study, 1999–2005<sup>a</sup> (Cont'd)

Potential predictor	OR <sub>crude</sub>	95% CI	OR <sub>adj</sub>	95% CI	Covariates included in multivariable model
Withdrawal symptoms <sup>b</sup>	0.77	0.69–0.86	0.92	0.79–1.07	Age, sex, other nicotine dependence symptoms, self-medication, no. cigarettes smoked per month in past 3 months, time since smoking initiation
Context-level indicators					
Social environment					
Parent(s) smoke					Age, sex, self-medication
No (ref)					
Yes	0.71	0.55–0.92	0.77	0.57–1.02	
Sibling(s) smoke					Age, sex
No (ref)					
Yes	0.81	0.62–1.08	0.82	0.61–1.09	
Friends smoke					Age, sex
No (ref)					
Yes	0.69	0.45–1.03	0.73	0.48–1.12	
Teachers/school staff smoke often					Age, sex, tolerance of smoking in local restaurant
No (ref)					
Yes	0.86	0.61–1.22	0.93	0.64–1.34	
Neighborhood indicators					
Tolerance of smoking at school					Age, sex, tolerance of smoking in local corner store
Low/moderate (ref)					
High	0.92	0.68–1.23	0.80	0.59–1.10	
Tolerance of smoking in local corner stores <sup>b</sup>	0.69	0.44–1.10	0.73	0.37–1.45	Age, sex, tolerance of smoking in local restaurant, tolerance of smoking at school, language spoken at home, parent(s) university-educated
Tolerance of smoking in local restaurants <sup>b</sup>	1.83	0.87–3.86	1.45	0.53–3.95	Age, sex, tolerance of smoking in local corner store, language spoken at home, impulsivity, teachers/school staff smoke often

<sup>a</sup>There were 3,862 to 3,921 person-surveys contributed by 248 to 257 participants.

<sup>b</sup>OR indicates the factor by which the 3-month odds of smoking discontinuation changes per one unit change in the given predictor variable. Because all ORs are derived based on unstandardized regression coefficients, the magnitude of the associations cannot be compared across predictors.

<sup>c</sup>Model converged 8 of 10 times.



products, LPA, MPA, VPA, television-viewing, number of cigarette smoked per month in the past 3 months, self-medication, withdrawal symptoms, and number of years since smoking initiation.

The results were not substantively different in sensitivity analyses that assessed the impact of the LOCF approach.

## Discussion

This longitudinal study of novice smokers is the first to identify predictors of smoking discontinuation, which is conceptualized herein as stopping smoking for at least one year (while not necessarily making a conscious effort to quit). Smokers included in this study were generally light, intermittent smokers, only 40% had smoked daily at some point during follow-up. The notion of smoking discontinuation may be more relevant than cessation or "trying to quit" in this group as many may not recognize themselves as being, or admit to being, a smoker.

In a recent systematic review of the predictors of cessation in longitudinal population-based studies of young smokers, Cengelli and colleagues (16) reported that five factors (namely, not having friends who smoke, not having intentions to smoke in the future, resisting peer pressure to smoke, being older at first use of cigarette, and having negative beliefs about smoking) consistently predicted quitting across studies in which the factor was investigated. However, although all the nine studies included in the review were school based, the study populations were generally older than in NDI and participants tended to be more established smokers. In addition, our study did not investigate several of the predictors that Cengelli and colleagues identified. Therefore, it is not possible to compare our findings with those reported by Cengelli and colleagues and more research is needed to determine if the predictors of smoking discontinuation differ from those of cessation in young smokers.

In this current study of novice smokers we identified 10 predictors of smoking discontinuation from among 37 potential predictors. These included male sex, older age, family stress, worrying about weight, believing cigarette package warnings, being overweight, not using illicit drugs, participation in team sports, symptoms of tolerance, and other nicotine dependence symptoms. Previous work suggests that there are sex differences in the reinforcing effects of nicotine, in smoking cessation rates, and in responses to nicotine therapies (37, 38). In contrast, Jarvis and colleagues (39), using data from major national surveys conducted in 2006–2007 in the United States, Canada, and the United Kingdom, reported that there were no apparent sex differences and that the widespread belief that women have more difficulty quitting than men relates to conducting studies in atypical clinical settings, rather than in the general population. Similarly, sex was not statistically significantly associated with cessation in several longitudinal studies in adolescents (40–42). Our result that male sex was strongly associated with discontinuation

provide further support for the hypothesis that there are sex differences in smoking discontinuation, at least in novice smokers. Given the importance of detecting a possible sex difference in discontinuation or cessation for the purpose of designing maximally effective cessation programs, investigation of differences in smoking discontinuation by sex among smokers should be a priority.

Older age was statistically significantly associated with discontinuation of smoking in this current study. Older youth may become more motivated to quit as they move into adult roles and responsibilities related to forming long-term relationships, living on their own or with a partner, and employment. They may have "practiced" quitting (i.e., made more quit attempts) to a greater extent than younger adolescents and through this practice, acquired the self-awareness and skills needed to quit successfully. In addition, they may be more likely to know about and use quit aids. Finally, they may have accumulated more years of exposure to tobacco control programs and to antismoking social norms, which eventually increases their motivation to quit. Messer and colleagues (43) found that young adults, aged 18 to 24, were more likely to quit successfully than older adults. It may be that late adolescence or early adulthood are critical time windows for discontinuation, when patterns of cigarette use and nicotine dependence are not yet fully entrenched.

In our study, participants who agreed with the statement that cigarette package warnings make them afraid to smoke were more likely to discontinue smoking than those who disagreed with it. In a review of 94 original articles, Hammond (44) reported that health warnings on cigarette packages are among the most direct means of communicating with smokers. These warnings can increase health knowledge, correct perceptions of risk, and promote cessation. Our results concord with Hammond's review and support the continued use of cigarette package warnings to promote smoking discontinuation in young smokers.

In a recent randomized controlled trial, Horn and colleagues (45) found that the addition of a physical activity module to N-O-T (Not On Tobacco), a proven youth cessation intervention, seemed to increase cessation success, particularly in boys. Our finding that participation in team sports is positively associated with discontinued smoking aligns with Horn and colleagues' results. It may be that youth who participate in team sports discontinue smoking to alleviate or prevent smoking-related symptoms so that they can remain physically competitive from a health perspective. Alternatively, peer pressure or support from team members and coaches may encourage youth to discontinue smoking.

Adolescents with lower levels of family stress were more likely to discontinue smoking in this study. It is possible that youth with higher family stress use cigarettes as a coping strategy. Both cigarette and marijuana use have in fact been associated with parental discord, separation, and divorce in nonclinical adolescent populations (46–50). It is also possible that adolescents use cigarettes

and marijuana for their mood-lifting and anxiolytic effects (51, 52), as an avoidance or escape mechanism from family problems, or to regulate negative affect associated with emotional dysfunction (53, 54). Gehricke and colleagues (55) presented converging findings from human behavioral research, brain imaging, and basic neuroscience on the use of smoking to cope with emotional dysfunction. Families may benefit from increased understanding of the sources and effects of relationship-related stress within the family, and adolescents may benefit from information about positive strategies to cope with family-related stress.

Participants in this study who worried about weight and those who were overweight were less likely to discontinue smoking than those who did not. It is well-established that weight gain is cited by many smokers, and especially adolescent girls, as a reason for not quitting smoking. While smokers generally weigh less than non-smokers, there is no evidence to support the belief among youth that smoking protects them from weight gain (56, 57). Young female smokers in particular may be more likely to discontinue smoking if tobacco control messages emphasize that cigarette smoking may not be associated with reduced weight in adolescents.

Polysubstance use is common in youth (58), which is possibly related to social affiliation (59). Concordant with several reports in adolescents (60, 61), not using illicit drugs (primarily cannabis in NDIT) was statistically significantly associated with discontinuation in our study. On the basis of an adult sample, Ford and colleagues (62) reported that difficulty quitting may be one of the most important adverse effects of marijuana use. Ellickson and colleagues (60) suggested that use of other substances may reinforce and sustain smoking possibly by exposing youth to higher levels of nicotine. Polysubstance users may also have less access to smoking cessation resources.

Finally, two nicotine dependence indicators were statistically significantly associated with discontinued smoking in this study: tolerance and other nicotine dependence symptoms. Indeed several recent longitudinal studies (39, 63, 64) all report that nicotine dependent youth were less likely to quit. A report on the natural course of cessation (6) suggests that some nicotine dependence symptoms such as craving emerge as early as 5 months after initiation in some novice smokers, and that tolerance appears at 14 months. These early nicotine dependence symptoms may not only prevent early discontinuation, but could also drive escalation in cigarette consumption (65). Youth tobacco control programs that do not consider

nicotine dependence symptoms in novice smokers may not be optimally effective.

Limitations of this analysis include that most data were based on self-report, which could be conducive to information bias. However, any misclassification was probably nondifferential and would therefore have biased parameter estimates toward the null. Imputation of missing data may also have resulted in information bias, which may have further shifted parameter estimates toward the null. Some predictors may not have been identified because the magnitude of the true association and/or the variability of the predictor variable at issue may not have been large enough to allow for detection of the association in a study of the given size. Finally, more research is needed to investigate each predictor in depth.

## Conclusions

Male sex, age, susceptibility to cigarette package warnings, participation in team sports, family stress, worrying about weight, overweight, use of illicit drugs, tolerance, and other nicotine dependence symptoms seem to be associated with smoking discontinuation in novice adolescent smokers. Tobacco control programs and policy targeting novice smokers may be more effective if these factors are taken into account in their conceptualization, design, and implementation.

## Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

## Authors' Contributions

**Conception and design:** J.L. O'Loughlin, M.-P. Sylvestre  
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**Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis):** J.L. O'Loughlin, M.-P. Sylvestre, E.N. Dugas  
**Writing, review, and/or revision of the manuscript:** J.L. O'Loughlin, M.-P. Sylvestre, E.N. Dugas, I. Karp  
**Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases):** J.L. O'Loughlin, E.N. Dugas  
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## References

1. U.S. Department of Health and Human Services. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. Atlanta, GA: Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.
2. Reid JL, Hammond D, Burkhalter R, Ahmed R. Tobacco Use in Canada: Patterns and Trends, 2012 Edition. Waterloo, ON: Propel Centre for Population Health Impact, University of Waterloo [accessed 15 May 2013]. Available from: [http://www.tobaccoreport.ca/2012/TobaccoUseinCanada\\_2012.pdf](http://www.tobaccoreport.ca/2012/TobaccoUseinCanada_2012.pdf).

3. Eaton DK, Kann L, Kinchen S, Shanklin S, Flint KH, Hawkins J, et al. Youth risk behavior surveillance - United States, 2011. *MMWR Morb Mortal Wkly Rep* 2012;61:1-162.
4. Health Canada. Health Concerns: Summary of Results of the 2010-2011 Youth Smoking Survey; 2011 [accessed 15 May 2013]. Available from: [http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/\\_survey-sondage\\_2010-2011/result-eng.php](http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/_survey-sondage_2010-2011/result-eng.php).
5. O'Loughlin J, DiFranza J, Tyndale R, Meshefedjian G, McMillan-Davey E, Clarke PB, et al. Nicotine dependence symptoms are associated with smoking frequency in adolescents. *Am J Prev Med* 2003;25:219-25.
6. O'Loughlin J, Gervais A, Dugas E, Meshefedjian G. Milestones in the process of cessation among novice adolescent smokers. *Am J Public Health* 2009;99:499-504.
7. Gervais A, O'Loughlin J, Meshefedjian G, Bancej C, Tremblay M. Milestones in the natural course of onset of cigarette use in adolescents. *CMAJ* 2006;175:255-61.
8. DiFranza JR, Savageau JA, Fletcher K, Pbert L, O'Loughlin J, McNeill AD, et al. Susceptibility to nicotine dependence: the development and assessment of nicotine dependence in youth 2 study. *Pediatrics* 2007;120:974-83.
9. DiFranza JR, Savageau JA, Fletcher K, O'Loughlin J, Pbert L, Ockene JK, et al. Symptoms of tobacco dependence after brief intermittent use. The development and assessment of nicotine dependence in youth-2 study. *Arch Pediatr Adolesc Med* 2007;161:704-10.
10. Bancej C, O'Loughlin J, Platt RW, Paradis G, Gervais A. Smoking cessation attempts among adolescent smokers: a systematic review of prevalence studies. *Tob Control* 2007;16:e8.
11. Eisenberg MJ, Filion KB, Yavin D, Bélisle P, Mottillo S, Joseph L, et al. Pharmacotherapies for smoking cessation: a meta-analysis of randomized controlled trials. *CMAJ* 2008;179:135-44.
12. Gervais A, O'Loughlin J, Dugas E, Eisenberg MJ, Wellman RJ, DiFranza JR. A systematic review of randomized controlled trials of youth smoking cessation interventions. *Drogues, santé, et société* 2007;6:ii1-26.
13. Hutton HE, Wilson LM, Apelberg BJ, Tang EA, Odelola O, Bass EB, et al. A systematic review of randomized controlled trials: web-based interventions for smoking cessation among adolescents, college students and adults. *Nicotine Tob Res* 2011;13:227-38.
14. Villanti AC, McKay HS, Abrams DB, Holtgrave DR, Bowie JV. Smoking-cessation interventions for U.S. young adults: a systematic review. *Am J Prev Med* 2010;39:564-74.
15. U.S. Department of Health and Human Services. Preventing Tobacco Use Among Young People: A Report of the Surgeon General. Atlanta, GA: Centers for Disease Control and Prevention, Public Health Services, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion; 1994.
16. Cengelli S, O'Loughlin J, Lauzon B, Cornuz J. A systematic review of longitudinal population-based studies on the predictors of smoking cessation in adolescent and young adult smokers. *Tob Control* 2012;21:355-62.
17. O'Loughlin J, Karp I, Koulis T, Paradis G, DiFranza J. Determinants of first puff and daily cigarette smoking in adolescents. *Am J Epidemiol* 2009;170:585-97.
18. Centers for Disease Control and Prevention (CDC). Point-of-purchase tobacco environments and variation by store type - United States, 1999. *MMWR Morb Mortal Wkly Rep* 2002;51:184-7.
19. Frohlich KL, Potvin L, Gauvin L, Chabot P. Youth smoking initiation: disentangling context from composition. *Health Place* 2002;8:155-66.
20. Centers for Disease Control and Prevention (CDC). Selected cigarette smoking initiation and quitting behaviors among high school students - United States, 1997. *MMWR Morb Mortal Wkly Rep* 1998;47:386-9.
21. Deschenes M. Life style of youth in secondary schools in Outaouais. Chapter 1. (In French). Hull, Quebec, Canada: Direction de la sante publique. Regie regionale de la sante et des services sociaux; 1997.
22. Dugas E, Low NC, Rodriguez D, Burrows S, Contreras G, Chaiton M, et al. Early predictors of suicidal ideation in young adults. *Can J Psychiatry* 2012;57:429-36.
23. Kandel DB, Davies M. Epidemiology of depressive mood in adolescents. *Arch Gen Psychiatry* 1982;39:1205-12.
24. Wills TA, Windle M, Cleary SD. Temperament and novelty seeking in adolescent substance use: Convergence of dimensions of temperament with constructs from Cloninger's theory. *J Pers Soc Psychol* 1998;74:387-406.
25. Eysenck SB, Eysenck HJ. The place of impulsiveness in a dimensional system of personality description. *Br J Soc Clin Psychol* 1977;16:57-68.
26. Vallieres EF, Vallerand R. Translation to French (Canadian) and validation of Rosenberg's self-esteem scale. (In French). *Int J Psychol* 1990;25:305-16.
27. Centers for Disease Control and Prevention. A SAS program for the CDC Growth Charts;2000 [accessed 15 May 2013]. Available from: [www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm](http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm).
28. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health. a recommendation from the centers for disease control and prevention and the american college of sports medicine. *JAMA* 1995;273:402-7.
29. O'Loughlin J, DiFranza J, Tarasuk J, Meshefedjian G, McMillan-Davey E, Paradis G, et al. Assessment of nicotine dependence symptoms in adolescents: a comparison of five indicators. *Tob Control* 2002;11:354-60.
30. Pabayo R, O'Loughlin J, Barnett TA, Cohen JE, Gauvin L. Does intolerance of smoking at school or in restaurants or corner stores decrease cigarette use initiation in adolescents? *Nicotine Tob Res* 2012;14:1154-60.
31. Honaker J, King G. What to do About Missing Values in Time Series Cross-Section Data. *Am J Polit Sci* 2010;54:561-81.
32. D'Agostino RB, Lee ML, Belanger AJ, Cupples LA, Anderson K, Kannel WB. Relation of pooled logistic regression to time-dependent Cox regression analysis: the Framingham Heart Study. *Stat Med* 1990;9:1501-15.
33. Rubin DB. Multiple Imputation for Nonresponse in Surveys. New York, NY: John Wiley & Sons; 1987.
34. R Development Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: The R Foundation for Statistical Computing; 2011 [accessed 15 May 2013]. Available at <http://www.R-project.org/>.
35. Honaker J, King G, Blackwell M. Amelia II: A Program for Missing Data. *J Stat Softw* 2011;45:1-47.
36. Imai K, King G, Lau O. 2006. Zelig: Everyone's Statistical Software [accessed 15 May 2013]. Available from: <http://projects.iq.harvard.edu/zelig>.
37. Perkins KA, Donny E, Caggiula AR. Sex differences in nicotine effects and self-administration: review of human and animal evidence. *Nicotine Tob Res* 1999;1:301-15.
38. Cosgrove KP, Esterlis I, McKee SA, Bois F, Seibyl JP, Mazure CM, et al. Sex differences in availability of  $\beta_2^*$ -nicotinic acetylcholine receptors in recently abstinent tobacco smokers. *Arch Gen Psychiatry* 2012;69:418-27.
39. Jarvis MJ, Cohen JE, Delnevo CD, Giovino GA. Dispelling myths about gender differences in smoking cessation: population data from the USA, Canada and Britain. *Tob Control* 2013;22:356-60.
40. Rohde P, Kahler CW, Lewinsohn PM, Brown RA. Psychiatric disorders, familial factors, and cigarette smoking: III. Associations with cessation by young adulthood among daily smokers. *Nicotine Tob Res* 2004;6:509-22.
41. Tucker JS, Elickson PL, Orlando M, Klein DJ. Predictors of attempted quitting and cessation among young adult smokers. *Prev Med* 2005;41:554-61.
42. Elickson PL, McGuigan KA, Klein DJ. Predictors of late-onset smoking and cessation over 10 years. *J Adolesc Health* 2001;29:101-8.
43. Messer K, Trinidad DR, Al-Delaimy WK, Pierce JP. Smoking cessation rates in the United States: a comparison of young adult and older smokers. *Am J Public Health* 2008;98:317-22.
44. Hammond D. Health warning messages on tobacco products: a review. *Tob Control* 2011;20:327-37.
45. Horn K, Dino G, Branstetter SA, Zhang J, Noerachmanto N, Jarrett T, et al. Effects of physical activity on teen smoking cessation. *Pediatrics* 2011;128:e801-11.
46. Chaiton M, Cohen J, O'Loughlin J, Rehm J. Use of cigarettes to improve affect and depressive symptoms in a longitudinal study of adolescents. *Addict Behav* 2010;35:1054-60.

47. Jeynes WH. The relationship between the consumption of various drugs by adolescents and their academic achievement. *Am J Drug Alcohol Abuse* 2002;28:15–35.
48. Reynolds I, Rob MI. The role of family difficulties in adolescent depression, drug-taking and other problem behaviours. *Med J Aust* 1988; 149:250–6.
49. Juliano LM, Fucito LM, Harrell PT. The influence of nicotine dose and nicotine dose expectancy on the cognitive and subjective effects of cigarette smoking. *Exp Clin Psychopharmacol* 2011;19:105–15.
50. Kristjansson AL, Sigfusdottir ID, Allegrante JP, Helgason AR. Parental divorce and adolescent cigarette smoking and alcohol use: assessing the importance of family conflict. *Acta Paediatr* 2009;98:537–42.
51. Phan KL, Angstadt M, Golden J, Onyewuanyi L, Popovska A, de Wit H. Cannabinoid modulation of amygdala reactivity to social signals of threat in humans. *J Neurosci* 2008;28:2313–9.
52. Veilleux JC, Kassel JD, Heinz AJ, Braun A, Wardle MC, Greenstein J, et al. Predictors and sequelae of smoking topography over the course of a single cigarette in adolescent light smokers. *J Adolesc Health* 2011;48:176–81.
53. Whalen CK, Jamner LD, Henker B, Delfino RJ. Smoking and moods in adolescents with depressive and aggressive dispositions: Evidence from surveys and electronic diaries. *Health Psychol* 2001;20:99–111.
54. Whalen CK, Jamner LD, Henker B, Delfino RJ, Lozano JM. The ADHD spectrum and everyday life: Experience sampling of adolescent moods, activities, smoking, and drinking. *Child Dev* 2002;73:209–27.
55. Gehricke JG, Loughlin SE, Whalen CK, Potkin SG, Fallon JH, Jamner LD, et al. Smoking to self medicate attentional and emotional dysfunctions. *Nicotine Tob Res* 2007;9:S523–36.
56. O'Loughlin J, Karp I, Henderson M, Gray-Donald K. Does cigarette use influence adiposity or height in adolescence? *Ann Epidemiol* 2008;18:395–402.
57. Mackay DF, Gray L, Pell JP. Impact of smoking and smoking cessation on overweight and obesity: Scotland-wide, cross-sectional study on 40,036 participants. *BMC Public Health* 2013;13:348.
58. Leatherdale ST, Burkhalter R. The substance use profile of Canadian youth: exploring the prevalence of alcohol, drug and tobacco use by gender and grade. *Addict Behav* 2012;37:318–22.
59. Jessor R. Risk behavior in adolescence: a psychosocial framework for understanding and action. *J Adolesc Health* 1991;12:597–605.
60. Ellickson PL, Tucker JS, Klein DJ. Sex differences in predictors of adolescent smoking cessation. *Health Psychol* 2001;20:186–95.
61. van den Bree MB, Whitmer MD, Pickworth WB. Predictors of smoking development in a population-based sample of adolescents: a prospective study. *J Adolesc Health* 2004;35:172–81.
62. Ford DE, Vu HT, Anthony JC. Marijuana use and cessation of tobacco smoking in adults from a community sample. *Drug Alcohol Depend* 2002;67:243–8.
63. Diemert LM, Bondy SJ, Brown KS, Manske S. Young adult smoking cessation: predictors of quit attempts and abstinence. *Am J Public Health* 2013;103:449–53.
64. Scherphof CS, van den Eijnden RJ, Harakeh Z, Raaijmakers QA, Kleinjan M, Engels RC, et al. Effects of nicotine dependence and depressive symptoms on smoking cessation: a longitudinal study among adolescents. *Nicotine Tob Res* 2013;15:1222–9.
65. Doubeni CA, Reed G, Difranza JR. Early course of nicotine dependence in adolescent smokers. *Pediatrics* 2010;125:1127–33.