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Prevalence, risk factors, and protective factors of tobacco use among school-going adolescents at drug-abuse hot-spots in Malaysia

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ABSTRACT

The high prevalence rate of tobacco consumption among teenage school students has become a global issue with profound implications for their developmental trajectory. Research conducted at drug-abuse hot-spots as a proximal factor related to tobacco use has been limited. Therefore, the present study examined the prevalence, risk factors, and protective factors of tobacco use among adolescents at drug-abuse hot-spots in Malaysia. Through stratified random sampling, the nationwide sample comprised 3382 school-going adolescents (71.4% male; mean age = 15.35 years [SD = 2.79]). The prevalence of tobacco use was 19.0% for current use and 28.5% for lifetime use. Stepwise logistic regression analysis showed that being male, being an older adolescent, living in urban areas, living many years in the hot-spot area, parental divorce, and having a high external locus of control were significant risk factors for tobacco use. High internal locus of control and good problem-coping skills were protective factors for tobacco use. Policy implications and suggestions for future research are discussed for the prevention and intervention of tobacco use among school-going adolescents.

1. Introduction

Tobacco use among adolescents has become a global public health concern, with significant implications for both physical and mental health outcomes (Basiru et al., 2024; Bilano et al., 2015; Buu et al., 2021; Chun, 2020; Das, 2022; Gurillo et al., 2015; Matuszka et al., 2017; Secades-Villa et al., 2024; Thepthien et al., 2023), as well as academic achievement (Ellis-Suriani et al., 2021; Pei et al., 2020). Despite efforts to curb tobacco use, the prevalence of cigarette smoking among students remains a global concern (Ling et al., 2020; Nordin et al., 2022; Owopetu et al., 2022; Pei et al., 2020; Peltzer & Pengpid, 2018; Reitsma et al., 2021; Warren et al., 2006). In Malaysia, as in many other countries, addressing tobacco use among adolescents remains a complex challenge (Bland et al., 2021; Chan & Adnan, 2020).

Tobacco use among Malaysian adolescents includes a range of products, from conventional cigarettes to emerging forms such as e-cigarettes and vaping devices, which have gained popularity in recent years. According to the National Health and Morbidity Survey (NHMS) 2022, approximately 6.2% of school-going adolescents reported current cigarette smoking, and 14.9% reported current use of e-cigarettes or vapes. These trends underscore the need for a comprehensive definition of tobacco use that includes both traditional and newer nicotine delivery systems when studying youth populations. The use of any tobacco products among adolescents in Malaysia in 2022 was 18.5%, reflecting a

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slight decline from 20.9% in 2017. However, the prevalence of current tobacco product use among Malaysian adolescents remains high compared to Indonesia (13.6%), Thailand (14.4%), the Philippines (15.8%), and Brunei (17.8%) (Institute for Public Health (IPH) Malaysia, 2022).

1.1. Tobacco use in general adolescent populations

Within this complex socio-environmental context, research examining general adolescent populations has identified several demographic factors associated with tobacco use, such as gender, age, and socioeconomic status, which can play a significant role in shaping tobacco use behaviors among adolescents (Pei et al., 2020). More specifically, studies consistently show that males are more likely to smoke cigarettes than females, and that older adolescents are more likely to smoke cigarettes than younger ones (Pei et al., 2020; World Health Organization/Organisation for Economic Cooperation and Development, 2020). Socioeconomic factors, such as parental education and household income, can also influence tobacco use behaviors, with adolescents from lower socioeconomic backgrounds being at greater risk of cigarette smoking initiation and maintenance (Pei et al., 2020). These demographic patterns have been observed across various cultural contexts and geographic regions, suggesting their robustness as predictors of adolescent tobacco use among general populations.

Psychosocial factors have also been extensively studied among general adolescent populations. Peer influence, in particular, has been identified as a significant predictor of smoking initiation and progression, with adolescents who have friends who smoke cigarettes being more likely to engage in smoking themselves (Das, 2022). Shared risk factors, including personality traits such as sensation-seeking (Siraj et al., 2021) and external influences such as peer pressure (Knoll et al., 2015), have also been associated with this behavior. Social norms within peer groups can strongly influence tobacco use because adolescents are highly influenced by their peers (Lahiri et al., 2021). Findings from multiple cross-national studies also indicate a significant association between personal tobacco use and the observation of others' tobacco use consumption, as well as the presence of peers engaged in tobacco use (Ali & Dwyer, 2009; Khan et al., 2019; Van Minh et al., 2011).

Similarly, parental attitudes towards cigarette smoking and parental monitoring of adolescent behavior can influence tobacco use behaviors (Haas & Schaefer, 2014; United States Department of Health and Human Services, 1994, 2012; Vitória, Salgueiro, Silva, & de Vries, 2009), with adolescents whose parents have permissive attitudes towards cigarette smoking being more likely to smoke (Das, 2022). Although both parental and peer influences are significant, peer influence tends to increase with age, whereas parental influence tends to decrease (Scalici & Schulz, 2017). Additionally, peer pressure and association with friends who engage in problematic behaviors (such as delinquent activities, antisocial behavior, academic misconduct, substance use, aggressive behavior, and risky sexual behavior) are positively associated with tobacco use. Conversely, parental involvement and setting high expectations for their children can have a protective effect against tobacco use (Simons-Morton et al., 2001). Research also shows that the likelihood of children and adolescents beginning to smoke cigarettes significantly increases if at least one parent is a smoker (Leonardi-Bee et al., 2011). This risk becomes greater when both parents are smokers (Addo et al., 2024). The presence of parental smoking creates an environment that normalizes tobacco use, making it more likely for adolescents to adopt similar behaviors (Mays et al., 2014; Scalici & Schulz, 2017). This parental behavior normalizes cigarette smoking as a common and acceptable practice, encouraging adolescents to adopt smoking as a potentially permissible behavior (Dickter et al., 2018).

Environmental factors such as access to tobacco products, exposure to tobacco advertising, and availability of smoking cessation services may also influence tobacco use behaviors among adolescents from general populations (Pei et al., 2020). Studies have shown that easy access to tobacco products, either through peer networks or commercial outlets, is more likely to initiate and maintain smoking behaviors (Pei et al., 2020). Adolescents who live in neighborhoods with a high density of tobacco retailers and tobacco users are more likely to experiment with and regularly use tobacco products (Valiente et al., 2021). These environmental influences have been reported across various settings and populations, contributing to the understanding of tobacco use among adolescents in general (Pei et al., 2020).

1.2. Drug-abuse hot spot areas: definition and characteristics

Drug-abuse hot spot areas present a unique context for studying health behaviors, including tobacco use. These areas are characterized by heightened levels of drug activity and associated social problems (Chan & Adnan, 2020; Jusoh et al., 2023). In Malaysia, specific communities have been identified as drug-abuse hot spot areas, officially referred to as 'high-risk areas' by the National Anti-Drugs Agency (NADA). These areas are identified based on four main criteria; (i) a high proportion ($\geq$60%) of the population under NADA supervision, (ii) a large number of individuals suspected of drug use, (iii) a high incidence of new drug addiction cases, and (iv) the community's readiness level to address drug-related problems (National Anti-Drugs Agency, 2024). As of 2020, NADA had identified 155 such high-risk areas across Malaysia, which span various administrative zones, including federal territories and districts in states such as Kelantan and Sarawak. These areas have become the focus of national rehabilitation and prevention efforts, with the aim of transforming them into drug-free zones by 2025 (Pelan Strategik, 2021, 2024, 2025).

Drug-abuse hot-spot areas in Malaysia present a unique context characterized by a combination of socio-economic, environmental, and cultural factors that may influence health behaviors, including tobacco use among adolescents (Chan & Adnan, 2020). These areas often have high levels of poverty, high unemployment, and social disorganization, which can create an environment conducive to various risky behaviors and exacerbate risk factors for tobacco use, such as stress, peer influence, and lack of access to health services (Chan & Adnan, 2020; Pei et al., 2020). Drug-abuse hot-spots are associated with crime and disorder, which often facilitate easier access to substances and increase exposure to peer pressure and drug-related behaviors (Weisburd & Mazerolle, 2000). Adolescents living in these areas may have heightened exposure to illicit substances, as well as tobacco, due to the increased availability and normalization of substance use in their environment (Karuppusamy et al., 2021). Peer pressure and the presence of older individuals engaging in substance use likely contribute to higher rates of substance consumption in these areas.

1.3. Socioecological framework for understanding tobacco use

The socioecological framework provides a valuable lens for understanding tobacco use among adolescents, particularly in high-risk environments such as drug-abuse hot-spots. This framework recognizes that health behaviors are shaped by multiple levels of influence, including individual factors (e.g., knowledge, attitudes, beliefs), interpersonal factors (e.g., family, peers, social networks), community factors (e.g., neighborhood characteristics, access to resources), and societal factors (e.g., policies, cultural norms) (Allen et al., 2017; Seghatoleslam et al., 2023). By considering these multiple levels of influence simultaneously, the socioecological framework offers a more comprehensive understanding of the complex determinants of tobacco use among adolescents.

In the context of drug-abuse hot-spots, the socioecological framework is particularly relevant because it acknowledges the interaction between individual choices and the broader environmental context (Allen et al., 2017; Seghatoleslam et al., 2023). For adolescents living in these areas, tobacco use may be influenced not only by personal factors and immediate social relationships but also by community-level factors

such as the prevalence of drug use, availability of substances, and normalization of substance use behaviors. The framework also recognizes that these various levels of influence interact with each other, creating a complex web of factors that shape adolescent tobacco use behaviors in these high-risk environments.

1.4. Substance use in drug-abuse hot-spot areas: current evidence

Research examining substance use in drug-abuse hot-spot areas has primarily focused on illicit drugs rather than tobacco use. Studies have documented higher rates of drug use, drug trafficking, and associated criminal activities in these areas compared to other communities (Weisburd & Mazerolle, 2000). The environmental characteristics of drug-abuse hot-spots, including social disorganization, limited economic opportunities, and high population density, have been identified as contributing factors to the elevated rates of substance use in these areas (Chan & Adnan, 2020).

In Malaysia, a recent study by Shafie et al. (2023) examined general drug use in drug-abuse hot-spot areas but did not specifically focus on tobacco use. This study highlighted the unique challenges faced by residents of these areas, including increased exposure to drug-related activities and limited access to prevention and intervention services. Similarly, Karuppusamy et al. (2021) found that living in drug-abuse hot-spot areas can exacerbate the likelihood of substance use among adolescents due to environmental factors such as increased availability and normalization of substance use.

The relationship between tobacco use and other forms of substance use has been well documented in the general literature. Tobacco often acts as a gateway substance, potentially triggering further drug use among adolescents (Weisburd & Mazerolle, 2000). This gateway effect may be particularly pronounced in drug-abuse hot-spot areas, where the progression from tobacco to other substances may be facilitated by the increased availability of drugs and the presence of drug-using peers and adults. However, despite the potential importance of understanding tobacco use in these high-risk environments, there is a notable gap in research specifically examining tobacco use patterns, risk factors, and protective factors among adolescents in drug-abuse hot-spot areas.

1.5. Research gap in tobacco use in drug-abuse hot-spot areas

While there is substantial research on tobacco use among adolescents in general populations and some research on drug use in hot-spot areas, a critical examination of the literature indicates a significant gap. To date, no previous study has specifically examined tobacco use in drug-abuse hot-spot areas. This gap is particularly important to address given the unique characteristics of these areas and their potential influence on tobacco use behaviors among adolescents. The existing literature on general adolescent populations has identified demographic, psychosocial, and environmental predictors of tobacco use (Nordin et al., 2022; Pei et al., 2020; Santana-Arias et al., 2021; Wang & Ma, 2012). However, these findings may not fully apply to adolescents living in drug-abuse hot-spot areas. Similarly, studies examining substance use in hot-spot areas have primarily focused on illicit drug use rather than tobacco use (Shafie et al., 2023), leaving a gap in the understanding of how these high-risk environments specifically influence tobacco use behaviors (Chan & Adnan, 2020; Pei et al., 2020).

Understanding the prevalence, as well as risk and protective factors of tobacco use among adolescents in drug-abuse hot-spot areas is important for several reasons. First, given tobacco's potential role as a gateway substance, addressing tobacco use in these high-risk environments may help prevent the progression to other substances (Das, 2022; Ma et al., 2021). Second, the unique characteristics of drug-abuse hot-spots (e.g., increased availability of substances, normalization of substance use, and social disorganization) may require tailored prevention and intervention strategies that differ from those that are effective among general populations (Weisburd & Mazerolle, 2000). Finally, as Malaysia works towards transforming drug-abuse hot-spots into drug-free zones, understanding all forms of substance use, including tobacco use, in these areas is essential for comprehensive prevention efforts (Karuppusamy et al., 2021).

1.6. The present study

The present study addressed the aforementioned gap in the literature by focusing specifically on adolescents in drug-abuse hot-spot areas, offering new insights into how drug-related environments may influence tobacco use. By employing a socioecological approach, the research examined individual smoking predictors simultaneously, considering the broader social and environmental factors unique to these high-risk areas. This comprehensive approach allows for a more nuanced understanding of the complex determinants of tobacco use behaviors among adolescents in drug-abuse hot-spots, which can inform targeted prevention and intervention strategies.

More specifically, the present study investigated the prevalence, risk factors, and protective factors associated with tobacco use among adolescents in Malaysian drug-abuse hot-spot areas. By focusing on this specific population and context, the study contributes to the evidence base on tobacco control and aims to inform strategies that reduce smoking-related harm and promote the health and well-being of adolescents in Malaysia and beyond.

1.7. Study hypotheses

Based on the existing literature and the socioecological framework, the study hypothesized that (i) peer influence would play a significant role in predicting tobacco use among adolescents in these areas (H_1); (ii) parental monitoring and negative attitudes towards smoking would serve as protective factors, reducing the likelihood of tobacco use among adolescents (H_2); and (iii) easier access to tobacco products would increase the likelihood of smoking among adolescents compared to those with limited access (H_3). These hypotheses address key factors at different levels in the socioecological framework—peer influence at the interpersonal level, parental monitoring at the family level, and access to tobacco products at the community level—providing a more comprehensive approach to understanding tobacco use in drug-abuse hot-spot areas.

2. Methods

2.1. Participants and procedure

The study was conducted from December 2021 to December 2022 using a cross-sectional survey approach in selected areas across Malaysia. These areas were identified by the National Anti-Drugs Agency (NADA, 2021) as regions with notably high rates of drug activity and associated problems (i.e., Malaysian 'hot-spots' for illicit drug use). These places were chosen because adolescents usually use tobacco before they abuse drugs.

The study was conducted to systematically identify and further assess adolescents at risk of substance use. Students completed a self-administered screening tool (i.e., the Alcohol, Smoking, Substance Involvement Screening Test [ASSIST] (Lee et al., 2023)) to assess risk levels related to substance use and associated behaviors along with other psychometric scales (see 'Measures' section). Trained researchers conducted face-to-face interviews and distributed the surveys. Participants aged between 13 and 19 years were recruited from 85 schools overseen by the Ministry of Education across five regions in Malaysia: North, East, Central, South, and Malaysian Borneo (Sabah and Sarawak). The study included schools from eight states across five regions, and each region has its own hot-spot area: West (Kedah and Penang), East (Kelantan and Terengganu), Center (Selangor), South (Johor) and Borneo (Sabah and Sarawak) (Fig. 1).

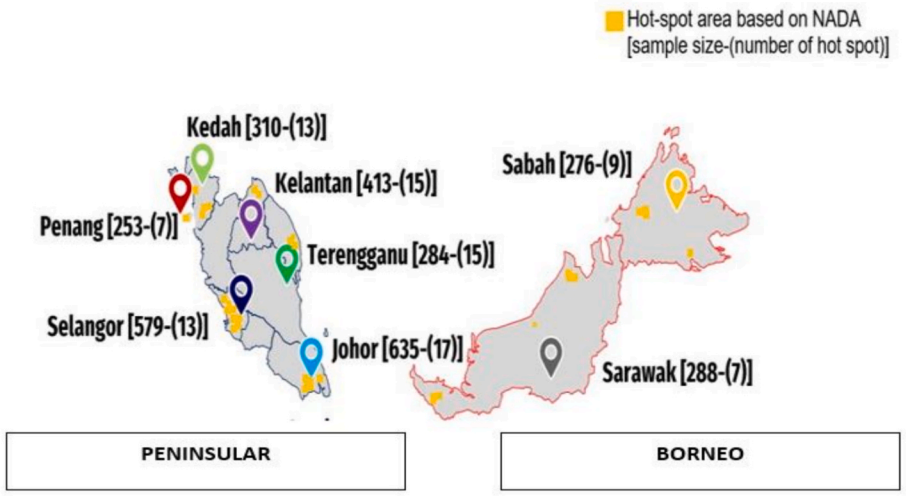

Fig. 1. Number of samples taken according to the selected state in Malaysia (n = 3382).

To enhance the representativeness of the sample, a multistage stratified cluster sampling approach was employed. Schools located in identified drug-abuse hot-spot areas across selected regions in Malaysia were stratified by state and urban–rural locality. Within each stratum, clusters (i.e., schools) were randomly selected, and all eligible students in the selected schools were invited to participate. The minimum required sample size was calculated using the single proportion formula, assuming a prevalence of 4.7%, with a design effect to account for clustering and a 30% anticipated non-response rate, resulting in a required sample of 1,096 participants. In the present study, 3,382 school-going adolescents volunteered with written parental or guardian consent. To ensure generalizability to the adolescent population in drug-abuse hot-spot areas, sampling weights were calculated and applied during data analysis. The weights were derived based on the inverse probability of selection at each stage of sampling and were further adjusted to account for non-response rates within strata and clusters.

Eligibility criteria included being a Malaysian school student aged 13 to 19 years, being free of significant physical or mental illness, having the ability to read and write in Malay, and having parental consent (if under 18 years old). Students were provided with a parental consent form and an accompanying information sheet outlining the objectives, procedures, potential risks, and benefits of the study, and assurances of confidentiality. These documents were distributed through the schools, and students were instructed to return the signed consent forms before participating. Only students who obtained written parental consent were eligible to take part in the study. In addition, written consent was obtained from all student participants prior to data collection, ensuring they understood their rights and the voluntary nature of participation.

2.2. Measures

The present study employed various measures to evaluate predictors, tobacco use, and other contributing factors. ASSIST version 3.0 was used to assess recent substance use, focusing specifically on the three months preceding the study. Tobacco use prevalence was determined by the question, "Have you used tobacco in the past 30 days?" with a binary response option ("Yes = 1" or "No = 0"). Participants who answered 'yes' and had used tobacco in the past 30 days were categorized as current users.

Socio-demographic variables assessed included location of origin (rural and urban), age, gender, ethnicity, years of residence in the location, school environment, parents' relationship status, parents' occupation, and parents' income.

The 53-item Youth Self Report (Achenbach, 1991; Malay version: Jaafar et al., 2013; Kadri et al., 2019; Latif & Norhedayah, 2018) was used to assess the emotional and behavioral problems of adolescents. The items cover internal and external domains and four subdomains: withdrawn (eight items; e.g., "I prefer to be alone than with other people"), anxious/depressed (13 items; e.g., "I cry a lot"), aggressive (15 items; e.g., "I damaged other people's things"), and rule-breaking (17 items; e.g., "I don't feel guilty after doing something I shouldn't have done"). Withdrawn and anxious/depressed behaviors are classified as internalizing problems, while aggressive and rule-breaking behaviors are classified as externalizing problems. Items are rated on a scale from 0 (not true ever) to 2 (very true or always true). Higher scores indicate greater emotional problems (Buehnerkemper, 2002). Cronbach's alphas in the present study for the four domains in the present sample ranged from 0.85 to 0.90. (0.85 for withdrawn, 0.86 for anxious/depressed, 0.89 for aggressive, and 0.90 for rule-breaking).

The 60-item Mooney Problem Check List (Mooney & Gordon, 1950; Malay version: Ismail et al., 2017) was used to assess challenges among adolescents. The scale comprises six domains: financial constraints (e.g., "Need to learn to save money"), self-esteem (e.g., "Taking time to get to know people and feeling awkward meeting new people"), family dynamics and support (e.g., "Parents favor my older or younger sibling and happy with mother and father"), religious beliefs and moral uncertainty (e.g., "Uncertain about the meaning of God"), job goal planning and alignment (e.g., "Need to know my skills in a particular career field"), and academic engagement and competency (e.g., "Knows effective study methods"). Each domain has ten items, and each item is rated from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate greater challenges adolescents face across different aspects (Marella & Prasetyawati, 2020). Cronbach's alphas in the present study were 0.74 (financial), 0.85 (self-esteem), 0.79 (family), 0.82 (religious/morality), 0.78 (job goal), and 0.86 (academic).

The 16-item Self Report Coping Scale (SRCS) (Causey & Dubow, 1992; Malay version: Hanina, 2009) was used to assess academic and peer coping skills among adolescents. Each of the two domains has eight items: coping skills related to academic problems (e.g., "Try to think of different ways to solve the academic problem") and coping skills related to peer problems (e.g., "Try to think of different ways to solve it"). Each item is rated from 1 (never) to 5 (always). Higher scores indicate greater use of the specific coping strategy (Keoy et al., 2023). The study's Cronbach's alphas were 0.78 (academic coping skills) and 0.81 (peer coping skills).

2.3. Statistical analysis

Selected variables were extracted from the raw data and calculated as frequencies and percentages for categorical variables and means and

standard deviations for continuous variables. Pearson's χ^2 tests (for categorical variables) and independent t-tests (for continuous variables) were then conducted to compare differences between current tobacco users and non-users in relation to the independent variables. Bivariate analysis was conducted using Statistical Package for the Social Sciences (SPSS) software version 27.

Logistic regression analysis was performed using STATA version 15 to predict current tobacco use. The logistic model analysis involved three stages. First, a univariate logistic regression analysis (i.e., simple logistic regression; SLR) was performed to assess the association of current tobacco use with sociodemographic, YSR, Mooney Problem Check List, and SRCS variables. Second, a multivariate (enter method) logistic regression (MLR) was used to assess the predictors of current tobacco use, which was the significant variable of the SLR that was included in the analysis. Third, stepwise logistic regression analysis was used to assess predictors of current tobacco use after entering all the variables in the model (i.e., the significant variables in the SLR analysis). Significant variables at the $p < 0.05$ level were the only ones retained in the final model. The adjusted odds ratios (AORs) and their 95 % confidence intervals (CIs) were then estimated, and associations at the $p < 0.05$ level were considered statistically significant.

All variables in the study were adjusted by the dependent variable (current tobacco user) using the variance inflation factor (VIF) as appropriate between variables, and a VIF < 10 was used to detect no multicollinearity (Gujarati, 2009). A Hosmer and Lemeshow test was applied to measure the model's effectiveness in describing the outcome variable. Pseudo-R-squared was used to measure the model's fitness with the data. The Correctly Classified software was used to determine the extent to which the model correctly classified or predicted data. The β coefficients were estimated using the method of maximum likelihood.

3. Ethics approval and informed consent

The study was approved by the Ethics Committee of the Secretariat of Research Ethics, University Kebangsaan Malaysia, Cheras, Kuala Lumpur (reference number UKM PPI/111/8/JEP-2020–174(2)). Written consent for participation was provided by each eligible participant, along with written parental permission for those aged below 18 years. Approval from the Education Planning and Research Division, Ministry of Education Malaysia, and the state and district education Offices was obtained prior to data collection. The study adhered to the Declaration of Helsinki when conducting the research involving human participants, ensuring that ethical principles such as informed consent, confidentiality, and the right to withdraw were upheld throughout the study.

4. Results

4.1. Demographic profile of tobacco use among school-going adolescents

Table 1 shows the demographic characteristics in relation to tobacco use. Males comprised 71.70% of the population, and Malays accounted for 74.48%. Overall, 19.00% of the adolescents had used tobacco in the past 30 days, and 28.50% reported lifetime use. The majority of the sample resided in urban areas (51.66%), with a mean age of 15.35 years. The sample primarily lived in shared properties (81.37%), and 69.63% had lived in their current community for 10 years or more. Also, 94.03% reported liking school, while 4.70% had changed schools due to disciplinary offences. In terms of family dynamics, 80.10% of adolescents lived with both parents. Regarding parental employment, 80.10% of fathers and 47.66% of mothers were employed. Most of the sample (86.01%) reported being in a low-income group (i.e., <MYR 4850/USD 1155).

With regard to tobacco users, 57.5% resided in rural areas, and the mean age was 15.61 years. Males comprised 97.51% of the tobacco user population, and 71.23% of tobacco users were Malay. A large majority lived in landed properties (houses, bungalows, etc.) (82.27%), and 75.89% had lived in their current community for 10 years or more. Additionally, 92.69% reported liking school. In terms of family, 74.96% of tobacco users lived with both parents, while 86.31% of their fathers were unemployed, and 51.48% of their mothers were unemployed. Moreover, 87.87% of tobacco users fell under the B40 income group (<MYR 4850/USD 1155). The bivariate analysis indicated that

Table 1
Socio-demographic characteristics of school-going adolescents in Malaysia by tobacco user status (N = 3382).

Characteristics	Entire sample		Tobacco User Yes		p
	n	%	n	%	
Locality					0.001
Rural	1635	48.34	370	57.54	
Urban	1747	51.66	273	42.46	
Age					<0.001
Mean	15.35		15.61		
Standard deviation	2.28		1.93		
Gender					<0.001
Male	2425	71.70	627	97.51	
Female	957	28.30	16	2.49	
Race					<0.001
Malay	2519	74.48	458	71.23	
Chinese	261	7.72	31	4.82	
Indian	176	5.20	23	3.58	
Bumiputera Sabah & Sarawak	426	12.60	131	20.37	
Type of house					0.54
Landed property	630	18.63	529	82.27	
Shared property	2752	81.37	114	17.73	
Years living in current community					<0.001
≤ 9 years	1027	30.37	155	24.11	
≥ 10 years	2355	69.63	488	75.89	
Liked school					0.12
Yes	3180	94.03	596	92.69	
No	202	5.97	47	7.31	
Changed school due to disciplinary offenses					0.01
Yes	159	4.70	43	6.69	
No	3223	95.30	600	93.31	
Parental relationship status					0.02
Living together	2709	80.10	482	74.96	
Separate	673	19.90	161	25.04	
Father's job status					0.74
Employed	2709	80.10	88	13.69	
Unemployed	673	19.90	555	86.31	
Mother's job status					0.36
Employed	1612	47.66	312	48.52	
Unemployed	1770	52.34	331	51.48	
Income classification					0.30
B40	2909	86.00	565	87.87	
M40	384	11.40	62	9.64	
T20	89	2.60	16	2.49	

Abbreviations: SD standard deviation, B40 (<MYR4850/USD 1155), M40 (MYR4850/ USD 1155 –MYR 10,970/ USD 2612, T20 (>MYR10,970/ USD 2612).

statistical significance was observed between locality, age, gender, race, years living in the current community, changing schools due to disciplinary offenses, and parental relationship status with tobacco users ($p < 0.05$).

4.2. Social and behavioral characteristics of adolescent tobacco users

Table 2 presents the YSR, Mooney Problem Check List, and SRCS scores for the entire sample and among tobacco users. For the entire sample, the YSR scores had an internal problem mean of 12.28 out of 42 (SD = 6.86) and an external problem mean of 11.84 out of 64 (SD = 8.31). In the Mooney Problem Check List, the financial mean score was 34.66 out of 50 (SD = 5.54), and the self-esteem mean score was 33.20 out of 50 (SD = 6.45). The family mean score was 28.44 out of 50 (SD = 4.94), and the religious/morality mean score was 33.97 out of 50 (SD = 7.29). The mean score for job goals was 35.98 out of 50 (SD = 7.55), and the academic mean score was 33.02 out of 50 (SD = 7.39). Additionally, the SRCS scores showed that coping skills related to academic problems were 27.65 out of 40 (SD = 7.01), and coping skills related to peer problems had a mean of 28.41 out of 40 (SD = 7.40).

Compared to non-tobacco users, tobacco users exhibited a slightly lower mean for internal problems at 11.28 out of 42 (SD = 6.44) and for external problems at 15.74 out of 64 (SD = 9.44). In the Mooney Problem Check List, the financial mean score for tobacco users was 34.87 out of 50 (SD = 5.33), and the self-esteem mean score was 32.69 out of 50 (SD = 6.51). The family mean score was slightly lower at 28.39 out of 50 (SD = 5.00), while the religious/morality mean score was 33.19 out of 50 (SD = 7.62). The mean score for job goals was 35.65 out of 50 (SD = 7.70), and the academic mean score was notably lower at 31.76 out of 50 (SD = 7.64). In the SRCS, tobacco users had a mean of 26.85 out of 40 (SD = 7.12) for coping skills related to academic problems. In the bivariate analyses, significant factors associated with tobacco use were financial, job goals, academic, coping skills related to academic issues, and coping skills related to peer problems ($p < 0.050$). This means that individuals facing these challenges were more likely to use tobacco as a coping mechanism.

4.3. Risk and protective factors of tobacco use among school-going adolescents

Table 3 shows the univariate logistic regression analysis (i.e., SLR). This shows that 13 predictor variables impacted tobacco use as risk factors or protective factors. There were seven risk factors associated with current tobacco use. These were: (i) locality (living in an urban area), (ii) age (being an older adolescent), (iii) gender (being male), (iv) residing more than 10 years in the community, (v) changing schools due to disciplinary offenses, (vi) parental separation, and (vii) high scores on external sources in the Youth Self-Report (YSR). Additionally, the analysis identified six protective factors. These were: (i) high scores on internal sources on the YSR, (ii) high scores on self-esteem on the YSR, (iii) high scores on religious morality on the YSR, (iv) high scores on academics on the YSR, (v) high scores on coping skills related to academic problems, and (vi) high scores on coping skills related to peer problems.

Table 2
Social and behavioral characteristics of school-going adolescents in Malaysia (N = 3382).

Variable	Entire sample		Tobacco User Yes		p
	Mean	SD	Mean	SD	
Youth Self Report					
Internal	12.28	6.86	11.28	6.44	0.17
External	11.84	8.31	15.74	9.44	<0.001
Mooney Problem Check List					
Financial	34.66	5.54	34.87	5.33	<0.001
Self-esteem	33.20	6.45	32.69	6.51	0.32
Family	28.44	4.94	28.39	5.00	0.09
Religious/morality	33.97	7.29	33.19	7.62	0.15
Job goal	35.98	7.55	35.65	7.70	0.02
Academic	33.02	7.39	31.76	7.64	0.001
Self-report Coping Scale					
Coping skills related to academic problems	27.65	7.01	26.85	7.12	0.001
Coping skills related to peer problem	28.41	7.40	27.80	7.29	0.49

The MLR indicated that an adolescent's engagement in other risky behaviors was strongly associated with current tobacco use (Table 4). The results of the MLR indicated that six significant predictor variables were associated with current tobacco use by adolescents: locality (living in an urban setting), age (being older), gender (being male), living in the same community (more than or equal to 10 years), parental relationship status (separated), and high external locus of control. The MLR also identified two significant protective factors among current tobacco use by adolescents: a high internal locus of control and having good coping skills related to academic problems.

The MLR (Table 5) showed that an adolescent's engagement in other risk behaviors was strongly associated with current tobacco use, as demonstrated in Tables 1 and 2. Table 5 specifically shows that the most significant risk factor for being a tobacco user was being male (AOR = 15.18, 95% CI 9.12–25.26, $p < 0.001$). Males were 15 times more likely to be current tobacco users than females. The second most significant risk factor for being a tobacco user was having parents who were separated (AOR = 1.48, 95% CI 1.18–1.85, $p < 0.001$). The third most significant risk factor was residing within the same community for more than 10 years (AOR = 1.45, 95% CI 1.17–1.81, $p < 0.001$).

It was also found that the older an adolescent gets, the more likely they were to be at risk of being a tobacco user (AOR = 1.16, 95% CI 1.06–1.27, $p < 0.05$). Adolescents who were living in urban areas were more at risk of being tobacco users than those living in rural areas (AOR = 1.24, 95% CI 1.02–1.50, $p < 0.05$). Additionally, adolescents exhibiting externalizing behaviors, including aggression and rule-breaking, were more at risk of being a tobacco user (AOR = 1.09, 95% CI 1.08–1.11, $p < 0.001$). Conversely, adolescents had a reduced likelihood of being a tobacco user if they exhibited good coping skills related to academic problems (AOR = 0.98, 95% CI 0.97–0.99, $p < 0.010$), and good internal behaviors (AOR = 0.93, 95% CI 0.92–0.949, $p < 0.001$).

The pseudo-R^2 value for model fit and performance metrics was 0.1858, indicating that the variables under study explained 18.58% of the variance associated with tobacco use. The Hosmer-Lemeshow Test result (p-value = 0.33) suggested that the data fitted the MLR model, although a smaller p-value would indicate a better fit. The correctly classified rate was 81.43%, signifying that the MLR model accurately predicted whether a case belonged to the positive or negative class in approximately 81.43% of instances. McFadden's R^2 value was 0.186, indicating that the model accounted for 18.6% of the variance in tobacco use. Moreover, the Cox-Snell R^2 value was 0.165, suggesting that the MLR model explained 16.5% of the variance in tobacco use. Lastly, the Nagelkerke R^2 value was 0.391, indicating that the model accounted for 39.1% of the variation in tobacco use. Multicollinearity was not a concern, given that the VIF values were below 10 for all predictor variables.

5. Discussion

5.1. Prevalence of tobacco use

The present study investigated the prevalence and predictors of tobacco use among school-going adolescents in drug-abuse hot-spot areas in Malaysia. These areas were identified by the National Anti-Drugs Agency (NADA, 2021) as regions with notably high rates of drug

Table 3
Analysis for factors associated with current tobacco use—simple logistic regression analysis (SLR) (N = 3382).

Current tobacco status (1 = Tobacco user; 0 = Tobacco non-user)	Coefficient	Crude odds ratio	Standard error	Z-value	p-value	[95 % (Confidence interval for Odds Ratio)	
						Lower	Upper
Locality (Reference: Rural)							
Urban	0.29	1.34	0.12	3.31	0.001	1.13	1.59
Age (years)	0.16	1.17	0.05	3.91	<0.001	1.08	1.27
Gender (Reference: Female)							
Male	3.02	20.51	5.26	11.78	<0.001	12.41	33.90
Type of house (Reference: Landed property)							
Shared property	0.07	1.08	0.12	0.65	0.52	0.86	1.35
Years living in the same community: (Reference: Less than ten years)							
More than or equal to 10 years	0.39	1.47	0.15	3.82	<0.001	1.21	1.79
Liked school (Reference: Yes)							
No	0.27	1.32	0.23	1.58	0.11	0.92	1.84
Changed school due to disciplinary offences (Reference: No)							
Yes	0.483	1.62	0.30	2.62	0.01	1.13	2.33
Parental relationship status (Reference: Living together)							
Separate	0.37	1.45	0.15	3.61	<0.001	1.19	1.78
Father's job status (Reference: Unemployed)							
Employed	−0.04	0.96	0.11	−0.33	0.74	0.78	1.19
Mother's job status (Reference: unemployed)							
Employed	0.08	1.08	0.10	0.92	0.36	0.91	1.29
Income Classification (Reference: T20)							
Income B40	0.20	1.22	0.16	1.51	0.13	0.94	1.58
Income M40	−0.22	0.80	0.16	−1.52	0.13	0.60	1.07
Youth Self-Report							
Internal	−0.03	0.97	0.01	−4.08	<0.001	0.96	0.99
External	0.06	1.07	0.01	12.55	<0.001	1.06	1.08
Mooney Problem Check List							
Financial	0.01	1.01	0.01	1.09	0.28	0.99	1.03
Self esteem	−0.01	0.99	0.01	−2.24	0.03	0.97	0.10
Family	−0.003	0.10	0.01	−0.31	0.75	0.98	1.02
Religious morality	−0.02	0.98	0.01	−3.02	0.003	0.97	0.10
Job goal	−0.01	0.99	0.01	−1.22	0.22	0.98	1.004
Academic	−0.03	0.97	0.01	−4.75	<0.001	0.96	0.98
Self-reporting Coping Scale							
Coping skills related to academic problems	−0.02	0.98	0.01	−3.22	0.001	0.97	0.99
Coping skills related to peer problems	−0.01	0.99	0.01	−2.35	0.02	0.98	0.10

B40 (<MYR4850/USD 1155), M40 (MYR4850/ USD 1155 –MYR 10,970/ USD 2612, T20 (>MYR10,970/ USD 2612).

activity and associated problems. The study's location in drug-abuse hot-spot areas is a particularly novel aspect that may have significantly influenced the findings (Karuppusamy et al., 2021). Adolescents living in these areas may have heightened exposure to illicit substances, including tobacco, due to the increased availability and normalization of substance use in their environment. Peer pressure and the presence of older individuals engaging in substance use likely contribute to the higher rates of tobacco consumption (Weisburd & Mazerolle, 2000). These environmental factors are crucial in shaping adolescents' attitudes and behaviors toward tobacco use, indicating the importance of addressing the broader social and environmental context in prevention efforts. In the present study, the prevalence rates of tobacco use in drug-abuse hot-spot areas were 19.0% for current use and 28.5% for lifetime use, which are higher compared to rates observed in the general adolescent population in non-hot-spot areas of Malaysia (Institute for Public Health (IPH) Malaysia, 2022).

When comparing the present study's findings from drug-abuse hot-spot areas with national data from the general adolescent population, several important differences emerge. According to the National Health and Morbidity Survey (NHMS), the use of any tobacco products among adolescents in the general Malaysian population in 2022 was 18.5%, reflecting a slight decline from 20.9% in 2017 (Institute for Public Health (IPH) Malaysia, 2022). The current tobacco use rate found in the present study of drug-abuse hot-spot areas was slightly higher (19.0%) than the general population rate in 2022 (18.5%). More striking is the comparison with cigarette smoking specifically, which decreased from 13.8% in 2017 to 6.2% in 2022 in the general adolescent population (Institute for Public Health (IPH) Malaysia, 2022). The 6.2% prevalence of cigarette smoking among the general adolescent population is substantially lower than the overall tobacco use prevalence of 19.0% found among adolescents in drug-abuse hot-spot areas in the present study.

The prevalence of current tobacco product use among Malaysian adolescents in drug-abuse hot-spots was also higher than the prevalence of use among general adolescent populations in neighboring Southeast

Table 4
Analysis for factors associated with current tobacco use—multivariate logistic regression (MLR) (N = 3382).

Current tobacco status (1 = Tobacco user; 0 = Tobacco non-user)	Coefficient	Crude odds ratio	Standard error	Z-value	p-value	[95 % (Confidence interval for Odds Ratio)	
						Lower	Upper
Locality (Reference: Rural)							
Urban	0.191	1.211	0.119	1.950	0.051	0.999	1.468
Age (in years)	0.153	1.166	0.054	3.330	0.001	1.065	1.276
Gender (Reference: Female)							
Male	2.711	15.039	3.909	10.430	<0.001	9.035	25.032
Years living in the same community: (Reference: Less than ten years)							
More than or equal to 10 years	0.360	1.433	0.160	3.230	0.001	1.152	1.783
Changed school due to disciplinary offences (Reference: No)							
Yes	0.094	1.099	0.227	0.450	0.649	0.733	1.648
Parental relationship status (Reference: Living together)							
Separated	0.403	1.497	0.174	3.480	0.001	1.192	1.879
Youth Self-Report							
Internal	−0.070	0.932	0.009	−7.150	<0.001	0.915	0.951
External	0.087	1.091	0.008	12.560	<0.001	1.077	1.106
Mooney Problem Check List							
Self esteem	−0.012	0.988	0.009	−1.360	0.174	0.971	1.005
Religious morality	−0.012	0.988	0.007	−1.570	0.116	0.974	1.003
Academic	−0.009	0.991	0.007	−1.180	0.238	0.977	1.006
Self-reporting Coping Scale							
Coping skills related to academic problems	−0.020	0.980	0.011	−1.760	0.079	0.958	1.002
Coping skills related to peer problems	0.016	1.016	0.011	1.480	0.140	0.995	1.038
Constant	−5.913	0.003	0.003	−6.310	<0.001	0.0001	0.017

B40 (<MYR4850/USD 1155), M40 (MYR4850/ USD 1155 –MYR 10,970/ USD 2612, T20 (>MYR10,970/ USD 2612).

Table 5
Analysis for factors associated with current tobacco use – stepwise multivariate logistic regression (SMLR) (N = 3382).

Current tobacco status (1 = Tobacco user; 0 = Tobacco non-user)	Coefficient	Adjusted odds ratio	Standard error	Z-value	p-value	95 % (Confidence interval for Odds Ratio)	
						Lower	Upper
Locality (Reference: Rural)							
Urban	0.21	1.24	0.12	2.17	0.030	1.02	1.50
Age (years)	0.15	1.16	0.05	3.17	0.002	1.06	1.27
Gender (Reference: Female)							
Male	2.72	15.18	3.94	10.47	<0.001	9.12	25.27
Years living in the same community: (Reference: Less than 10 years)							
More than or equal to 10 years	0.37	1.45	0.16	3.33	0.001	1.17	1.81
Parental Relationship Status (Reference: Living together)							
Separate	0.39	1.48	0.17	3.37	0.001	1.18	1.85
Youth Self-Report							
Internal	−0.07	0.93	0.01	−7.43	<0.001	0.91	0.95
External	0.09	1.09	0.01	13.18	<0.001	1.08	1.11
Self-reporting Coping Scale							
Coping skill related to academic problems	−0.02	0.98	0.01	−2.72	0.06	0.97	0.99

Asian countries: Indonesia (13.6%), Thailand (14.4%), the Philippines (15.8%), and Brunei (17.8%). The prevalence of cigarette smoking also decreased from 13.8% in 2017 to 6.2% in 2022, which is significantly lower compared to Brunei (9.8%), Thailand (11.5%), Indonesia (12.5%), and the Philippines (13.3%) (Institute for Public Health (IPH) Malaysia, 2022). Conversely, the prevalence of e-cigarette/vape use increased by 5.1% over five years among the general Malaysian adolescent population, rising from 9.8% in 2017 to 14.9% in 2022 (Institute for Public Health (IPH) Malaysia, 2022). Moreover, the recent report by the Institute for Public Health (IPH) Malaysia, 2022, showed that the prevalence of tobacco smoking in the general population had declined, but the pace was too slow to achieve the target of 15% or lower by 2025.

However, the use of electronic cigarettes (vaping) is increasing, posing a pressing public health concern.

While the present study's results indicated that age (older adolescence) and gender (male) were key demographic factors influencing tobacco use, the study's setting in a drug-abuse hot-spot area also likely plays a role in amplifying these effects. For instance, older adolescents may have more opportunities to access tobacco and other substances in such environments, while males, who often face stronger social pressures to engage in risky behaviors, may be more susceptible to tobacco use in areas where substance abuse is prevalent. This finding aligns with previous research highlighting gender differences in smoking prevalence (Giovino et al., 2012; Warren et al., 2006), but the study's focus on drug-abuse hot-spots adds a new layer of understanding to the social dynamics at play.

Similarly, findings from non-hot-spots studies in 2012, 2017, and 2022, reported by the Institute for Public Health (IPH) Malaysia, 2022, also indicate that males have a higher prevalence of current tobacco product use and smoking compared to females. Similarly, the most recent results from the Institute for Public Health (IPH) Malaysia, 2022, highlighted that sociodemographic disparities are evident: tobacco smoking was more common among middle-aged individuals (35–44 years), those living in rural areas, and those from lower-income households (B40), while e-cigarette use/vaping use was more prevalent among younger individuals (15–24 years), those in urban areas, and those from higher-income households (T20), and in 2023, the prevalence of tobacco smoking among individuals aged 15 years and above was lower than in the previous nationwide surveys (2019), but the decline was insufficient to meet the target of under 15% by 2025. Conversely, vaping remained unchanged in 2023, highlighting a pressing public health concern. Smoking is more prevalent among males in rural areas, while vaping use is slightly higher in urban areas. A higher proportion of current cigarette smokers comes from lower socioeconomic backgrounds compared to e-cigarette users. Both groups are predominantly of working age, which could negatively impact workforce productivity due to the health effects associated with tobacco use.

5.2. Risk and protective factors of tobacco use

The results of this study highlight the significant role that psychosocial factors appear to play in influencing tobacco use among adolescents, alongside demographic characteristics. Poor academic coping skills emerged as a key risk factor, suggesting that adolescents who struggle to handle academic pressures are more likely to resort to tobacco use as a coping mechanism. This finding aligns with existing literature indicating that academic stress can contribute to risky health behaviors (Bilano et al., 2015; Buu et al., 2021). Consequently, this underscores the importance of incorporating academic support programs that teach adolescents effective coping mechanisms for stress, which could serve as protective measures against tobacco use. Additionally, the study showed that low self-esteem and weak family support were also associated with higher rates of tobacco use. In line with Pederson et al. (2022), improving self-esteem and parental support may help reduce the negative effect of tobacco use as predictors of substance use outcomes. Adolescents who lack emotional stability or experience family strain may engage in tobacco use as a form of self-medication (Gualano et al., 2015), which emphasizes the need for interventions that foster emotional resilience and strengthen familial bonds, such as family-based counseling or mentoring programs. Strong family ties and emotional support are crucial in helping adolescents navigate stressors without resorting to harmful behaviors (Zhao et al., 2024).

High external problem scores, indicating delinquent or aggressive behaviors, were strongly associated with tobacco use. Adolescents who exhibit these behaviors are more prone to engage in risky activities, including smoking (Tate et al., 2021). This suggests that behavioral interventions aimed at addressing externalizing behaviors could have a significant impact on reducing tobacco use among high-risk adolescents. Programs that promote self-regulation, impulse control, and positive behavioral strategies could be valuable components in tobacco prevention efforts (Sweileh, 2024).

The implications of these findings are particularly relevant for developing targeted, multifaceted intervention programs. Rather than focusing solely on demographic factors, prevention strategies must address the psychosocial dimensions that contribute to tobacco use (Sweileh, 2024). Interventions should integrate academic support, emotional well-being programs, and behavioral interventions to mitigate the various factors driving tobacco use (Tate et al., 2021). Additionally, given the significant role of family support, involving parents or guardians in these interventions could enhance their effectiveness. Addressing the smoking and vaping epidemic requires intensified efforts across all sectors. The enforcement of the Control of Smoking Products for Public Health Act 2024 [Act 852], for tobacco control measures, strengthens jurisdiction for tobacco control, supporting robust interventions, enforcement, and health education (National Health and Morbidity Survey, 2024).

5.3. Strengths, limitations, and directions for future research

The present study has several noteworthy strengths that contribute to the understanding of tobacco use among adolescents in Malaysia. First, although the study focused on adolescents living in drug-abuse hot-spot areas, it is essential to note that the sample was not nationally representative due to this specific focus. While there is a study on national data of tobacco use among adolescents in Malaysia (Institute for Public Health (IPH) Malaysia, 2022), the present study's emphasis on national drug-abuse hot-spot areas highlights a significant gap in the literature, particularly in understanding the unique challenges faced by adolescents in these contexts. Most existing studies have not differentiated between general populations and those in drug-abuse hot-spot areas (Pei et al., 2020), making this study particularly valuable.

Second, this study's unique combination of elements, including the large and diverse sample size of 3,382 school-going adolescents, adds valuable context to the existing literature. This robust sample, drawn from Malaysian students aged 13 to 19 years and meeting specific eligibility criteria, comprehensively represented this demographic. Such a large-scale study allows for more reliable insights into the prevalence and predictors of tobacco use among adolescents, a key area of concern in Malaysia's drug-abuse hot-spot regions.

Despite these strengths, several limitations must be acknowledged. The exploratory cross-sectional design restricts the ability to draw causal conclusions between the studied variables, and there was no comparison group. The present study focused solely on adolescents residing in drug-abuse hot-spot areas as identified by the National Anti-Drugs Agency (NADA). While this targeted approach provided valuable insights among populations at higher risk of substance use, it limited the generalizability of the findings because adolescents in non-hotspot areas were not surveyed. Future research should consider including comparative samples from both hotspot and non-hotspot areas to allow for a more comprehensive understanding of contextual differences in risk factors, behavioral patterns, and intervention needs. This would enhance the applicability of findings across broader adolescent populations and strengthen the evidence base for nationwide preventive strategies (Ismail et al., 2024). It should also be noted that although the present study focused on identifying current tobacco use among adolescents in drug-use hot-spot areas, it did not conduct a detailed analysis of the levels of tobacco use (e.g., daily vs. occasional use) or differentiate between specific types of tobacco products used. Future research should address this gap by examining the patterns, frequency, and types of tobacco products consumed, including traditional cigarettes, e-cigarettes, and other emerging products, to better inform targeted prevention efforts (Albadrani et al., 2024).

Additionally, the reliance on self-report data can introduce biases related to social desirability and memory recall. Another significant

limitation was that the key variable, tobacco use, was assessed with only a single question, which did not capture the frequency or intensity of use, thereby reducing the analytical depth of the findings. In addition, self-reported tobacco use may be subject to social desirability bias. That is, adolescents might under-report their use of tobacco because they know the fact that cigarette smoking is unhealthy.

Future research should prioritize context-specific interventions, particularly in Malaysia, where unique socio-economic and cultural factors, such as family structure, peer influence, religious practices, economic disparities, and community support systems, play a crucial role in shaping adolescent behaviors. For instance, exploring the effectiveness of mobile health technologies and community-based programs in addressing tobacco use could yield insights directly applicable to local contexts. Additionally, longitudinal studies should be designed to investigate the long-term effects of psychosocial and environmental factors on smoking initiation and cessation. Although many longitudinal studies on tobacco use exist, there is a need to focus on how these factors interact specifically in the Malaysian context (Bilano et al., 2015; Buu et al., 2021).

Lastly, the multivariate logistic regression models constructed in the present study used significant independent variables derived from several independent univariate logistic regression models. In this regard, the significant independent variables chosen to be included in the multivariate logistic regression models could be due to type I error inflation. That is, without controlling multiple comparisons (e.g., using Bonferroni adjustment) to select significant independent variables, the selection might over-select independent variables that are actually not significant. However, the present study did not control the multiple comparisons in the univariate logistic regression model. The reason for not controlling type I error in multiple comparisons is because the authors wanted to include all potential predictors for further testing. Some predictors at marginal significance after type I error adjustment in univariate logistic might be important factors in the multivariate logistic regression model. More specifically, some important factors may only show their significance to the outcome (i.e., current tobacco use in the present study) when other independent variables are included in the logistic model (Clarke, 2005). Therefore, the present study adopted the method of purposeful selection to identify all potential predictors in the univariate logistic regression that could be further examined again in the multivariate logistic regression (Bursac et al., 2008). Nevertheless, the present study's logistic regression results should be interpreted with caution due to possible type I error inflation.

5.4. Implications for policy and practice

The findings of this study highlight several key implications for policy and practice, particularly in the context of drug-abuse hot-spot areas. First, schools should implement intervention programs that teach students effective stress management skills because poor academic coping abilities are a significant predictor of tobacco use (Jagiello et al., 2024). In hot-spot areas, these programs should be more intensive and contextually relevant, addressing the unique stressors faced by adolescents in these environments. Historically, programs such as PINTAR 2.0, implemented since 1998, and SHIELDS have targeted at-risk students in Malaysian schools (National Anti-Drugs Agency, 2024), but the findings of the present study suggest these need specific adaptations for hot-spot contexts where tobacco use prevalence (19.0%) slightly exceeds that of the general adolescent population (18.5%).

Second, family-centered prevention strategies are crucial, emphasizing the importance of parental involvement and support to reduce the likelihood of cigarette smoking. The Family on Alert (FoA) program implemented by the National Anti-Drugs Agency represents a promising approach that could be expanded specifically in drug-abuse hot-spot areas. These programs should address the unique challenges faced by families in high-risk environments, including the normalization of substance use, which the present study identified as one the most significant risk factors for adolescent tobacco use. Additionally, behavioral interventions targeting adolescents with external problem behaviors, such as delinquency, are needed to address the association between such behaviors and tobacco use (Francis et al., 2020). The present study's findings indicate that adolescents exhibiting externalizing behaviors in hot-spot areas need specialized interventions that address both behavioral issues and environmental influences.

Expanding mental health services, particularly in schools, is essential to support adolescents dealing with low self-esteem and emotional challenges, which are associated with increased tobacco use (Pederson et al., 2022). These services should incorporate trauma-informed approaches that recognize the higher prevalence of adverse experiences in drug-abuse hot-spot areas. Community-based programs should engage young people in positive activities and offer mentorship to reduce feelings of social isolation, contributing to a holistic approach to prevention (Luo & Stoeger, 2023). The "Program Penghijauan Kawasan Berisiko Tinggi Penagihan Dadah" (Greening of High-Risk Drug Addiction Areas Program), which targets all 155 identified hot-spots in Malaysia (National Anti-Drugs Agency, 2024), should incorporate specific tobacco prevention components alongside its focus on illicit drugs.

For maximum effectiveness, these interventions should be integrated across multiple levels of influence—individual, family, school, community, and policy—rather than implemented in isolation. This multilevel approach is particularly important in drug-abuse hot-spot areas where risk factors exist at all these levels simultaneously. Coordination mechanisms should be established to ensure consistent messaging and seamless referral pathways between different types of services. Public health campaigns should also incorporate these psychosocial factors, moving beyond traditional tobacco-related messaging (Institute for Public Health (IPH), 2022) to address the specific contexts and challenges of hot-spot areas. The implementation of the Control of Smoking Products for Public Health Act 2024 [Act 852] provides an opportunity for enhanced enforcement in drug-abuse hot-spot areas, supporting robust interventions that address the unique risk factors identified in the present study.

Finally, evaluation of these interventions should include disaggregated data for hot-spot versus non-hot-spot areas to determine whether adapted approaches are effective in reducing the disparities in tobacco use prevalence. Long-term follow-up is essential given the persistent nature of risk in these environments, and success should be measured not only by tobacco use rates but also by changes in the multilevel risk and protective factors identified in the present study. By addressing these implications with targeted, integrated, and contextually-relevant approaches, policymakers and practitioners can more effectively combat tobacco use among adolescents in drug-abuse hot-spot areas.

6. Conclusion

The findings of the study emphasize the necessity of adopting a comprehensive, multifaceted approach to tobacco prevention among adolescents, particularly in drug-abuse hot-spot areas. Recognizing the challenges of crime and disorder faced by youth in these environments is important because these contexts may exacerbate the risk factors associated with tobacco use. By integrating academic, behavioral, emotional, and familial support systems, alongside targeted interventions that consider the specific influences of living in drug-abuse hot-spot areas, policymakers and practitioners can more effectively address the root causes of tobacco use and reduce smoking prevalence among this vulnerable population. This approach will not only support healthier choices among adolescents but also contribute to broader community efforts to combat substance abuse and its related consequences.

Ethical statement

The study was approved by the Ethics Committee of the Secretariat of Research Ethics, University Kebangsaan Malaysia, Cheras, Kuala Lumpur (reference number UKM PPI/111/8/JEP-2020–174(2). Written consent for participation was provided by each eligible participant, along with written parental permission for those aged below 18 years. Approval from the Education Planning and Research Division, Ministry of Education Malaysia, and the state and district education offices was obtained before data collection. The study adhered to the Declaration of Helsinki when conducting the research.

CRediT authorship contribution statement

Rozmi Ismail: Validation, Project administration, Funding acquisition, Conceptualization. **Siti Aishah Hassan:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Md Shafiin Shukor:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Nurul Shafini Shafurdin:** Writing – review & editing, Writing – original draft, Data curation. **Norshafizah Hanafi:** Writing – review & editing, Resources. **Musheer A. Aljaberi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources. **Chung-Ying Lin:** Writing – review & editing, Visualization, Validation. **Mark D. Griffiths:** Writing – review & editing, Writing – original draft, Visualization, Validation.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available upon reasonable request to the corresponding author.

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