SOCIO-DEMOGRAPHIC CHARACTERISTICS OF NICOTINE DEPENDENCE AMONG MALAYSIAN ADOLESCENT SMOKERS

Nawwal Alwani Mohd Radzi[1,2], Roslan Saub[1], Zamros Yuzadi Mohd Yusof[1], Maznah Dahlui[3] and Sharol Lail Sujak[4]

[1]Department of Community Oral Health and Clinical Prevention, Faculty of Dentistry, University of Malaya, Kuala Lumpur; [2]Centre of Population Oral Health and Clinical Prevention Studies, Faculty of Dentistry, Universiti Teknologi MARA, Sg. Buloh, Selangor; [3]Centre of Population Health, Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur; [4]Department of Community Dentistry, Faculty of Dentistry, Manipal University College Malaysia, Bukit Baru, Malacca, Malaysia

Abstract. It is well established that nicotine dependence could provide information regarding an individual smoking frequency and habits. Here, a cross-sectional study was conducted among students (n = 349) identified as smokers from four secondary schools in Negeri Sembilan, Malaysia. Students (13-17 years of age) completed a self-administrated questionnaire that sought to understand their smoking patterns and self-reported nicotine dependence level, the latter ascertained from scores of a Hooked on Nicotine Checklist (HONC). The survey revealed the majority of adolescent smokers were male (~93%), both among students attending urban and rural schools, and came from households with a total monthly income of ≤MYR 3,900 (USD 933) (low income bracket). Mean ± standard deviation (SD) HONC score for adolescents from rural schools was higher (3.1 ± 2.8) compared to those attending urban schools (2.3 ± 2.4). Multiple logistic regression analysis revealed independent factors associated with nicotine dependence were male gender, exhaled breath carbon monoxide level of ~1 ppm, perceived ability to quit smoking, and requirement of assistance to quit smoking. These results should provide insights into problems that need to be addressed in improving smoking prevention programs targeting students, in particular taking into account differences in smoking behavior between those attending schools located in rural and urban settings.

Keywords: addiction, nicotine, adolescence, Hooked on Nicotine Checklist, smoking

Correspondence: Roslan Saub, Department of Community Oral Health and Clinical Prevention, Faculty of Dentistry, University of Malaya, Kuala Lumpur 50603, Malaysia
Tel: +60 3 796774805; Fax: +60 3 79674532
E-mail: roslans@um.edu.my

INTRODUCTION

According to the World Health Organization (WHO), tobacco-related morbidity is estimated to be 8 million people every year (WHO, 2019). Among the Association of Southeast Asian Nations (ASEAN) countries with approximately 2.26 million adolescents, Indonesia has the highest (19.4%) prevalence of young smokers (13-15 years of age), followed by Malaysia (18.2%), then Thailand (11.3%), Brunei (11%), and Singapore (6%) (Tan and Dorotheo, 2016).

In Malaysia, the prevalence of current smokers among adolescents (13-17 years of age) is 13.8% and 68.4% began smoking before 14 years of age (IPH, 2017). These statistics have raised public health concern as to the effectiveness of the national tobacco control or related policy in preventing tobacco consumption among the Malaysian population, especially among children and young adults (Tohid *et al*, 2012). This concern appears in several other nicotine dependency research on demographic characteristics (Islam *et al*, 2019, Lim *et al*, 2019a). For example, The National Tobacco and E-cigarette Survey Among Malaysian Adolescents (TECMA) conducted in 2016 found several key characteristics of nicotine dependence among the adolescents, such as nicotine dependence being exhibited by 28.5% of adolescent smokers and 25% of adolescent female smokers having first experience with cigarette smoking at ≤7 years of age (IPH, 2016).

TECMA 2016 report uses a Heaviness of Smoking Index (HSI) to measure self-reported nicotine dependence (Kozlowski *et al*, 1994), which employs two questions from an earlier Fagerstrom Test for Nicotine Dependence (Fagestrom and Schneider, 1989). HSI uses a six-point scale to stratify answers to queries regarding the number of cigarettes smoked per day (1-10, 11-20, 21-30, and >31) and the time following waking to smoking the first cigarette (≤5, 6-30, 31-60, and >61 minutes), and based on the sum of the two answers, a nicotine dependence level is then categorized into three levels: low (0-1), medium (2-4) and high (5-6) (Kozlowski *et al*, 1994). Furthermore, other studies showed that individuals with an early introduction to cigarette smoking display higher nicotine dependence levels that correlate with lower success in discarding the habit and a higher tobacco-related morbidity (Chassin *et al*, 1990; O'Loughlin *et al*, 2017).

Factors contributing to an increase in adolescent smokers in developing and developed countries are not dissimilar (Joung and Chung, 2019; Tate *et al*, 2021). Early childhood and adolescent exposures to cigarettes are perceived to have primarily resulted from social impact of peer pressure (Perry, 1999). Four factors, namely, socio-demographic, environmental, behavioral, and personal factors,

influence adolescents to start smoking (US Department of Health and Human Services, 2012; Ling *et al*, 2019; Lim *et al*, 2019b; Joung and Chung, 2019; Tate *et al*, 2021). Tohid *et al* (2012) pointed out that among the various factors that influence adolescent smokers, personal factors such as cunning behaviour of the adolescent, poor self-efficacy to overcome nicotine addiction and low self-esteem are the two most prevalent factors. In addition, adolescents are at risk from the tobacco industry, which focuses on this age group through systematic market targeting and influencers (Assunta and Chapman, 2004). Thus, adolescent smokers are viewed as a potentially significant consumer segment for the tobacco industry sustainability (Perry, 1999; Pollay, 2000).

Milton *et al* (2008) reported that factors for initial engagement of adolescent smokers are multiple. Smoking among Malaysian adolescents continue to rise, with a prevalence of 10% among secondary school age range (IPH, 2017). An earlier local study investigating the effects of existing domestic national smoking cessation programs, especially those targeting adolescent smokers, revealed, among a number of reasons, the ineffectiveness of the national campaigns is due to an inadequacy in content of the delivered message, particularly the deficiency of information on ways to quit smoking (Tohid *et al*, 2012).

The level of nicotine exposure and subsequent dependency in adults is measured using the Fagerstrom Test for Nicotine Dependence (FTND) (Fagerstrom and Schneider, 1989). Poorthuis *et al* (2009) suggested that exposure to nicotine during pregnancy has a lasting effect on the development of prenatal brain. A more recent research on nicotine dependence has established the general premise that adult nicotine dependence results from prolonged exposure that leads to nicotine addiction (Sargent *et al*, 2017). DiFranza *et al* (2000) suggested that adolescents show signs of nicotine addiction within days of first exposure to smoking. DiFranza *et al* (2000) also pointed out the typical smoking patterns among adolescent smokers depend on environmental factors, such as school regulations and parental guidance at home. In order to ensure effectiveness and efficacy of smoking policy for adolescents, Wiium and Wold (2006) suggested that parental control and norms at home can help to support non-smoking policy and regulations at school.

In addition to FTND that measures level of nicotine dependence among adults, a tool "Hooked on Nicotine Checklist" (HONC) that examines factors of nicotine addiction among adolescents has been employed (DiFranza *et al*, 2002; O'Loughlin *et al*, 2003). While much is known about adolescents smoking risk factors, limited research has focused on factors that influence the severity of their

nicotine dependency especially among Malaysian adolescents. Here, the present study examined the association between demographical factors and nicotine addiction among adolescent Malaysian smokers. The findings of this study could potentially improve the current mitigation efforts by the government concerning the tobacco-control policy toward adolescents

MATERIALS AND METHODS

Participants recruitment and location

This was a school-based cross-sectional study carried out from March to April 2019. Stratified sampling was employed among the daily public schools in urban and rural localities of the district of Seremban, Negeri Sembilan, an autonomous administrative state 50 km south of Kuala Lumpur, Malaysia. In 2019, Negeri Sembilan's ethnic composition and monthly household income were comparable with the national average (DOSM, 2020). Two schools were randomly selected from each locality. Same-gender and vernacular schools were excluded from the study. Inclusion criteria of participants were having a smoking habit, medically fit and healthy. Calculation for sample size utilized a G* Power Statistical Analysis software version 3.1.9.3 (Faul *et al*, 2007), with an α value, desired power and effect size of 0.05, 0.80 and 0.3, respectively (Flay, 2009). The calculated sample size was 350 with a possibility of 15% dropout rate (Hansen *et al*, 1985).

Ethical approval to conduct this study was obtained from the Faculty of Dentistry, University of Malaya (DFCO1811/0080[P]0), the Ministry of Education's Educational, Planning and Research Division (KPM.600-3/2/3-ERAS (2336), the Negri Sembilan Oral Health Director's Office (JKNNS.G.600-56/5/5/(76), and the Seremban's District Education Office [JPNS.SPS.PP.100-1/7.Jld.19(24)]. The study was also registered with the National Medical Research Registry (NMRR-18-3415-44030) and the ClinicalTrials.gov Protocol Registration Systems (ID NCT04378725). Administrators of the selected public schools provided permission to conduct the study. Prior written consent was obtained from parents or legal guardians of each participant. Participants were assured of anonymity of data collected, which were not to be shared with their parents, peers and teachers.

Study instrument

The study used a self-administered questionnaire designed to collect information on socio-demographic characteristics, smoking habits and patterns, and self-reported nicotine dependency. Items on the respondent's nicotine exposure and tobacco habits were modified from the Global Youth Tobacco Survey Core Questionnaire guide (GYTS Collaborative Group, 2012) and on nicotine dependency

adapted from the Hooked on Nicotine Checklist (HONC) (DiFranza *et al*, 2002). HONC lists ten items with specific scores, which determine the level of nicotine dependence based on the loss of an individual's autonomy over cigarette smoking (HONC ≥1). HONC was translated from English to Malay verbatim and two experts on dental health commented on the contents validity. The reviewed Malay HONC version was amended by the National Translation Institute, Malaysia and then translated back to English by two language experts, each from a different university. This English version was then compared to the original version for both linguistic and semantic accuracy and the final Malay HONC version was again checked for any other conceptual and pragmatic issues before being applied in the study.

Exhaled breath carbon monoxide (CO) assay

In order to confirm a participant smoking status, exhaled breath CO level was measured using a breath analyzer (Smokerlyzer; Bedfont Scientific Instruments, Upchurch, UK). Exhaled breath CO level of 5-6 ppm is categorised as light smoker and ≥7 ppm as frequent smoker (Sargent *et al*, 2017).

Data analysis

Descriptive and categorical data are reported as frequency and percentage. Nicotine dependence is recorded as a dichotomous variable, ie, no addiction = 0, addicted = 1. Chi-square test was employed to examine the relationship between socio-demographic factors and smoking characteristics. Simple and multiple logistic regression analyses were utilised to identify factors associated with nicotine dependence. A p-value <0.05 is considered significant. Calculations were carried out using a Statistical Package for the Social Sciences (SPSS) version 22 software package (IBM, Chicago, IL).

RESULTS

Adolescent smokers (n = 349) attending daily public schools in the district of Seremban, Negeri Sembilan, Malaysia from March to April 2019 were enrolled in the study. Participants were 14.5 ± 1.3 years of age, 28% in Form 3 (15 years of age under the Malaysian education law) (Ministry of Education Malaysia, 2013), 78% of Malay ethnicity, 63% attending schools located in rural regions of Seremban, 84 and 79% with mother and father respectively having secondary or lower education level, and 77% from families with a monthly household income of ≤MYR 3,900 (USD 933) (Table 1). Significantly higher proportions of participants attending rural schools were of Malay ethnicity and had mothers and fathers with secondary or lower education level (Table 1).

Survey of smoking characteristics of the participants revealed a mean HONC score (a measurement of nicotine dependency severity) of >1.0

Table 1

Socio-demographics of adolescent participants attending daily public schools in Seremban district, Negeri Sembilan, Malaysia (March - April 2019)

Characteristic	Urban location (N = 129)	Rural location (N = 220)	Total (N = 349)	*p*-value*
Mean age ± SD, years	14.4 ± 1.3	14.5 ± 1.3	14.5 ± 1.3	0.388[a]
School class (age in years), *n* (%)				0.075[b]
Form 1 (13)	18 (14)	29 (13)	47 (13.5)	
Form 2 (14)	24 (19)	51 (23)	75 (21.5)	
Form 3 (15)	47 (36)	50 (23)	97 (28)	
Form 4 (16)	17 (13)	40 (18)	57 (16)	
Form 5 (17)	23 (18)	50 (23)	73 (21)	
Gender, *n* (%)				0.824[b]
Male	120 (93)	206 (94)	326 (93)	
Female	9 (7)	14 (6)	23 (7)	
Ethnicity, *n* (%)				0.031[c]
Malay	97 (75)	176 (80)	273 (78)	
Chinese	0 (0)	8 (4)	8 (2)	
Indian	30 (23)	33 (15)	63 (18)	
Others	2 (2)	3 (1)	5 (2)	

Table 1 (cont)

Characteristic	Urban location (N = 129)	Rural location (N = 220)	Total (N = 349)	*p*-value*
Father's education, *n* (%)				0.039[b]
Up to secondary school	91 (73)	178 (83)	269 (79)	
University	33 (27)	37 (17)	70 (21)	
Mother's education, *n* (%)				0.003[b]
Up to secondary school	95 (76)	190 (88)	285 (84)	
University	30 (24)	25 (12)	55 (16)	
Monthly household income (MYR), *n* (%)				0.825[b]
≤3,900	95 (75)	166 (78)	261 (77)	
3,900-8,300	24 (19)	39 (18)	63 (18)	
>8,300	7 (6)	9 (4)	16 (5)	

*Significant at $p < 0.05$

[a]Man-Whitney U test; [b]Pearson chi-square test; [c]Fisher's exact test

MYR: Malaysian Ringgit (MYR 4.18 = USD 1.00); SD: standard deviation

(indicative of loss of autonomy towards nicotine) with a significantly higher score among adolescents attending rural schools, 77% regarded themselves as addicted to nicotine, 42% started smoking at 12-13 years of age, 50% took up smoking due to peer influence, 26% preferred to smoke at home and significantly more from urban than rural schools at malls and food stalls, 73% came from families who smoked, 81% tried to quit smoking during the previous year, some 80% intended (significantly higher proportion from urban than rural schools) or considered themselves capable of quitting smoking, with 61% expressing no need of assistance (Table 2).

Simple logistic analysis showed among adolescent smokers significant associations with male gender, breath CO level of ~1 ppm (occasional smoker), having friends who smoked, and wish, ability but need for help to quit smoking, and not confident with abstinence in the future (Table 3). Applying multiple logistic regression analysis, independent association factors were male gender, breath CO level of ~1 ppm, ability to quit smoking, and need for help to quit smoking.

DISCUSSION

Adolescents are particularly susceptible to nicotine addiction (Rojas *et al*, 1998). The current research findings on smoking habits and nicotine addiction were conducted among secondary schoolchildren in Negeri Sembilan, Malaysia. The majority of adolescent smokers reported one or more symptoms of loss of autonomy over nicotine use, with 72% reporting nicotine dependence, in agreement with a previous study conducted among adolescent smokers in Kuala Lumpur reporting 78.7% nicotine dependence (Nur Atikah *et al*, 2019).

Globally, public health research utilizing HONC on nicotine dependence among adolescent smokers found a lower prevalence of nicotine dependence ranging from 39.7% (DiFranza *et al*, 2002) to 46% (Kanyoni *et al*, 2015) compared to data from Malaysia, but a higher percentage (87.9%) was reported from Australia (Guo *et al*, 2010). The wide variation in prevalence could be due to differences in definition of age range of adolescents (between 10 to 19 years of age) in each study. There is a gradual rise in HONC score with increase of adolescent age (Nur Atikah *et al*, 2019; Islam *et al*, 2019), reaching a HONC score of 7.1 ± 2.7 when study subjects enter into adulthood (Wellman *et al*, 2005) with 98.9% fulfilling one category listed in HONC (Wellman *et al*, 2006).

Mean HONC score of adolescent smokers attending rural schools is significantly higher than that of those in urban schools. Higher levels of nicotine dependence among lower socio-demographic and economic status of smokers have been reported (Rozi *et al*, 2007; Guo *et al*, 2010; Islam *et al*, 2019). The majority of adolescent

Table 2

Smoking characteristics of adolescent participants attending daily public schools in Seremban district, Negeri Sembilan, Malaysia (March - April 2019)

Characteristic	Urban school (N = 129)	Rural school (N = 220)	Total (N = 349)	*p*-value*
Hooked on Nicotine Checklist score, mean ± SD	2.3 ± 2.4	3.1 ± 2.8	2.8 ± 2.7	0.014[a]
Nicotine dependence status, *n* (%)				0.079[b]
Not Addicted	36 (28)	43 (20)	79 (23)	
Addicted	93 (72)	175 (80)	268 (77)	
Began smoking (age in years), *n* (%)				0.789[b]
≤7	5 (4)	9 (4)	14 (4)	
8-9	8 (6)	12 (6)	20 (7)	
10-11	20 (16)	36 (17)	56 (16)	
12-13	51 (40)	94 (44)	145 (42)	
14-15	38 (30)	50 (23)	88 (26)	
≥16	5 (4)	13 (6)	18 (5)	
Reason for taking up smoking, *n* (%)				0.721[b]
Peer influence	70 (55)	104 (48)	174 (50)	
Family member smoker	10 (8)	21 (10)	31 (9)	
Emotional stress	16 (13)	28 (12)	44 (13)	
Curiosity	26 (20)	56 (26)	82 (24)	
Other	5 (4)	9 (4)	14 (4)	

Table 2 (cont)

Characteristic	Urban school (N = 129)	Rural school (N = 220)	Total (N = 349)	*p*-value*
Usual smoking place, *n* (%)				0.026[b]
Within own house and/or premise	28 (22)	64 (29)	92 (26)	
School premise	16 (12)	50 (23)	66 (19)	
Mall and/or food stall	24 (19)	32 (14)	56 (16)	
Friend and/or neighbor house	9 (7)	7 (4)	16 (5)	
Open space (playground and/or public space)	40 (31)	47 (21)	87 (25)	
Hidden location	12 (9)	20 (9)	32 (9)	
Family member who smokes, *n* (%)				0.049[b]
Yes	100 (79)	151 (70)	251 (73)	
No	26 (21)	66 (30)	92 (27)	
Attempt to quit smoking in past 12 months, *n* (%)				0.233[b]
Yes	108 (84)	171 (79)	279 (81)	
No	20 (16)	45 (21)	65 (19)	
Intention to quit smoking, *n* (%)				0.006[b]
Yes	110 (87)	162 (74)	272 (79)	
No	17 (13)	57 (26)	74 (21)	
Perceived ability to quit smoking, *n* (%)				0.038[b]
Yes	110 (86)	168 (77)	278 (80)	
No	18 (14)	51 (23)	69 (20)	

Table 2 (cont)

Characteristic	Urban school (N = 129)	Rural school (N = 220)	Total (N = 349)	*p*-value*
Requires assistance to quit smoking, *n* (%)				0.114[b]
Yes	43 (34)	93 (42.5)	136 (39)	
No	84 (66)	126 (57.5)	210 (61)	

*Significant at $p < 0.05$

[a]Man-Whitney U test; [b]Pearson chi-square test; [c]Fisher's exact test

SD: standard deviation

Table 3

Factors associated with nicotine dependence among adolescent participants attending daily public schools in Seremban district, Negeri Sembilan, Malaysia (March - April 2019).

Factor	Simple logistic regression analysis		Multiple logistic regression analysis	
	cOR (95% CI)	*p*-value*	aOR (95% CI)	*p*-value*
Age	0.99 (0.82-1.20)	0.977		
Gender				
Male	2.84 (1.19-6.76)	0.018	5.00 (1.67-15.00)	0.004
Female[†]	1.00		1.00	
School locality				
Urban[†]	1.00	0.080		
Rural	1.57 (0.94-2.62)			

Table 3 (cont)

Factor	Simple logistic regression analysis		Multiple logistic regression analysis	
	cOR (95% CI)	*p*-value*	aOR (95% CI)	*p*-value*
Ethnicity				
Malay†	1.00			
Chinese	2.34 (0.28-19.4)	0.409		
Indian	1.77 (0.85-3.68)			
Mother's education				
Up to secondary school	1.70 (0.90-0.23)	0.102		
Degree (University)†	1.00			
Father's education				
Up to secondary school	1.07 (0.57-2.01)	0.827		
Degree (University)†	1.00			
Monthly household income				
≤MYR 8,300	1.14 (0.35-3.64)	0.823		
>MYR 8,300†	1.00			
Carbon monoxide reading (ppm)#	1.32 (1.14-1.53)	<0.001	1.27 (1.05-1.54)	0.013
Age of the first attempt to smoke				
Before the age of 10	0.79 (0.35-1.78)	0.575		
After the age of 10†	1.00			

Table 3 (cont)

Factor	Simple logistic regression analysis		Multiple logistic regression analysis	
	cOR (95% CI)	*p*-value*	aOR (95% CI)	*p*-value*
Causative factor for taking up smoking				
Friend†	1.00	0.042	1.00	0.099
Family	10.15 (1.34-76.65)		8.46 (1.04-68.38)	
Stress	1.78 (0.74-4.30)		1.62 (0.54-4.87)	
Curiosity	0.67 (0.38-1.20)		0.60 (0.29-1.24)	
Family member who smoke				
Yes	1.11 (0.63-1.95)	0.716		
No†	1.00			
Do you want to quit now?				
Yes†	1.00	<0.001	1.00	0.056
No	0.11 (0.03-0.36)		3.84 (0.96-15.34)	
Do you think you can quit?				
Yes†	1.00	0.001	1.00	0.006
No	4.66 (1.80-12.04)		7.18 (1.76-29.2)	
Do you need help quitting?				
Yes	4.69 (2.42-9.09)	0.001	5.74 (2.73-12.06)	<0.001
No†	1.00		1.00	

Table 3 (cont)

Factor	Simple logistic regression analysis		Multiple logistic regression analysis	
	cOR (95% CI)	*p*-value*	aOR (95% CI)	*p*-value*
Do you think you can smoke in the future?				
Yes	3.09 (1.62-5.89)	0.001	2.09 (0.97-4.52)	0.059
No[†]	1.00			

*Significant at $p < 0.05$

[†]Reference group; [#]Breath analyzer device (Smokerlyzer; Bedfont Scientific Instruments, Upchurch, UK)

aOR: adjusted odds ratio; CI: confidence interval; cOR: crude odds ratio; MYR: Malaysian Ringgit (MYR 4.18 = USD 1.00); ppm: parts per million

smokers in Negeri Sembilan were from families with a monthly income below the median household income of the bottom 40% of income earners in Malaysia (DOSM, 2020). On the other hand, a Rwandan study of adolescent smokers demonstrated a correlation between lower nicotine dependence and lower rural socio-demographics and economic status (Kanyoni *et al*, 2015). This is to be expected given disparities in education level, school policy and/or students and parents attitudes towards smoking and addiction (Guo *et al*, 2010).

A Pakistani study indicated adolescent smokers in Karachi with uneducated parents are at a higher risk of nicotine addiction than those with parents having a formal education (including parents with a university degree) (Rozi *et al*, 2007). Our study showed a similar correlation.

A higher percent student population from rural compared to urban schools smoked at school premises, while a larger proportion attending urban schools preferred to smoke in shopping malls and food stalls. Leão *et al* (2019) in Portugal observed 40% of students in the least affluent areas smoke at the school gate compared to 38% in the more affluent regions. In the Netherlands, adolescents in vocational schools reported they smoke outside their school premises at specified designated smoking areas (Schreuders *et al*, 2019).

In the determination of adolescents nicotine dependence a correlation was shown with family members nicotine dependence. Several studies have shown a strong link between parents who smoke with their children nicotine exposure and subsequent dependence. This is consistent with other studies that illustrate the same correlation between parental or familial smoking habits and that of the adolescent's own exposure and subsequent dependence (Lim *et al*, 2014; Kandel *et al*, 2015; Lim *et al*, 2017; Lim *et al*, 2019b; Ling *et al*, 2019).

Male gender was an independent association factor of adolescence nicotine dependence, as observed in studies conducted elsewhere in Malaysia (Rojas *et al*, 1998; Kanyoni *et al*, 2015; Nur Atikah *et al*, 2019; Islam *et al*, 2019). A possible explanation is that the smoking habit is more culturally acceptable among males than females (Kalaboka *et al*, 2008).

An indicator of nicotine dependence is the intention to quit smoking (Ramo *et al*, 2010). Ramo *et al* (2010) reported that a higher intention to quit smoking could be related to a higher smoking cessation self-efficacy among smokers with a lower level of nicotine addiction. Previously, Bancej *et al* (2007) noted that almost all adolescent smokers, regardless of demographics, report a high occurrence of relapse within six months of their attempt to quit smoking. However, we found no significant relationship between intention to quit and nicotine dependence. Additionally, exhaled breath CO level among adolescents was indicative of low frequency of smoking, consistent with their nicotine dependence status, as has been reported in an earlier study conducted in Kuala Lumpur (Nur Atikah *et al*, 2019).

One limitation of our study was that a causal relationship cannot be established from the data, analysis of which produced binary outcomes that are not comprehensive or sufficiently conclusive to indicate the gravity of nicotine dependence among participants.

In conclusion, nicotine addiction among adolescents in the district of Seremban, Negeri Sembilan, Malaysia was independently associated with male gender, breath CO level of ~1 ppm, perceived ability to quit smoking, and need for help to quit smoking. These findings are critical factors that need to be taken into consideration in future smoking cessation programs, particularly the differences in smoking behavior between adolescents attending schools in rural and urban settings. Our study also provides new opportunities for future research into markers of nicotine use in biological specimens, such as saliva, to validate self-reported nicotine addiction. In addition, our study also highlighted the need to review current national policies in tobacco control targeted at students.

ACKNOWLEDGEMENTS

The authors are very grateful to the University of Malaya, the Ministry of Health and the Ministry of Education, Malaysia for approval to conduct the study. The authors thank the University of Malaya for funding this study through the LRGS-NanoMITe (RU029-2014 and RU029A-2019) research grant. The views expressed in this article are those of the authors and do not necessarily reflect the policies of any organization.

CONFLICTS OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

Assunta M, Chapman S. Industry sponsored youth smoking prevention programme in Malaysia: a case study in duplicity. *Tob Control* 2004; 13 (Suppl 2): ii37-42.

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.

Chassin L, Presson CC, Sherman SJ, Edwards DA. The natural history of cigarette smoking: predicting young-adult smoking outcomes from adolescent smoking patterns. *Health Psychol* 1990; 9: 701-16.

DiFranza JR, Rigotti NA, McNeill AD, *et al*. Initial symptoms of nicotine dependence in adolescents. *Tob Control* 2000; 9: 313-9.

DiFranza JR, Savageau JA, Fletcher K, *et al*. Measuring the loss of autonomy over nicotine use in adolescents: the DANDY (Development and Assessment of Nicotine Dependence in Youths) study. *Arch Pediatr Adolesc Med* 2002; 156: 397-403.

Department of Statistics Malaysia (DOSM). Demographic Statistics Fourth Quarter 2019 Malaysia, 2020 [cited 2020 Apr 20]. Available from: URL: https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=UDc0e-VJ4WEJiYmw0Rmt5cjYvWHFkdz09

Fagerstrom KO, Schneider NG. Measuring nicotine dependence: a review of the Fagerstrom Tolerance Questionnaire. *J Behav Med* 1989; 12: 159-82.

Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007; 39: 175-91.

Flay BR. School-based smoking prevention programs with the promise of long-term effects. *Tob Induc Dis* 2009; 5: 6.

Global Youth Tobacco Survey Collaborative Group (GYTS Collaborative Group). Global Youth Tobacco Survey (GYTS) Collaborative Group: Core Questionnaire with Optional Questions Version 1.0, 2012 [cited 2019 Oct 07]. Available from: URL: https://nccd.cdc.gov/GTSSDataSurveyResources/Ancillary/DownloadAttachment.aspx?ID=33

Guo H J, McGee R, Reeder T, Gray A. Smoking behaviours and contextual

influences on adolescent nicotine dependence. *Aust N Z J Public Health* 2010; 34: 502-7.

Hansen WB, Collins LM, Malotte CK, Johnson CA, Fielding JE. Attrition in prevention research. *J Behav Med* 1985; 8: 261-75.

Institute for Public Health (IPH). National Health and Morbidity Survey (NHMS) 2017: Adolescent Health 2017, 2017 [cited 2019 Jun 01]. Available from: URL: https://iku.moh.gov.my/images/IKU/Document/REPORT/NHMS2017/AHSReportNHMS2017.pdf

Institute for Public Health (IPH). Tobacco & E-Cigarette Survey Among Malaysian Adolescents (TECMA) 2016, 2016 [cited 2019 Jun 01]. Available from: URL: https://iku.moh.gov.my/images/IKU/Document/REPORT/TECMA2016/TabaccoandECigarette.pdf

Islam K, Datta AK, Seth S, Roy A, Das R. A study on the prevalence and correlates of nicotine dependence among adolescents of Burdwan Town, West Bengal. *Indian J Psychiatry* 2019; 61: 89-93.

Joung KH, Chung SS. Factors affecting cigarette smoking among adolescents in South Korea, Vietnam, and Thailand. *J Spec Pediatr Nurs* 2019, 24: e12267.

Kalaboka S, Piau J, King G, Moreau D, Choquet M, Annesi-Maesano I. Sex and gender differences in tobacco smoking among adolescents in French secondary schools. *Monaldi Arch Chest Dis* 2008; 69: 142-51.

Kandel DB, Griesler PC, Hu MC. Intergenerational patterns of smoking and nicotine dependence among US adolescents. *Am J Public Health* 2015; 105: e63-72.

Kanyoni M, Gishoma D, Ndahindwa V. Prevalence of psychoactive substance use among youth in Rwanda. *BMC Res Notes* 2015; 8: 190.

Kozlowski LT, Porter CQ, Orleans CT, Pope MA, Heatherton T. Predicting smoking cessation with self-reported measures of nicotine dependence: FTQ, FTND, and HSI. *Drug Alcohol Depend* 1994; 34: 211-6.

Leão T, Kunst AE, Schreuders M, *et al*. Adolescents' smoking environment under weak tobacco control: a mixed methods study for Portugal. *Drug Alcohol Depend* 2019; 204: 107566.

Lim KH, Chong Z, Khoo YY, Kaur J. Parental smoking status, stress, anxiety, and depression are associated with susceptibility to smoking among non-smoking school adolescents in Malaysia. *Asia Pac J Public Health* 2014; 26 (5 Suppl): 81S-90S.

Lim KH, Ghazali SM, Lim HL, *et al*. Smoking susceptibility among non-smoking school-going adolescents in Malaysia: findings from a national school-based survey. *BMJ Open* 2019a; 9: e031164.

Lim KH, Lim HL, Teh CH, *et al*. Smoking among school-going adolescents in selected secondary schools in Peninsular Malaysia-findings from the Malaysian Adolescent Health Risk Behaviour (MyaHRB) study. *Tob Induc Dis* 2019b; 15: 9.

Ling MYJ, Rodzlan Hasani WS, Mohd Yusoff MF, *et al*. Cigarette smoking among secondary school-going male adolescents in Malaysia: findings from the National Health and Morbidity Survey: Adolescent Health Survey 2017. *Asia Pac J Public Health* 2019; 31 (8 Suppl): 80S-87S.

Milton B, Woods S, Dugdill L, Porcellato L, Springett R. Starting young? Children's experiences of trying smoking during pre-adolescence. *Health Educ Res* 2008; 23: 298-309.

Ministry of Education Malaysia. Malaysia Education Blueprint 2013-2025 (Preschool to post-secondary education), 2013 [cited 2021 Jun 01]. Available from: URL: https://www.moe.gov.my/menumedia/media-cetak/penerbitan/dasar/1207-malaysia-education-blueprint-2013-2025/file

Nur Atikah AH, Wee LH, Nur Zakiah MS, *et al*. Factors associated with different smoking statuses among Malaysian adolescent smokers: a cross-sectional study. *BMC Public Health* 2019; 19 (Suppl 4): 579.

O'Loughlin J, DiFranza J, Tyndale RF, *et al*. Nicotine-dependence symptoms are associated with smoking frequency in adolescents. *Am J Prev Med* 2003; 25: 219-25.

O'Loughlin J, O'Loughlin EK, Wellman RJ, *et al*. Predictors of cigarette smoking initiation in early, middle, and late adolescence. *J Adolesc Health* 2017; 61: 363-70.

Perry CL. The tobacco industry and underage youth smoking: tobacco industry documents from the Minnesota litigation. *Arch Pediatr Adolesc Med* 1999; 153: 935-41.

Pollay, RW. Targeting youth and concerned smokers: evidence from Canadian tobacco industry documents. *Tob Control* 2000; 9: 136-47.

Poorthuis RB, Goriounova NA, Couey JJ, Mansvelder HD. Nicotinic actions on neuronal networks for cognition: general principles and long-term consequences. *Biochem Pharmacol* 2009; 78: 668-76.

Ramo DE, Prochaska JJ, Myers, MG. Intentions to quit smoking among youth in substance abuse treatment. *Drug Alcohol Depend* 2010; 106: 48-51.

Rojas NL, Killen JD, Haydel KF, Robinson TN. Nicotine dependence among adolescent smokers. *Arch Pediatr Adolesc Med* 1998; 152: 151-6.

Rozi S, Butt ZA, Akhtar S. Correlates of cigarette smoking among male college students in Karachi, Pakistan. *BMC Public Health* 2007; 7: 312.

Sargent JD, Gabrielli J, Budney A, Soneji S,Wills TA. Adolescent smoking experimentation as a predictor of daily cigarette smoking. *Drug Alcohol Depend* 2017; 175: 55-9.

Schreuders M, Klompmaker L, van den Putte B, Kunst AE. Adolescent smoking in secondary schools that have implemented smoke-free policies: in-depth exploration of shared smoking patterns. *Int J Environ Res Public Health* 2019; 16: 2100.

Tan YL, Dorotheo U. The Tobacco Control

Atlas: ASEAN Region 2016, 3rd ed, 2016 [cited 2020 Jan 08]. Available from: URL: https://seatca.org/dmdocuments/The%20Tobacco%20Control%20Atlas%20ASEAN%20Region%203rd%20Edition%202016.pdf

Tate C, Kumar R, Murray JM, *et al*. Socio-environmental and psychosocial predictors of smoking susceptibility among adolescents with contrasting socio-cultural characteristics: a comparative analysis. *BMC Public Health* 2021; 21: 2240.

Tohid H, Ishak N, Muhammad NA, Ahmad FN, Aziz AA, Omar K. Perceived effects of the Malaysian national tobacco control programme on adolescent smoking cessation: a qualitative study. *Malays J Med Sci* 2012; 19: 35-47.

US Department of Health and Human Services. Preventing tobacco use among youth and young adults. A report of the Surgeon General, 2012 [cited 2020 Jun 08]. Available from: URL: https://www.acosh.org/wp-content/uploads/2016/04/Preventing-Tobacco-Use-Among-Youth-and-Young-Adults.pdf

Wellman RJ, DiFranza JR, Savageau JA, Godiwala S, Friedman K, Hazelton J. Measuring adults' loss of autonomy over nicotine use: The Hooked on Nicotine Checklist. *Nicotine Tob Res* 2005; 7: 157-61.

Wellman RJ, Savageau JA, Godiwala S, *et al*. A comparison of the Hooked on Nicotine Checklist and the Fagerström Test for Nicotine Dependence in adult smokers. *Nicotine Tob Res*. 2006; 8: 575-80.

Wiium N, Wold B. Family and school influences on adolescent smoking behaviour. *Health Educ* 2006; 106: 465-79.

World Health Organization (WHO). WHO report on the global tobacco epidemic, 2019: offer help to quit tobacco use, 2019 [cited 2021 Jul 21]. Available from: URL: https://www.who.int/publications/i/item/9789241516204