A Multilevel Latent Class Analysis of Smoking Stages in Adolescents and Its Predictors

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Abstract- Adolescent smoking status is the powerful predictor for adult smoking where the most people who start smoking at lower ages continue to smoke later. The smoking process is complicated and is not limited to smokers and non-smokers, but includes patterns and different stages that need to be identified and evaluated. The main objectives of the current study were to identify the stages of smoking in adolescents and to assess factors influencing the patterns of smoking in this population. Using the multistage random sampling, 56 high schools with a total of 205 classrooms were randomly selected. The total number of 4907 high school students in Tabriz, Iran participated in the current study and completed a self-administered questionnaire. The multilevel latent class analysis was used in smoking stage determination. Three stages of smoking were identified non-smokers, moderate, and heavy smokers with prevalence 71.3%, 22.4%, and 6.3%, respectively. In gender-specific analysis, such figures were 82.6%, 14.5%, and 2.7% for girls and 77.3%, 15.6%, and 7% for boys, respectively. Age, the grade point average, living with parents, having smoking friends and family, risk-taking behaviors, self-injury, attitude and positive thinking about smoking were significantly associated with smoking stages in students. The social-economic status did not have significant association with the smoking stage. Using multilevel classification technique that considers the hierarchal construct of data, a more reliable stage of smoking was measured in male and female adolescents.

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Keywords: Adolescents; Smoking stages; Multilevel latent class analysis

Introduction

Smoking is a leading cause of death and a main threat to health worldwide (1). According to the World Health Organization (WHO), 5.4 million people die annually from smoking tobacco and cigarette, and it is estimated that this amount will escalate to 8.3 million and account for 10% of all mortality over the globe in 2030 (1,2). Due to the fact that smoking onset was reduced in recent years (3,4), it is important to study the smoking and substance use patterns in adolescences. Based on the study of *Meysami et al.,* (5) the age of starting smoke was from 17.2 to 23.5-year-old in Iran.

Adolescent and young adult smoking status are powerful predictors of adult smoking where the most people who start smoking at lower ages continue to smoke in later years, and the chance of being a smoker has a reverse association with the age of smoking onset (6). Also, by reducing the onset age of smoking, the frequency of smoking increased in adulthood (7).

In spite of the fact that the prevalence of smoking in American adolescences (9^{th} school grade students) declined from 27.5% in 1991 to 19.5% in 2009, it is still a high prevalence (8). Daily Cigarette smoking prevalence among 15-year-old adolescents in seven European countries was between 18.1 to 23.6% (9).

Several types of research showed that the prevalence of cigarette smoking among Iranian students has been increasing in recent years. The prevalence of cigarette smoking in Iranian adolescence has a wide range of 2.5 to 21.8% (5,10-18). The large survey study on Iranian students reported that the smoking prevalence in adolescents was 6.7% (10.1% for boys and 3.4% for girls) (14).

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Researchers in the field of risk behaviors and substance abuse believe that the smoking process is complicated and is not limited to smokers and non-smokers, but includes patterns and different stages that need to be identified and evaluated (19-21).

Latent Class Analysis (LCA) is a powerful statistical approach for categorizing individuals into different and interpretable groups (22). This method has been used in many studies in the fields of psychology, behavioral sciences, medical assessments, lifestyle and substance abuse (23-33). Various studies have been carried out using LCA models to identify the stages of smoking in adolescents and to examine the effects of different factors on the smoking pattern (12,13,19,34).

A study (19) on Iranian high school students identified nine stages of cigarette smoking using the LCA statistical technique. Students were classified in the following 9 groups of smoking: Committer, Immotive, Progressive, Contemplator, Preparatory, and Tried, Experimenter, Regular and Established /daily smokers.

Kaplan's exploratory algorithm (11) which define adolescents in three class of smoking stages, was used in recent studies on the smoking pattern of Iranian adolescents and the impact of demographic, family and social factors on the patterns of smoking was evaluated (10,13,15,35).

Traditional LCA assumes that observations are independent of one another. However, when the data structure includes hierarchal pattern such as students nested within schools and schools nested in districts, these nested data structures leading to dependency among observation within a school or districts. Especially in adolescents, since smoking behavior is influenced by close friends and school conditions (36,37) having homogeneous smoking behaviors within a school is unavoidable. Multilevel models are appropriate for research designs where data organized at more than one level (nested data) (38). Various studies presented a framework to assess LCA with nested data, and multilevel LCA (MLCA) models were offered (39-41). An MLCA study of substance use patterns in adolescents categorized them into three groups of non-users, experimenters and multi-users and superiority of two-level LCA (school was considered as the second level of observations) over LCA was shown in this study (42).

Henry et al., (43) proposed an MLCA to identify cigarette smoking typology of females in 9th grade from 206 rural communities and the effect of potential covariates were examined in predicting latent classes of cigarette smoking. Female students were classified as heavy smokers (14.6%), moderate smokers (24.1%), and nonsmokers (61.3%).

Cigarette smoking is the main health and social problem in teenagers and assessing its patterns is of high importance. Due to inconsistent and wide reports of smoking status and lack of complete and precise information on subgroups of cigarette smokers in Iranian high school teenagers, the current study aimed to identify stages of cigarette smoking using the MLCA statistical methodology based on various indicators of smoking and to assess factors influencing the pattern of smoking in this population.

Materials and Methods

Participants

In this school-based longitudinal study (with 2 waves, during 2010-2012) a total number of 5196 students from the high schools of Tabriz city (North-West of Iran) invited to participate in the study and 4907 students (14-18 years) completed a self-administered questionnaire for the first phase of the study. Using multistage random sampling of the 56 high schools and 205 classes were randomly selected by school type and number of students in each school. More details about sampling can be found elsewhere (15,19).

Measurement tools

The questionnaire had been designed in three sections including: 1) demographic and socio-economic variables (age, school type, the field of study, average grades, socioeconomic status and living with parents), 2) Smoking-related behaviors (substance abuse experience, smoking norms of the family and friends, general risk-taking behaviors, self-esteem, attitude towards smoking and positive thinking about smoking), and section 3) Which includes 4 indicators to recognize the smoking stages.

The general risk-taking behavior was measured using the question "Do you enjoy doing a little risky action?" with "Yes" and "No" response. Self-esteem was measured using the 10-item questionnaire, and scores ranged from 10 to 40 where the lower score show higher self-esteem. The attitude toward smoking was measured through 6 questions and ranged from -12 to +12. The scale of positive thinking to smoking measured with 5 items which asked about positive effects of cigarette smoking and answered each question from "completely agree=5" to "completely disagree=1" and this scale ranged from 5 to 25, which the higher scores indicated more positive attitude toward smoking.

Principal Component Analysis (PCA) was used to

measure the socio-economic status based on the father and mother level of education, the family assets and the family income and students were categorized into five levels of SES from very high (=5) to very low (=1).

According to the studies about the algorithm of smoking stages in adolescents (11,20,21) a questionnaire of the determinants of the smoking stage was developed by *Mohammadpoorasl et al.,* (19) which include 5 indicators as follows: 1. Smoking status at present with the responses of "never," "occasionally" and "every day," 2. Intention to start smoking with the responses of "never," "no within six months" and "no within a month," 3. Smoking in the last month, and 4. Smoking in the last week with "no" and "yes" responses.

The full description of the tools used in this study, the process of content validity (relevancy and clarity percent of the experts) and reliability analysis (inter-consistency and test-retest reliability) of scaled measured were explained and evaluated in the study of *Mohammadpoorasl et al.,* (10,15,44).

Multilevel latent class analysis (MLCA)

In this article, a new statistical methodology, multilevel latent class analysis (MLCA) which overcome the intra-class correlation of the data into higher level of observations (56 high schools) was employed to determine the precise latent classes of cigarette smoking patterns among Iranian high school students. The two-level LCA (students are level-1, and schools are level-2) was conducted in modeling nested structure of multilevel data. The effect of individual (Level 1) covariates included in the model to predict the probability that an individual will belong to a certain latent class (a certain smoking stage).

LCA is conducted with the prior hypothesis about the number of the latent classes. Several proposed models with different class numbers were provided, and the optimal model was selected according to fit indices. Particular fit indices in LCA that determines which model best fits the data were as follows: sample size adjusted Bayesian Information Criterion (BIC), Likelihood Ratio Test (LRT) and Lo-Mendell-Rubin (LMR) test (45). In addition to these criteria, the interpretability of the classes is a key criterion in determining the optimal final model (46).

Three processes of modeling were presented here. 1. The sex-specific and total population LCA, 2. The sex-specific and total population MLCA, and finally 3. The MLCA with covariates that were conducted on the total population. The preliminary statistical analysis was conducted by *IBM SPSS Statistics 22* (47) and MLAC modeling was done by *Mplus 6.1* (48).

Ethical Issues

The confidentiality of student self-report responses have been reassured, and they were informed about the voluntary nature of their participation in the study. The questionnaire was approved by the Ethics Committee of Tabriz University of Medical Sciences and Research Committee of the East Azarbaijan Province Education Organization.

Results

The baseline characteristics of the studied population are displayed in table 1. The sample included 5196 students (56.9% girls) with age of 15.69±0.77 (Min=14, Max=19). Of these students, 94.4% were living with their parents were 39.8% and 18.3% of students' parents, and friends were smoker, respectively. Also, 1.4% of students had history of substance use. All variables had significant relationships with gender (P<0.05), except for status of living with parents, having risk-taking behaviors and self-injury.

The results of multilevel LCA with candidate number of classes of 1 to 6 in total sample and subgroups of gender (results not shown here) indicated that using 3 classes fit the data best. According to the 3 class model with 4 determinants of smoking, the total sample is divided into three different smoking stages as follows:

1. Non-smokers (prevalence=84%), 88.4% of them report that they never smoke at all, they never intend to start smoking (95%), and did not have cigarette smoking at last month or last week.

2. Moderate smokers (prevalence=12.6%) who occasionally smoked. 52.3% over the last month and 1.5% have smoked over the last week, 76 percent of these students report that they never intend to smoke and 23 percent no intended to smoke within six month, and final group is

3. Heavy smokers class (prevalence=3.4%) where 51 percent of whom smoked every day, 98 percent smoked last week, and all smoked last month.

In the MLCA for gender groups, non-smokers, moderate smokers, and heavy smokers constituted prevalence of 82.6%, 14.5% and 2.7% of girls and 77.3%, 15.6% and 7% of boys, respectively. The pattern of 4 indicators at three detected stages of smoking have almost similar definition to total sample analysis. See Table 2 for more details.

Odds Ratios (ORs) and corresponding 95% confidence intervals of covariates are shown in Table 3

where the non-smoker class is considered as the reference category. Age, average grades, living with parents, having smoking friends and family, risk-taking behaviors, self-injury, attitude, and positive thinking about smoking were significantly associated with the smoking pattern in students. Increase in average grades had reverse impact on odds of student being in moderate-smoker (OR=0.86, *P*<0.001) and heavy-smoker (OR=0.80, *P*<0.001) classes compared to the non-smoker group. Odds of being in heavy-smoker class increased significantly for those students who did not live with their parents (OR=2.12, *P*=0.003). Having smoking family increased the odds of being in moderate class by 42% (*P*=0.004) and the odds of being in heavy smoker class by 69% (*P*=0.007). Having smoking friends significantly increased the chance of being in heavy smoker class (OR=15.47, *P*<0.001) and moderate class (OR=3.63, *P*<0.001). Also, positive attitude toward smoking significantly increased the odds of the smoker by 22%. Positive thinking toward smoking was significantly related to moderate smoking (OR=5.58, *P*<0.001) and being heavy smoker (OR=8.38, *P*<0.001). SES did not show significant relation to smoking (*P*>0.05) and history of substance use were excluded from the final model due to so small percentage of students with substance use.

Table 1. Descriptive statistics of demographic and smoking-related variables

Variables	Categories	Girl n=2800	Boy n=2107	Total n=4907	*P*
School	Governmental	2534 (90.5)	1829 (86.8)	4363 (88.9)	< 0.001
	Non-governmental	266 (9.5)	278 (13.2)	544 (11.1)	
Live with parents	No	142 (5.1)	131 (6.2)	273 (5.6)	0.09
	Yes	2652 (94.9)	1968 (93.8)	4620 (94.2)	
Socioeconomic status	Very low	485 (18.7)	432 (22.1)	917 (20.2)	< 0.001
	Low	489 (18.8)	427 (21.9)	916 (20.1)	
	Middle	553 (21.3)	364 (18.6)	917 (20.2)	
	High	546 (21.0)	358 (18.3)	904 (19.9)	
	Very high	524 (20.2)	371 (19.0)	895 (19.7)	
Field of study	Mathematic&physics	614 (21.9)	526 (25.0)	1140 (23.2)	< 0.001
	Emperical science	888 (31.7)	380 (18.0)	1268 (25.8)	
	Humanities	492 (17.6)	264 (12.5)	756 (15.4)	
	Technical&vocational	806 (28.8)	937 (44.5)	1743 (35.5)	
Family smoke	No	1745 (63.1)	1172 (56.4)	2917 (60.2)	< 0.001
	Yes	1020(36.9)	907 (43.6)	1927 (39.8)	
Attitude toward smoke	< -12 (low)	1728 (61.9)	1126 (53.6)	2854 (58.3)	< 0.001
	-12 to -9 (middle)	633 (22.7)	486 (23.1)	1119 (22.9)	
	> -9 (high)	432 (15.5)	489 (23.3)	921 (18.8)	
Risk taking behaviors	No	1171 (42.0)	859 (41.0)	2030 (41.6)	0.50
	Yes	1614 (58.0)	1234 (59.0)	2848 (58.4)	
Self-injury	No	2419 (87.0)	1829 (88.1)	4248 (87.5)	0.27
	Yes	360 (13.0)	246 (11.9)	606 (12.5)	
Friend smoking	No	2554 (91.3)	1453 (69.1)	4007 (81.7)	< 0.001
	Yes	244 (8.8)	651 (30.9)	895 (18.2)	
Substance abuse	No	2759 (99.4)	2041 (97.6)	4800 (98.6)	< 0.001
	Yes	17 (0.6)	50 (2.4)	67 (1.4)	
Age (year)		15.60 ± 0.65	15.81 ± 0.82	15.69 ± 0.73	< 0.001
Average grades		17.33 ± 1.91	15.54 ± 2.22	16.56 ± 2.23	< 0.001
Positive thinking		8.64 ± 3.64	9.22 ± 3.97	8.89 ± 3.80	< 0.001

Table 2. The results of multilevel LCA (3 classes) of smoking stages among total students and gender groups. The prevalence for 3 classes and membership probabilities were reported

A. Total students [#]		**None Smoker**	**Moderate Smoker**	**Heavy Smoker**
Latent Class Prevalence		0.840	0.126	0.034
Smoking status	Never	0.884	0.077	0.056
	Occusionally	0.110	0.803	0.432
	Every day	0.005	0.119	0.509
Intention to start smoking	Never	0.952	0.767	0.715
	No within six months	0.043	0.233	0.244
	No within a month	0.005	0.000	0.042
Smoking in the last month	No	1.000	0.478	0.000
	Yes	0.000	0.523	1.000
Smoking in the last week	No	0.999	0.985	0.019
	Yes	0.001	0.015	0.981
B. Girls *		**None Smoker**	**Moderate Smoker**	**Heavy Smoker**
Latent Class Prevalence		0.826	0.146	0.028
Smoking status	Never	0.925	0.082	0.254
	Occusionally	0.075	0.894	0.486
	Every day	0.000	0.024	0.260
Intention to start smoking	Never	0.955	0.642	0.711
	No within six months	0.038	0.358	0.289
	No within a month	0.007	0.000	0.000
Smoking in the last month	No	1.000	0.608	0.000
	Yes	0.000	0.392	1.000
Smoking in the last week	No	0.999	0.989	0.107
	Yes	0.001	0.011	0.893
C. Boys **		**None Smoker**	**Moderate Smoker**	**Heavy Smoker**
Latent Class Prevalence		0.773	0.156	0.070
Smoking status	Never	0.786	0.060	0.013
	Occusionally	0.191	0.783	0.142
	Every day	0.023	0.157	0.845
Intention to start smoking	Never	0.947	0.882	0.000
	No within six months	0.052	0.118	0.690
	No within a month	0.001	0.000	0.310
Smoking in the last month	No	0.999	0.045	0.000
	Yes	0.001	0.955	1.000
Smoking in the last week	No	0.999	0.672	0.020
	Yes	0.001	0.328	0.982

number of parameteres=22, AIC=9394.2, BIC=9456.9, Log-Likelihood=-4670.1, LMR test for 4 classes vs 3 classes (value = 8.8, P = 0.62) indicates 3 classess is appropriate, Entropy=0.87.

* number of parameteres=22, AIC=3911.1, BIC=4041.37, Log-Likelihood=-1933.6, LMR test for 4 classes vs 3 classes (value = 7.64, P = 1.00) indicates 3 classess is appropriate, Entropy=0.56.

** number of parameteres=22, AIC=5379.0, BIC= 5433.1, Log-Likelihood -2667.5, LMR test for 4 classes vs 3 classes (value = 11.8, P = 0.50) indicates 3 classess is appropriate, Entropy=0.87.

Table 3. The Odds Ratio (95% confidence interval) of covariates in predicting smoking stages of students. The results were calculated from multilevel LCA

Latent Classes		Moderate Smoker		Heavy Smoker	
Prevalence		0.224 #		0.063 #	
Covariates	Categories	OR (95% CI)	*P*-value	OR (95% CI)	*P*
Age		1.02 (0.82-1.26)	0.89	1.58 (1.19-2.09)	0.001
Average grades		0.86 (0.79-0.94)	<0.001	0.80 (0.71-0.91)	0.001
Live with parents	Yes (ref)	-		-	
	No	1.47 (0.73-2.97)	0.28	2.12 (1.06-4.22)	0.033
Social, economic status		0.94 (0.82-1.08)	0.39	0.98 (0.83-1.17)	0.83
Family smoke	No (ref)	-		-	
	Yes	1.42 (1.02-1.97)	0.041	1.69 (1.15-2.46)	0.007
Risk-taking behaviors	No (ref)	-		-	
	Yes	2.97 (1.92-4.59)	<0.001	2.84 (1.51-5.33)	0.001
Self-injury	No (ref)	-		-	
	Yes	2.77 (1.73-4.45)	<0.001	4.71 (2.61-8.49)	<0.001
Friend smoking	No (ref)				
	Yes	3.63 (2.08-6.34)	<0.001	15.47 (8.16-29.31)	<0.001
Positive thinking		1.08 (1.02-1.14)	0.013	1.22 (1.14-1.32)	<0.001
Attitude toward smoke		5.58 (4.16-7.49)	<0.001	8.38 (5.32-13.21)	<0.001

Based on Multilevel LCA with covariates: number of parameteres=42, AIC=7112.9, BIC=7246.3, Log-Likelihood=-3514.5, Entropy=0.78

Discussion

This study was conducted on Iranian high school students to determine whether the certain pattern of cigarette smoking exists in adolescents and to identify factors influencing smoking stages of adolescence. Using MLCA with covariates, our results revealed three latent classes of smoking stages among students:

1. Heavy smokers (6.3%) whom all smoked occasionally or every day, all of these students smoked within last week. 2. Moderate smokers (22.4%) who occasionally smoke, half of them smoked within the last month, and very low percentage of them have smoked over the last week, more than two thirds of them reported that they never intend to smoke and 23 percent with no intention to smoke within six months and 3. the final group is non-smokers (71.3%), who never smoked at all, they never intend to start smoking and did not have cigarette smoking within last month.

In the gender-specific analysis, MLCA resulted in similar three smoking patterns for male and female students. The prevalence of smoking stages of non-smokers, moderate smokers, and heavy smokers were 82.6%, 14.5% and 2.7% for girls and 77.3%, 15.6% and 7% for boys, respectively.

The study of smoking stages assessment (19) presented nine groups of smoking stages in high school students. The number of classes makes it difficult to interpret them. Although all classes were interpretable in this study, it was not statistically justified, and the fit indices for the 9 classes were weaker than the smaller ones.

When identifying the number of classes, there are many studies consistent with our results (18,20,29,43). *Brian et al.*, (34) proposed five interpretable classes of smoking where in addition to the three groups defined in this study, the past experiments and past smoking stage of smoking were defined. *Kaplan et al.*, (11) introduced three stage of smoking that are included 1. Never smoked (adolescents who have never smoked, 2. experimenter (adolescents who have tried cigarette but have smoked less than 100 cigarettes in lifetime and 3. regular smokers (adolescents who have smoked 100 cigarettes and more in lifetime without considering their present consumption). According to Kaplan's definition of cigarette smoking pattern *Ayatollahi et al.*, (10), *Khosravi et al.*, (35) and *Mohammadpoorasl et al.*, (13,15) classified high school students in three mentioned groups of smoking. Kaplan's definition of cigarette is the exploratory methods of population grouping which is

based on the theoretical definition of smoking stages whereas these algorithms may not have a significant and confirmatory determination for identifying smokers or non-smokers.

The prevalence of identified smoking stages in our study was consistent with the school survey study (14) in Iranian high school students that the prevalence of daily smokers was 6.7%. The studies about the smoking stages definition in Iran (10,13,15,35) reported the regular smoker's prevalence from 2.5% to 5%. The non-smoker group in these studies had the prevalence from 77.4% to 79.8%, and the moderate smoker students almost had similar prevalence to our study. It seems that compared to the studies mentioned, our study reduced the number of non-smokers and added to smokers.

In the process of multilevel modeling in this study, it has been revealed that applying the hierarchical structure of the data can improve the model and fit indices for multilevel models displayed, as well as, better fit to the data. These results were similar to the multilevel modeling of smoking typology (43) and substance use pattern (42) studies. *Holmes et al.,* (49) and *Vermunt et al.,* (39,40) and *Asparouhov et al.,* (41) introduced that with large group number in level-2 and high intraclass correlation among observation into higher level leading to better multilevel LCA models than the traditional LCAs which does not considered the nested structure of the data.

Also, the multilevel model with covariates has more appropriate fitness compared to MLCA and LCA models. The entry of covariates increased the predictability of the model and improved the model. The studies about multilevel modeling in LCA confirmed such findings (39,40,43).

In terms of the impact of demographic, parental, peers and smoking related covariates on the stage of smoking in adolescents, having smoker parents and close friends led students to be heavy smokers. Living with parents reduced the odds of being heavy smoker. More studies confirmed these results and introduced that the smoking prevalence was increased by having smoker parents and close friends (10,13,15,50,51).

In this study, SES was not a significant predictor of smoking stages in adolescence. This finding is similar to study of *Mohammadpoorasl et al.,* (15) where displayed that SES was not different among smoker, experimenter and non-smoker students and in another study (13) revealed that SES had no significant impact in the transition from none smoker to experimenter class and experimenter to regular smoker class.

In the study of smoking related factors, consistent to *Mohammadpoorasl et al.,* (15,33), *Khosravi et al.,* (35), *Kaplan et al.,* (11), *Ayatollahi et al.,* (10) and *Kelishadi et al.,* (14), general risk taking behaviors, positive thinking and attitude toward smoking, self-esteem, and self-injury had positive and ascending effects on smoking stage.

Considering the nested structure of data in the present study, the MLCA methods were employed to evaluate and identify the smoking stages in adolocesnts. MLCA as a method of classification with reduction in error variance yields more precise and valid findings. In addition to being multi-level and using the hierarchical structure of data, another major benefit of this study is that by incorprating demographic factors such as social and smoking related behaviours as the covariates in the model, more information can be utilized to estimate probalities and identify the number of smoking classes. In spite of all these benefits, this study is a cross-sectional study of students, thus cannot be used to evaluate causal relationships. A longitudinal study of smoking pattern in Iranian students is necessary to identify more accurate relationships and more valid classes of smoking. Also, this study was conducted in a province of Iran that some socio-economic indicators, family relationships, and smoking restrictions can be differed from other provinces. A larger study that covered all Iranian communities can be more beneficial.

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