ORIGINAL INVESTIGATION

Developmental Trajectories of Cigarette Use and Associations With Multilayered Risk Factors Among Chinese Adolescents

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ABSTRACT

Introduction: We aimed to identify developmental trajectories of cigarette use and risk factors associated with the distinct developmental courses of smoking in Chinese early adolescents from age 12 to 16 years.

Methods: Analysis was conducted with secondary data from a longitudinal, prospective cohort of 3,521 Chinese adolescents randomly selected from 4 rural and 7 urban middle schools in Wuhan, China. A group-based growth mixture modeling approach was adopted to identify developmental trajectories of cigarette use. Multilayered intrapersonal (e.g., attitudes toward smoking) and interpersonal (e.g., parental smoking and perceived parental disapproval of smoking) risk factors selected from an ecological perspective were prospectively linked to the identified patterns of smoking trajectory.

Results: Three trajectory patterns were identified from the whole cohort: nonsmokers (48.7%), stable light/occasional smokers (48.6%), and accelerating smokers (2.7%). After adjustments for gender, urban residence, and family socioeconomic status, adolescents with higher levels of problems in parent–child relationships and family disharmony, higher perceived norms of peer smoking, higher proportion of good friend smoking, having more troubles with teachers, poorer academic performance, and reporting more frequent depressive symptoms were significantly more likely to be in the trajectory group of either stable light/occasional smokers or accelerating smokers than in the group of nonsmokers. The probability of being in the accelerating smoking trajectory group was positively and significantly related to parental smoking and lack of school bonding.

Conclusions: Study findings help to advance knowledge of the distinct developmental courses of smoking behavior and their associations with multilayered risk factors among Chinese early adolescents.

INTRODUCTION

China is the world's largest producer and consumer of tobacco according to the report from the World Health Organization Framework Convention on Tobacco Control (World Health Organization, 2009). Cigarette smoking is the number one cause of preventable death in China. Smoking and passive smoke are the key contributors to the mortality of major chronic diseases, namely, cardiovascular disease, chronic respiratory disease, and cancer. Prevalence rates from the National Tobacco Surveys and a recent report indicated that more than 60% of Chinese male adults are smokers, and about 53% of nonsmokers are exposed to secondhand smoke (Shi, Liu, Zhang, Lu, & Quan, 2008; Yang et al., 1999; Yang, Ma, Liu, & Zhou, 2005; Yang et al., 2010). The prevalence of quit attempts has increased from 1996 to 2002, but 74% of current smokers still report no intention to quit (Yang et al., 2005, 2010). Our prior research also indicated that smoking among

Chinese adolescents is also on the increase with the initiation taking place earlier in life (Johnson et al., 2006; Ma et al., 2008; Unger, Li et al., 2001). The past-month smoking prevalence from the China Seven Cities Study of a large representative sample of 7th to 12th graders living in seven major cities in the mainland China in 2002 was 9%, 8%, and 26% among middle, academic high, and vocational high school students, respectively (Johnson et al., 2006). Boys were at particularly higher risks for smoking than girls, and risk factors for smoking were multifaceted. Past studies targeting Chinese adolescents, most with cross-sectional designs, have provided some findings on multiple smoking-related risk factors that develop from a variety of intrapersonal and interpersonal settings and environments, such as individual attitudes and knowledge of cigarette smoking, personal feelings, and depressive symptoms, and influences from parents, peers, and schools (Booker et al., 2007; Grenard et al., 2006; Li, Mao, Stanton, & Zhao, 2010; Ma et al., 2008; Petraitis, Flay, & Miller, 1995; Shakib et al., 2005;

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Weiss, Palmer, Chou, Mouttapa, & Johnson, 2008). There is an urgent need of rigorous investigations with longitudinal data for an improved understanding of these intrapersonal and interpersonal factors and their roles in influencing the developmental course of smoking behavior among Chinese adolescents.

The process of smoking initiation and escalation or progression may not follow the same pattern of trajectory or developmental course. In a limited but growing body of literature, multiple distinct trajectories that vary in initiation and escalation or progression of smoking behavior during adolescence or from early adolescence to adulthood, such as non/experimental smokers, light/occasional smokers, and heavy/regular smokers, have been identified among Western populations (Brook et al., 2008; Chassin et al., 2008; Colder et al., 2001; Orlando, Tucker, Ellickson, & Klein, 2004; White, Pandina, & Chen, 2002). Identifying the underlying heterogeneous developmental trajectories during adolescence is very important to understand the natural history of smoking behavior development. To our knowledge, no prior effort has been made to investigate developmental trajectories of smoking behaviors among Chinese adolescents. In this study, we adopted a group-based growth mixture modeling approach to identify the developmental trajectories of cigarette smoking among Chinese adolescents from age 12 to 16 years. Based on the Theory of Triadic Influence with an ecological perspective (Flay & Petraitis, 1994; Grenard et al., 2006; Petraitis et al., 1995), multilayered intrapersonal (e.g., attitudes toward smoking, grade point average, subjective academic performance, school bonding, and depressive symptoms), and interpersonal (e.g., parental smoking, perceived parental disapproval of smoking, parent-child relationships, family disharmony, perceived norms of peer smoking, good friend smoking, and troubles with teachers) risk factors were prospectively linked to the identified patterns of smoking trajectory. Types of risk factors and the relative importance among those risk factors can inform the development of prevention and intervention strategies to help reduce the consumption of tobacco products in China. This study represents the first longitudinal analysis effort identifying developmental trajectories of cigarette smoking and risk factors associated with distinct developmental trajectories of smoking among Chinese adolescents.

METHODS

Sample and Data

The data analyzed were derived from the Wuhan Smoking Prevention Trial (WSPT) conducted from 1999 to 2004 among 7th to 9th grade Chinese students in Wuhan, China. The WSPT was a school-based randomized control trial carried out to evaluate the effectiveness of a culturally adapted school and family smoking prevention curriculum with a social normative approach for Chinese adolescents. Detailed sampling procedures and trial curriculum were explained in our previous articles (Chou et al., 2006; Unger, Yan et al., 2001). The study population consisted of adolescents randomly selected from 22 middle schools in urban and rural Wuhan. In each selected school, six classes (four seventh-grade, one eighth-grade, and one ninth-grade) were randomly selected for data collection.

Students and both parents were also invited to participate in the study. At baseline, data were collected from 6,994 students (3,669 in control group and 3,325 in intervention group) and 12,383 parents with an overall 98% participation rate. The cohort follow-up retention rate was 91.1% in Year 2 and 88.2% in Year 3. In this article, we used this sample from the control arm and baseline ranging in age from 12 to 15 years old ($n = 3,521$) for the analysis. Questionnaire items comprising sociodemographic, psychological, and behavioral information were translated from English to Mandarin, then back translated to English by translators fluent in both languages and trained in behavioral research. The final versions of questionnaires and the study protocol detailing the sample recruitment and data collection procedures were approved by the Institutional Review Boards from both the University of Southern California and Wuhan Anti-Epidemic Station (now the Wuhan CDC).

Measurements of Cigarette Smoking Behavior

The following two questions were asked in the questionnaire to assess cigarette smoking: "Have you ever tried cigarette smoking, even a puff?" (0 = *no*, 1 = *yes*) and "During the past 30 days, on how many days did you smoke cigarettes?" As suggested by Pierce, Choi, Gilpin, Farkas, and Merritt (1996) and Unger, Johnson, and Rohrbach (1995), and adopted by many other researchers (Audrain-McGovern, Rodriguez, Epstein, Cuevas, Rodgers, & Wileyto, 2009; Rodriguez, Romer, & Audrain-McGovern, 2007; Simons-Morton, Chen, Abrams, & Haynie, 2004; Simons-Morton, Haynie, Saylor, Crump, & Chen, 2005), smoking can be categorized as an ordinal scale. Accordingly, we grouped subjects based on these smoking measures into mutually exclusive ordinal categories including 0 for lifetime never users (never smoke, even a puff), 1 for recent nonusers (ever puff but not smoking during the past 30 days), 2 for recent occasional users (smoke but less than 10 days during the past 30 days), and 3 for recent frequent users (smoke and 10 or more days in the past 30 days).

Measurements of Family Characteristics

Family relationships (three items with Cronbach's alpha of 0.57) assessed adolescents' perception of parental-child and family member relationships (e.g., "Do you think that your parents care deeply for you?," "How do your family members get along?," and "Do you consider yourself obedient to your parents?") (Shakib et al., 2005). Parental disapproval of smoking (two items with reversed coding and Cronbach's alpha of 0.77) assessed adolescents' perceptions of their parents' attitudes toward them smoking (e.g., "Do you think your mom would agree if you wanted to smoke?" and "Do you think your dad would agree if you wanted to smoke?") (Shakib et al., 2005). "Parental smoking" was determined by asking if either the mother or father smoked cigarettes. "Parental sanctioning of smoking" assessed adolescents' perceptions of how their parents would act if they smoked ("How would your parents act toward you if you smoked" with response options ranged from 1 = *Very badly* to 5 = *Very well*) and were collapsed to a dichotomized variable for analysis due to the skewed distribution. Six items of "family disharmony" (Cronbach's alpha of 0.73) were adopted from items of family domain of a stressful life event checklist that was validated for Chinese adolescents (Unger, Yan et al., 2001). Adolescents

were asked whether they had experienced any of the following problems in the past 6 months: (a) being beaten by parents, (b) being blamed by parents, (c) had arguments with parents, (d) quarreled more with parents, (e) quarreled more with family members, and (f) felt less concern from parents.

Measurements of Peer Characteristics

“Peer sanctioning of smoking” assessed adolescents’ perception of how their friends would act if they smoke (“How would your friends act toward you if you smoked” used response options ranging from 1 = *Very badly* to 5 = *Very well*), which were collapsed to a dichotomized variable for analysis due to the skewed distribution. “Friend smoking norm” was assessed by asking a question “In your opinion, how many out of 100 people of your age smoke at least once a month?” (Grenard et al., 2006). The percentage of smokers was then calculated and used for the analysis. “Peer isolation” (four items with Cronbach’s alpha of 0.73) was assessed by asking adolescents if they had experienced the following four problems in the past 6 months: (a) being looked down upon by classmates, (b) being insulted or attacked by classmates, (c) being isolated by peers, (d) feeling peers did not care about them, with responses ranging from “never experienced” to “experienced and greatly affected” (Xie et al., 2005).

Measurements of School Characteristics

“Trouble with teachers” was assessed with four items asking “In the past six months, did you ever experience being criticized or punished by your teachers?,” “. . . conflict with teacher?,” “. . . feeling dislike by teachers?,” “. . . feeling ignored by teacher?” (Cronbach’s alpha of 0.6) (Xie et al., 2003). “School connectedness” was assessed with one item asking if an adolescent liked his/her school on a 1–4 scale ranging from *not at all* to *very much*, and responses were further collapsed into *yes* or *no*. “Teacher sanctioning of smoking” assessed adolescents’ perception of how their teachers would act if they smoked (“How would your teachers act toward you if you smoked?” with response options ranging from 1 = *Very badly* to 5 = *Very well*) and then collapsed to a dichotomized variable for analysis due to the skewed distribution (Grenard et al., 2006). Adolescents’ grade point average (GPA) in the last semester was asked with responses ranging from 1 to 5 representing “below 60” to “above 90.” “Subjective school performance” was also assessed by asking “How good do you think your scores are; compared with your classmates?” with responses of 1–5 representing from *very poor* to *excellent*.

Measurements of Individual Characteristics

“Depressive symptoms” (four items with Cronbach’s alpha of 0.79) were assessed with a validated four-item short form of the Center for Epidemiological Studies Depression Scale (CES-D) (Cheung & Bagley, 1998; Melchior, Huba, Brown, & Reback, 1993). The four items were as follows: (a) “I felt depressed,” (b) “I felt lonely,” (c) “I felt sad,” and (d) “I felt like crying out.” Adolescents were asked to rate the frequency of each symptom during the past week on a 4-point Likert scale using *almost never*, *seldom*, *occasionally*, and *often*. “Attitudes towards smoking” (15 items with Cronbach’s alpha of 0.71) were assessed by asking adolescents’ attitudes and beliefs

regarding smoking with a 4-point Likert scale and response choices *definitely not*, *maybe not*, *maybe yes*, and *definitely yes* (e.g., “Do you think people can get addicted to smoking just as they do to other drugs?”) (Grenard et al., 2006). “Alcohol drinking in past month” was assessed by asking adolescents to report on how many days they drank an alcohol beverage in the past month. A dichotomized variable was created with 0 for never drank and 1 representing alcohol drinking at least 1 day in the past month.

Covariates

“Age,” “urbanicity,” and “parental education attainment” were included in the analysis as covariates. Urbanicity was coded as 1 = *urban* and 0 = *rural*, based on the population density of the district. Parental education was collected in categorical increments ranging from illiterate to college diploma or higher. The attainment of education was collapsed into three categories: below high school, high school, and college or above.

Data Analysis

Descriptive statistics (mean, *SD*, and percentage) were calculated to reflect the background characteristics of the sample. The WSPT collected up to three waves of data from adolescents in multiple overlapping age cohorts. Therefore, the analysis data were restructured to form age cohorts for the developmental trajectory analysis. This approach provides an opportunity to examine longitudinal developing trajectories spanning early to late adolescence by linking the cohorts together based on age in a “cohort-sequential design” (Costello, Dierker, Jones, & Rose, 2008; Duncan, Duncan, Strycker, & Chaumeton, 2007; Miyazaki & Raudenbush, 2000). Group-based Growth Mixture Modeling approach implemented in SAS Proc Traj was employed to classify the growth trajectory pattern of smoking behavioral outcomes (Jones & Nagin, 2007; Jones, Nagin, & Roeder, 2001; Nagin, 1999). The estimated response growth curve from the conventional longitudinal models is based on the assumption that all individuals in the sample come from a single population, which may not be able to capture the heterogeneity of growth trajectory of behavioral outcomes during adolescence. The growth mixture modeling approach is able to identify the underlying growth curve shapes of smoking behaviors (i.e., the average growth trajectory class or membership) as a categorical latent variable, and estimate posterior probabilities of class membership for all individuals (Muthén, 2001; Muthén & Muthén, 2000; Nagin, 1999; Nagin & Tremblay, 1999, 2001). The heterogeneity of developmental trajectory in growth factors (i.e., initial status and slope) was captured in a categorical latent class variable. The number of latent classes was determined by Bayesian information criterion (BIC) (Schwarz, 1978), and the model with the smallest Bayesian information criterion indicates the specified model that best fits the data (Muthén, 2001; Muthén & Muthén, 2000; Nagin, 1999; Nagin & Tremblay, 2001). Each adolescent was assigned to the most probable trajectory class of smoking behaviors based on the estimated posterior probability, which was the probability of each adolescent belonging to each trajectory group. Misclassification of group membership was evaluated by the average posterior probability with close to 1 being considered as an acceptable value for adequate classification (Nagin & Tremblay, 2001). Finally, generalized

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estimating equation (GEE) modeling was used to prospectively link baseline multilayered family, peer, school, and individual characteristics to the identified trajectory class memberships of smoking behavioral outcomes with control for the potential intraclass correlation for the data situation of students from the same classroom nesting within school. Gender, urbanicity, parental education levels, and school enrollment were adjusted in the models. All statistical analyses were carried out using SAS (version 8.0; SAS Institute).

RESULTS

Baseline general characteristics of the sample were summarized in Table 1. The majority reported parental education attainment at the high school level (64.4%). Significantly, more girls than boys reported being never-smokers (81.7% vs. 53.9%, $p < .05$), whereas more boys than girls smoked cigarettes. There was

no significant gender difference in family characteristics, or most peer, school, or individual characteristics, except for peer sanctioning of smoking (85% in girls vs. 73% in boys), GPA (3.78 ± 1.03 in girls vs. 3.51 ± 1.14 in boys), and subjective school performance (3.25 ± 0.93 in girls vs. 3.05 ± 1 in boys), depressive symptoms (0.85 ± 0.77 in girls vs. 0.6 ± 0.66 in boys), and past-month alcohol drinking (15.9% in girls vs. 23.3% in boys).

The group-based growth mixture modeling approach was applied to identify the developmental trajectories of smoking behaviors. A two-group (BIC = -7326.25), three-group (BIC = -7213.36), and four-group (BIC = -7225.59) models were tested (Table 2). Based on the BIC criterion, a three-group model was selected as the best-fitting model. Additional tests such as Lo-Mendell-Rubin likelihood ratio test (LMR LRT) (Lo, Mendell, & Rubin, 2001) and bootstrap likelihood ratio test (BLRT) (McLachlan & Peel, 2000) have been suggested although these tests are not as frequently used as BIC in the

Table 1. General Characteristics of the Sample at Baseline

	Female	Male	Overall
Demographics			
Age in years, <i>n</i> (%)			
12 years old	258 (15.7%)	229 (12.2%)	487 (13.8%)
13 years old	792 (48.3%)	915 (48.7%)	1707 (48.5%)
14 years old	346 (21.1%)	456 (24.3%)	802 (22.8%)
15 years old	245 (14.9%)	280 (14.9%)	525 (14.9%)
Urbanicity, <i>n</i> (%)			
Rural	721 (43.9%)	870 (46.3%)	1,591 (45.2%)
Urban	920 (56.1%)	1,010 (53.7%)	1,930 (54.8%)
Parental education, <i>n</i> (%)			
Below high school	406 (24.8%)	482 (25.8%)	888 (25.3%)
High school	1,065 (65.1%)	1,192 (63.7%)	2,257 (64.4%)
College or above	166 (10.1%)	196 (10.5%)	362 (10.3%)
Smoking behaviors, <i>n</i> (%)			
Never smoke	1,325 (81.7%)	962 (53.9%)	2,287 (67.2%)
Lifetime ever puff but not	252 (15.5%)	588 (32.9%)	840 (24.7%)
Smoke in past month			
Smoke 10 days or less in past month	41 (2.5%)	192 (10.8%)	233 (6.8%)
Smoke >10 days in past month	3 (0.2%)	43 (2.4%)	46 (1.4%)
Family characteristics			
Family relationships, mean (<i>SD</i>)	3.16 (0.62)	3.02 (0.7)	3.09 (0.67)
Parental disapproval, mean (<i>SD</i>)	2.95 (0.26)	2.87 (0.47)	2.91 (0.38)
Family disharmony, mean (<i>SD</i>)	0.35 (0.29)	0.35 (0.28)	0.35 (0.28)
Parental smoking, <i>n</i> (%)	1207 (77.4%)	1339 (75%)	2546 (76.1%)
Parental sanctioning of smoking, <i>n</i> (%)	1608 (98.9%)	1821 (97.5%)	3429 (98.2%)
Peer characteristics			
Peer sanctioning of smoking, <i>n</i> (%)	594 (85%)	731 (73%)	1325 (77.9%)
Peer isolation, mean (<i>SD</i>)	0.35 (0.35)	0.33 (0.34)	0.34 (0.35)
Friend smoking norm, mean (<i>SD</i>)	0.2 (0.23)	0.23 (0.26)	0.22 (0.25)
School characteristics			
Trouble with teachers, mean (<i>SD</i>)	0.46 (0.32)	0.45 (0.31)	0.45 (0.31)
School connectedness, <i>n</i> (%)	1367 (83.3%)	1529 (81.6%)	2896 (82.4%)
Teacher sanctioning of smoking, <i>n</i> (%)	1615 (98.7%)	1825 (97.6%)	3440 (98.1%)
GPA, mean (<i>SD</i>)	3.78 (1.03)	3.51 (1.14)	3.63 (1.09)
School performance, mean (<i>SD</i>)	3.25 (0.93)	3.05 (1)	3.15 (0.97)
Individual characteristics			
Depressive symptoms, mean (<i>SD</i>)	0.85 (0.77)	0.6 (0.66)	0.72 (0.73)
Attitudes toward smoking mean(<i>SD</i>)	1.65 (0.37)	1.65 (0.42)	1.65 (0.39)
Alcohol drinking in past month, <i>n</i> (%)	246 (15.9%)	412 (23.3%)	658 (19.9%)

practical research. Either LMR LRT or BLRT is not available in SAS Proc TRAJ, but only available in MPlus. To double check our results, we reran the analysis with MPlus with Tech 11 and 14 to provide both LMR LRT and BLRT results. In general, a small p value of LMR LRT or BLRT suggests that the model with k classes is preferred over $k-1$ classes. Comparisons across the two-, three-, and four-class models consistently supported our findings from SAS Proc TRAJ that the three-class model was the final model. Figure 1 presents the observed trajectories for each of three trajectory groups. The three trajectory groups were labeled as nonsmokers (48.7%), stable light/occasional smokers (48.6%), and accelerating smokers (2.7%). The average class posterior probability for each class was 0.905 (Class 1), 0.984 (Class 2), and 0.847 (Class 3), respectively. In addition, 16% of stable light/occasional smokers and 53.8% of accelerating smokers reported ever trying to quit smoking in the past 12 months.

Table 3 presents results of adjusted odds ratios for predictors of smoking trajectory group membership. Adolescents with

good parent-child or family member relationships, high levels of parental disapproval of smoking, sanctioning of smoking from peers and teachers, high school connectedness, and good GPA and school performance were less likely to be in the trajectory group of either stable light/occasional smokers or accelerating smokers. For example, a 1-point unit higher in baseline GPA led to 13% (i.e., $[0.87 - 1] \times 100\%$) or 47% (i.e., $[0.53 - 1] \times 100\%$) less odds of being stable light/occasional or accelerating smoker from nonsmokers, and 39% (i.e., $[0.61 - 1] \times 100\%$) less odds of being accelerating smokers from stable light/occasional smoker. Adolescents with parents who smoked cigarettes, those who came from families with higher disharmony in the environment, perceived higher norms of friend smoking, or positive attitudes of smoking behaviors, reported more troubles with teachers, more frequent depressive symptoms, or alcohol drinking were significantly more likely to be in the trajectory group of either stable light/occasional smokers or accelerating smokers. For example, a 1-point unit higher scores of baseline depressive symptoms led to 61% (i.e., $[1.61 - 1] \times 100\%$) or 152% (i.e., $[2.52 - 1] \times 100\%$) greater odds of being stable light/occasional or accelerating smoker from nonsmokers, and 74% (i.e., $[1.74 - 1] \times 100\%$) greater odds of being accelerating smokers from stable light/occasional smoker.

Table 2. Bayesian Information Criteria (BIC) and Average Class Probability for Mixture Models

Model	BIC		
Two groups	7326.25		
Three groups	7213.36		
Four groups	7225.59		
	Average class probability		
Final three-group model	1	2	3
Class 1 ($n = 1,896$)	0.905	0.094	0.001
Class 2 ($n = 1,544$)	0.000	0.984	0.016
Class 3 ($n = 81$)	0.000	0.153	0.847

DISCUSSION

The developmental course of smoking initiation and progression may not follow the same trajectory pattern among adolescents. In this study, three distinct trajectory patterns were identified and labeled as nonsmokers (48.7%), stable light/occasional smokers (48.6%), and accelerating smokers (2.7%). To our knowledge, there is no previous report on smoking

Figure 1. Average smoking scores across age for three classes of smoking trajectories. Group sizes are indicated in parentheses in the legend. Group 1: nonsmokers; Group 2: stable light/occasional smokers; Group 3: accelerating smokers.

Table 3. Adjusted Odds Ratio for Predictors of Smoking Trajectory Group Membership

	Nonsmokers vs. stable light/ occasional smokers		Nonsmokers vs. accelerating smokers		Stable light/occasional smokers vs. accelerating smokers	
	OR (95% CI)	<i>p</i> Value	OR (95% CI)	<i>p</i> Value	OR (95% CI)	<i>p</i> value
Family characteristics						
Family relationships	0.67 (0.58–0.77)	<.0001	0.24 (0.14–0.41)	<.0001	0.36 (0.21–0.61)	.00
Parental disapproval	0.66 (0.5–0.88)	<.005	0.29 (0.16–0.52)	<.0001	0.43 (0.24–0.77)	.00
Family disharmony	1.53 (1.32–1.77)	<.0001	2.16 (1.36–3.42)	<.005	1.41 (0.89–2.23)	.14
Parental smoking	1.52 (1.28–1.81)	<.0001	1.59 (0.88–2.86)	.12	1.04 (0.58–1.88)	.89
Parental sanctioning of smoking	0.57 (0.33–0.99)	.04	0.44 (0.12–1.54)	.20	0.77 (0.23–2.59)	.67
Peer characteristics						
Peer sanctioning of smoking	0.59 (0.45–0.76)	<.0001	0.28 (0.16–0.48)	<.0001	0.47 (0.28–0.8)	.00
Peer isolation	1.13 (0.98–1.31)	.09	1.24 (0.78–1.96)	.37	1.09 (0.69–1.72)	.71
Friend smoking norm	1.39 (1.2–1.6)	<.0001	5 (2.96–8.44)	<.0001	3.6 (2.14–6.06)	<.0001
School characteristics						
Trouble with teachers	1.33 (1.15–1.53)	<.001	2.07 (1.29–3.32)	<.005	1.56 (0.97–2.5)	.07
Like of school	0.73 (0.6–0.88)	<.001	0.59 (0.35–1.02)	.06	0.82 (0.48–1.39)	.46
Teacher sanctioning of smoking	0.45 (0.26–0.77)	<.005	0.62 (0.14–2.77)	.53	1.38 (0.32–5.88)	.67
GPA	0.87 (0.81–0.93)	<.0001	0.52 (0.43–0.63)	<.0001	0.6 (0.49–0.73)	<.0001
School performance	0.86 (0.8–0.93)	<.0001	0.62 (0.49–0.78)	<.0001	0.72 (0.57–0.9)	.00
Individual characteristics						
Depressive symptoms	1.61 (1.39–1.87)	<.0001	2.78 (1.75–4.41)	<.0001	1.72 (1.09–2.73)	.02
Attitudes toward smoking	1.71 (1.48–1.97)	<.0001	3.43 (2.09–5.63)	<.0001	2.01 (1.23–3.28)	.01
Alcohol drinking	2.09 (1.73–2.51)	<.0001	4 (2.46–6.52)	<.0001	1.92 (1.19–3.09)	.01

Notes. OR = odds ratio; CI = confidence interval.

Nonsmokers was the reference group for comparisons between nonsmokers versus Stable light/occasional smokers or accelerating smokers. Stable light/occasional smokers was the reference group for the comparison of stable light/occasional smokers versus accelerating smokers. Gender, urbanicity, parental education levels, and school enrollment were adjusted in the multinomial logistic regressions.

trajectory patterns in the Chinese adolescent population. This study represents the first longitudinal analysis effort identifying developmental trajectories of cigarette smoking with the distinct developmental courses of smoking initiation and progression in Chinese early adolescents from age 12 to 16 years.

In prior studies among Western populations, multiple distinct trajectories have been reported (Brook et al., 2008; Chassin, Presson, Rose, & Sherman, 2001; Chassin et al., 2008; Colder et al., 2001; Gabrhelik et al., 2012; Metzger et al., 2012; Morin, Rodriguez, Fallu, Maiano, & Janosz, 2012; Orlando et al., 2004; White et al., 2002). Colder et al. (2001) examined smoking behavior during the period of early to middle adolescence (aged 11–16 years) and identified five distinct trajectory patterns that were labeled as stable puffers, stable light smokers, late slow escalators, late moderate escalators, and early rapid escalators (Colder et al., 2001). Several investigators extended their exploration from adolescence to young adulthood. White and associates (2002) identified three distinct smoking trajectories (i.e., non/experimental smokers, occasional/maturing out smokers, and heavy/regular smokers) from a sample of 374 subjects aged from 12 to 30/31 years. Other investigators examined smoking trajectories over a similar age range (e.g., 11–31 years (Chassin, Presson, Pitts, & Sherman, 2000), 13–23 years (Orlando et al., 2004), or 14–32 years (Brook et al., 2008)) with a much larger sample. Either five or six trajectories (e.g., nonsmokers or abstainers, experimenters or occasional smokers, early stables, late starter or stable smokers, stable higher or heavy/continuous smokers, decreaseers or

quitters) were identified with further differentiation of subgroups that varied in initiation, escalation or progression, and regression or quitting of smoking behavior. In our sample, the age range was from 12 to 16 years old. Prevalence of smoking 10 days or less in the past month was 6.8%, whereas prevalence of smoking more than 10 days in the past month was about 1.4%. A substantial proportion of students were either never-smokers (67.2%) or those who ever puffed/smoked but did not smoke in the past month (24.7%). The narrow age range and relatively low smoking prevalence did not enable us to quantify more subgroups of trajectory patterns. Identifying the underlying heterogeneous developmental trajectories during adolescence could advance our knowledge of the natural history of smoking behavior development, which might provide important information for the development of tailored smoking prevention programs (Orlando et al., 2004; Rapkin & Dumont, 2000).

Numerous studies among Western populations have indicated that an adolescent's smoking behavior may be related, in part, to certain individual, family, peer, and school characteristics as described in the Theory of Triadic Inferences. These characteristics include positive attitudes toward smoking (Carvajal, Wiatrek, Evans, Knee, & Nash, 2000; Castrucci, Gerlach, Kaufman, & Orleans, 2002), peer and good friend smoking norm and pressure (Alexander, Piazza, Mekos, & Valente 2001; Sussman, Dent, & Leu 2000; Unger et al., 2002), parental attitude toward smoking and the parent's current smoking status (Carvajal, Hanson, Downing, Coyle, & Pederson,

2004; Castrucci et al., 2002), perceived or actual academic performance (Carvajal et al., 2004; Collins & Ellickson, 2004). Our previous studies within Chinese adolescents, most with cross-sectional designs, replicate some of the findings reported in the Western studies, such as individual attitudes and knowledge of cigarette smoking, personal feelings, and experience of depressive symptoms, influences from parents, peers, and schools (Booker et al., 2007; Grenard et al., 2006; Li et al., 2010; Ma et al., 2008; Shakib et al., 2005; Weiss et al., 2008). In this study, our findings suggest that the trajectory pattern of either stable light/occasional smokers or accelerating smokers was less likely to be found among adolescents with good parent-child or family member relationships, high levels of parental disapproval of smoking, sanctioning of smoking from peers and teachers, high school connectedness, and good GPA and school performance. On the other hand, the trajectory pattern of either stable light/occasional smokers or accelerating smokers was more likely to be found among adolescents with parents who smoke cigarettes, those who came from families with higher disharmony in the environment, perceived higher norms of friend smoking or positive attitudes of smoking behaviors, reported more troubles with teachers, more frequent depressive symptoms, or alcohol drinking. Results of this study extend our previous findings within Chinese adolescents that these multilayered characteristics are not only related to smoking assessed at one point in time but are also predictive of the developmental trajectories of smoking behavior during the period of adolescence (Grenard et al., 2006; Guo et al., 2007, 2010; Ma et al., 2008; Shakib et al., 2005; Unger et al., 2002).

In conclusion, findings of this study help advance knowledge on the distinct developmental courses of smoking behavior among Chinese early adolescents. The study results highlight the importance of the multilayered ecological influences in the etiology and development of smoking behavior by providing empirical support of the linkage between trajectories of smoking behavior assessed over time and their associations with multilayered characteristics. As some of these multilayered characteristics change over time, future research may focus on examining the dynamic interrelationships between these time-variant multilayered characteristics and developmental trajectories of smoking behaviors. For example, we may consider other approaches such as latent transition model may help to address some other research questions, like questions on transitions from one state to another. Advanced analyses exploring the potential mediation and moderation pathways may also help understand the underlying mechanisms of these dynamic interrelationships.

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DECLARATION OF INTERESTS

None declared.

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