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Determinants of E-Cigarette Expenditure Among Malaysian School-Going Adolescents

(*Faktor Yang Mempengaruhi Perbelanjaan Rokok Elektronik di Kalangan Remaja Bersekolah di Malaysia*)

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ABSTRACT

The use of e-cigarettes has detrimental effects on health. It is common among the adolescent population. This study provides important insights into the associations between demographic characteristics (age, gender, ethnicity, pocket money, and smoking habits) and e-cigarette expenditure. Data were extracted from the Tobacco and E-Cigarette Survey among Malaysian Adolescents. An ordered probit model was employed to assess factors influencing different levels of expenditure on e-cigarettes among adolescents aged between 10 and 19 years. Adolescents with high expenditure on e-cigarettes tended to be older, male, Malay, and smokers. Adolescents who had not been taught about the dangers of cigarette smoking, thought that quitting the use of e-cigarettes was not difficult, believed e-cigarettes to be less harmful compared to cigarettes, were exposed to health-related images and texts on cigarette packs, and were unaware of posters or pamphlets on the dangers of e-cigarettes, tended to spend large amounts of money on e-cigarettes. This study highlights the roles of demographic factors, knowledge, and awareness of cigarettes and e-cigarettes in influencing adolescents' decisions to spend on e-cigarettes. Therefore, targeted anti-e-cigarette programmes and further reductions in e-cigarette use are necessary.

Keywords: Adolescents; awareness; demographic factors; knowledge; e-cigarettes

ABSTRAK

Penggunaan rokok elektronik memberi kesan buruk ke atas kesihatan. Rokok elektronik digunakan secara meluas di kalangan golongan remaja. Kajian ini memberikan pandangan baru terhadap hubungan antara perbelanjaan atas rokok elektronik dengan faktor demografik (iaitu umur, jantina, etnik, wang saku, merokok) serta pengetahuan dan kesedaran mengenai rokok dan rokok elektronik di kalangan remaja. Data diperolehi daripada Tobacco and E-Cigarette Survey among Malaysian Adolescents. Regresi probit berperingkat digunakan untuk menilai faktor-faktor yang mempengaruhi tahap perbelanjaan rokok elektronik dalam sampel remaja bersekolah berumur antara 10 hingga 19 tahun. Remaja yang berupaya belanja tinggi untuk membeli rokok elektronik adalah daripada golongan yang berusia tinggi, lelaki, berbangsa Melayu, dan perokok. Remaja yang tidak pernah diajar tentang bahaya merokok, berpendapat berhenti menggunakan rokok elektronik adalah tidak sukar, percaya bahawa rokok elektronik kurang berbahaya daripada rokok biasa, terdedah kepada mesej dan gambar amaran kesihatan pada bungkusan rokok, serta tidak menyedari poster atau risalah tentang bahaya rokok elektronik cenderung untuk belanja tinggi untuk rokok elektronik. Kajian ini menekankan peranan penting faktor demografik serta pengetahuan dan kesedaran tentang rokok dan rokok elektronik dalam mempengaruhi keputusan remaja untuk belanja untuk rokok elektronik. Oleh itu, program anti-rokok elektronik yang lebih khusus dan pengurangan lanjut dalam penggunaan rokok elektronik adalah diperlukan.

Kata kunci: Remaja; kesedaran; faktor demografi; pengetahuan; rokok elektronik
JEL: D1, I1

INTRODUCTION

E-cigarettes, which are commonly referred to as electronic devices that function by heating a metal coil, which vaporises an e-liquid consisting of nicotine, flavourings, glycerol, and distilled water (Polosa et al. 2019). This vapour, nicotine-containing aerosol, is then inhaled by the users. People often use e-cigarettes as a safer alternative to conventional smoking or to quit smoking. However, the risk of e-cigarettes remains unclear due to limited empirical evidence (Marques et al. 2021). There is evidence suggesting that the heat generated by e-cigarettes can produce compounds that are harmful to human health (Herrington & Myers 2015). Respiratory tract irritation, constriction of the airways, deterioration in pulmonary function and cardiovascular diseases, for instance, are more frequent among e-cigarette users than non-users (Grana et al. 2014; Kruse et al. 2017). People who had large expenditures on e-cigarettes were more likely to suffer from heart disease and poor oral health than those who did not consume e-cigarettes (Yao et al. 2017). Moreover, an empirical study showed that e-cigarette use had a substantial economic impact, accounting for $179.6 million of healthcare costs annually (Gordon & Preston 2024). Of these, $102.2 million was associated with respiratory diseases, and $49.6 million was associated with cancers.

Since most e-cigarettes contain nicotine, they may contribute to dual use – a situation where individuals use both traditional cigarettes and e-cigarettes, potentially making it even harder to quit smoking entirely. As stressed by Owusu et al. (2019) and Coleman et al. (2022), the majority of e-cigarette users smoked cigarettes, and they did not have any intentions to quit smoking. Studies also show a significant positive association between the use of e-cigarettes and substance abuse, thereby resulting in many health problems. McCabe et al. (2017) observed that people who used e-cigarettes were 11.8 times as likely to use illicit drugs as non-users. Azagba (2018) identified the likelihood of cannabis use to be higher among people who used e-cigarettes compared to those who did not.

Use of e-cigarettes among consumers of all age groups, especially adolescents, is no longer a negligible issue worldwide, including Southeast Asia (SEA). A recent study showed that approximately 3.3–11.8% of adolescents in SEA engaged in e-cigarette use (Jane Ling et al. 2023). Although the number of e-cigarette users in SEA is not as high as that in high-income countries, they are expected to increase at a growing rate in the near future. The rising e-cigarette use rate in the adolescent population is concerning, as it can increase morbidity among adolescents and has adverse health impacts in adulthood. In Malaysia, the incidence of e-cigarette use within the adolescent population has risen sharply. Results from a nationwide survey conducted in 2012 showed that only 2.5% of school-going adolescents engaged in e-cigarette use (Institute for Public Health 2012). However, in 2017, nearly one-tenth (9.8%) of students at primary and secondary schools were e-cigarette users (Institute for Public Health 2017). This prevalence increased to 14.9% in 2022, according to the latest Malaysian adolescent health survey (Institute for Public Health 2022).

Prior studies related to addictive behaviours have explored factors influencing e-cigarette use in the adolescent population. Empirical studies using large data found that older adolescents and males had a higher probability of using e-cigarettes than their younger and female counterparts (Camenga et al. 2018; Vogel et al. 2018; Gali et al. 2022; Benny et al. 2023). The increased likelihood of using e-cigarettes was observed among urban dwellers and ordinary cigarette smokers (Park et al. 2017; Han et al. 2022). Furthermore, higher income adolescents were more likely to indulge in e-cigarette use than lower income adolescents (Park et al. 2017). There was also evidence suggesting that ethnicity was associated with the decisions of adolescents to use e-cigarettes (Moustafa et al. 2021; Benny et al. 2023). However, most previous studies focused on developed countries and only very few researchers devoted their attention to SEA countries, especially Malaysia, where e-cigarette use has become an alarming concern. Moreover, previous studies often treated e-cigarette use as a dichotomous variable (yes vs. no) instead of a continuous variable; thus, the magnitude of e-cigarette use could not be measured.

The present study aims to use expenditure on e-cigarettes as a variable to measure the degree of e-cigarette usage and explore its determining factors based on a large, representative sample of school-going adolescents in Malaysia. Owing to the common metric of money (in currency), expenditure is assumed to be an appropriate proxy for the magnitude of e-cigarette use, especially considering that it is difficult to develop a unit that can quantify the e-cigarette use intensity. Furthermore, e-cigarettes are costly, and spending on e-cigarettes constitutes a significant proportion of users' budgets. Hence, it is worth acquiring in-depth knowledge of factors influencing the amount of money adolescents spend on e-cigarettes.

This study presents important contributions to the existing literature. First, this study is novel to the population, as nationwide studies on e-cigarette expenditure among adolescents in Malaysia are nearly non-existent. Second, the present study categorises e-cigarette expenditure into several levels and uses an ordinal regression model to analyse its determining factors. With this information, policymakers and researchers can identify which groups of adolescents are likely to spend low, moderate, or high amounts of money on e-cigarettes. Third, this study takes into consideration the influences of several variables regarding knowledge and awareness related to cigarettes and e-cigarettes. Obtaining comprehensive information about the roles of cigarette- and e-cigarette-related knowledge and awareness in e-cigarette expenditure is crucial because it can assist public health administrators and school authorities in formulating more effective anti-vaping policies.

INSIGHTS FROM THE LITERATURE

THEORETICAL FRAMEWORK

E-cigarette consumption is a hazardous health behaviour as it can diminish users' health capital. The theoretical foundations for risky health behaviours are the model of health capital developed by Grossman (2000) and the economics of risky health behaviours analysed by Cawley and Ruhm (2012). According to the model of health capital, people possess a certain level of health capital when they are born, but it depreciates with age. When the capital falls below the threshold, mortality occurs. Health exhibits both demand and investment characteristics. It is included in consumers' utility functions and can also determine the number of healthy days available for work- and non-work-related activities. Health can be improved through investments, such as taking dietary supplements and participating in physical activity, and deteriorates via disinvestments, such as involvement in risky health behaviours. As emphasised by Cawley and Ruhm (2012), individuals will engage in risky health behaviours when they equalise the marginal costs (MC) of risky health behaviours and the marginal benefits (MB). This means that people will use e-cigarettes only if they equalise the MC (the costs of purchasing e-cigarettes and suffering from illnesses) and the MB of e-cigarettes (the immediate pleasure generated by e-cigarettes).

Of all the sociodemographic factors, education plays the most important role in influencing participation in risky health behaviours as it improves allocative efficiency of health, that is, adopting a healthy lifestyle, without being correlated with occupation and income (Grossman 2000). This means that better-educated people or those having more schooling years are more effective health producers than their less-educated counterparts. They are expected to have a clearer understanding of the disadvantages and risks of e-cigarettes, and thus have a higher tendency to avoid using e-cigarettes. In addition, Cawley and Ruhm (2012) argue that time preference may mediate the relationship between education and risky health behaviours. Better-educated people are likely to have a lower rate of time preference, i.e., they are more willing to exchange their current utility for future utility, than less educated people, and consequently have a lower likelihood of engaging in risky health behaviours. In other words, they are regarded as future-oriented or patient consumers.

The effects of income on risky health behaviours are unclear (Cawley & Ruhm 2012). On one hand, if e-cigarettes are normal goods, individuals may consume more e-cigarettes when their income increases, but on the other hand, income can promote health investment, assuming that being healthy is a normal good. Since individuals can earn more money if they are healthy, they may have a strong tendency to avoid the use of e-cigarettes when their income rises.

Apart from sociodemographic factors, information may affect the likelihood of people engaging in risky health behaviours (Cawley & Ruhm 2012). Generally, people do not have sufficient information about the costs and benefits of risky health behaviours. They are unlikely to understand how risky health behaviours increase the likelihood of mortality and morbidity if they do not seek the information. If people underestimate the risks of e-cigarettes, they may use them. Cawley and Ruhm (2012) suggest that government intervention measures aimed at providing people with health information are necessary, so that the prevalence of risky health behaviours can be reduced.

EMPIRICAL STUDIES

In adolescent research, age was often used as a proxy for schooling years or educational levels. Older adolescents have more schooling years and higher education levels than younger adolescents and thus may better understand the risks of e-cigarettes. However, three studies found positive relationships between e-cigarette use and age and grades, which contradict theories by Grossman (2000) and Cawley and Ruhm (2012). Vogel et al. (2018) observed that the frequency of using e-cigarettes increased with adolescents' age. Camenga et al. (2018) found age to be positively associated with the odds of using e-cigarettes. Wills et al. (2015) suggested that use of e-cigarettes was more frequent among higher grade students. Therefore, the present study expects that age is associated with adolescents' preference for e-cigarettes, but without specifying whether the association is positive or negative.

Since adolescents are unemployed and not income recipients, most studies did not investigate the association between income and e-cigarette consumption in the adolescent population, except for the study by Park et al. (2017). The authors observed that adolescents were more likely to use e-cigarettes if they received a higher weekly allowance. In the present study, the effect of income on the consumption of e-cigarettes is hypothesised to be significant, especially given that e-cigarettes are expensive.

Earlier studies consistently found that information-related factors, such as anti-e-cigarette programmes and perceptions about e-cigarettes, may affect consumption of e-cigarettes in the adolescent population (Kelder et al. 2020; Pulvers et al. 2020; Moustafa et al. 2021; Tercyak et al. 2021). In particular, adolescents with a positive perception of e-cigarettes, that is, those with limited information on e-cigarettes, were more likely to consume e-cigarettes compared to those with a negative perception. The current study anticipates that cigarette- and e-cigarette-related knowledge and awareness, that is, proxies for information, may influence adolescents' decisions to indulge in e-cigarette use. These knowledge and awareness factors are supposed to reduce demand for e-cigarettes.

Other variables that may affect the consumption of e-cigarettes amongst adolescents but are not discussed in the health capital and risky health behaviour theories include gender and locality. Using Canadian data, Benny et al. (2023) found gender as a significant predictor of e-cigarette use, with male adolescents being more likely to use e-cigarettes when

compared to females. Gali et al. (2022), who based their study in Germany, evidenced identical outcomes. They found the odds of e-cigarette consumption to be higher among boys than girls. Han et al. (2022) performed a systematic review of factors affecting the use of e-cigarettes. They found that adolescents from urban areas exhibited higher odds of e-cigarette use than those residing in rural areas. Therefore, the present study anticipates that being male and residing in urban areas are positively correlated with the use of e-cigarettes.

In terms of educational factors, Chaplin et al. (2020) found that adolescents who attended an educational intervention programme about the health risks of vaping were more likely to lower their demand for e-cigarettes. In the study by Graham et al. (2024), receiving information regarding the adverse effects of vaping on health could discourage adolescents from using e-cigarettes. McCauley et al. (2023), conducting a large-scale survey study, found that participation in a vaping prevention education programme could help prevent vaping initiation among adolescents. There was also evidence suggesting that high parental education about e-cigarettes was a protective factor for adolescent vaping (Choi et al. 2022). In addition, a study found that the intensity of e-cigarette use was associated with harm perception and peer smoking (Xie et al. 2024). Short and Cole (2021) pointed to age, gender, and cost of e-cigarettes influencing the spike in the frequency and intensity of vaping. Using a large dataset, Mantey et al. (2019) stressed that the frequency of e-cigarette use was affected by retail access to e-cigarettes.

METHODOLOGY

DATA

The present study conducted a secondary analysis of cross-sectional data extracted from the Tobacco and E-Cigarette Survey among Malaysian Adolescents (TECMA) (Institute for Public Health 2016). The survey was conducted throughout Malaysia and lasted for about a month, from 4th to 30th April 2016. At the time this research was conducted, TECMA was the latest and most comprehensive survey, comprising detailed information regarding the consumption of cigarettes and e-cigarettes among adolescents in primary and secondary schools. The population of interest for the survey was adolescents aged 10 to 19 years. Inclusion criteria were Standard 4–6 (aged between 10 and 12 years) and Form 1–6 students (aged between 13 and 19 years). Exclusion criteria were those who could not read or write English or the Malay language.

The survey employed multi-stage stratified sampling to obtain a nationally representative sample. Firstly, systematic probability sampling was used to select primary and secondary schools in each state. Next, classes in each selected school were chosen using simple random sampling. All students within the selected classes were eligible respondents. The target sample size was calculated using a single-proportion formula. It was determined based on the estimated prevalence of 3% e-cigarette users in the adolescent population, with a 1.5% margin of error and 95% confidence interval. Then, the number was adjusted for the total studied population, an estimated non-response rate of 20%, and a design effect of 1.5. Out of 14,832 eligible respondents, only 13,162 agreed to participate. Nevertheless, this sample size was sufficient to generate meaningful findings.

Details of respondents' demographic profiles, smoking behaviours, as well as knowledge and awareness regarding cigarettes and e-cigarettes were collected. The questionnaires were written in the Malay language. Then, they were translated into English by a professional translator. Additionally, back translation and pilot tests were conducted. To reduce social desirability bias, respondents were told that they would remain anonymous throughout the survey, and their information was used solely for research and policy planning purposes. Prior to conducting the survey, approval from school authorities had to be obtained. Surveyors were responsible for distributing parental consent forms to eligible participants, and only students with parental consent were enrolled in the survey. Ethics clearance was granted by the Medical Research and Ethics Committee of the Ministry of Health Malaysia (NMRR-16-108-28789).

DEPENDENT VARIABLE

The dependent variable used in this study, levels of e-cigarette expenditure, was a qualitative variable with ordinal categories. In the survey, respondents were asked to report how much they spent on e-cigarettes within the past 30 days using a closed-ended question. The possible answers were 'I never buy e-cigarettes', 'less than Ringgit Malaysia (RM) 50', 'RM 50 to RM 100', 'RM 101 to RM 300', 'RM 301 to RM 500', and 'more than RM 500'. Because of the small number of observations, researchers combined several responses, creating four categories: 'RM 0', 'RM 1 to RM 49', 'RM 50 to RM 300', and 'RM 301 and above'. 'RM 0' referred to respondents who reported 'I never buy e-cigarettes'. Previously published studies used expenditure as a proxy for alcohol consumption (Cheah et al. 2020), tobacco use (Cheah et al. 2022), and demand for pharmaceuticals (Ang & Cheah 2023). Hence, expenditure data are considered of high quality for analysis in consumer studies.

INDEPENDENT VARIABLE

The independent variables used in this study were selected considering the health capital and risky health behaviour theories (Grossman 2000; Cawley & Ruhm 2012), previous findings regarding factors determining adolescent consumption of e-cigarettes (Park et al. 2017; Camenga et al. 2018; Vogel et al. 2018; Gali et al. 2022; Han et al. 2022; Benny et al. 2023),

as well as the availability of data. Demographic variables included age, locality, gender, ethnicity, pocket money, and smoking behaviours. Respondents' age was categorised into three groups: 10–12 years (primary school), 13–15 years (lower-secondary school), and 16–19 years (upper-secondary school). Respondents' locality was stratified into urban and rural areas. The ethnic variable comprised four categories: Malay, Chinese, Indian, and other ethnicities. Respondents' income was measured by asking how much pocket money respondents received per day. The possible responses were 'RM 1 and below,' 'RM 2 to less than RM 5,' 'RM 5 to less than RM 10,' and 'RM 10 and above.' In terms of smoking, respondents were asked to declare whether they smoked cigarettes during the past 30 days (yes vs. no).

To examine the role of information in e-cigarette use, cigarette- and e-cigarette-related knowledge and awareness were treated as independent variables. One knowledge variable was evaluated by asking whether respondents had been taught about the risk or danger of tobacco use in the last school year (yes vs. no). Researchers defined two other knowledge variables based on the following questions: 'Once someone has started smoking tobacco or using e-cigarettes, do you think it would be difficult for them to quit?' and 'Do you feel that e-cigarettes are less harmful than ordinary cigarettes?' Respondents answered these questions with either 'yes' or 'no.'

Respondents' awareness of cigarettes and e-cigarettes consisted of three variables. First, respondents were asked whether they had seen any anti-tobacco advertisements on television, cinema, or the internet during the past 12 months (yes vs. no). Second, respondents answered either 'yes' or 'no' to the following question: 'During the past 30 days, did you see any health warning messages and pictures on cigarette packages?' Third, respondents declared whether they had read or been exposed to any posters or pamphlets regarding the dangers of e-cigarettes in the past 12 months (yes vs. no). Although the first and second awareness variables were not directly related to e-cigarettes, researchers expected that, to some extent, they might influence adolescents' decisions to spend money on e-cigarettes.

STATISTICAL ANALYSIS

Due to incomplete information reported by some participants, only 12,844 respondents were included in the statistical analysis. Nonetheless, the sample remained representative as only 2.4% of respondents were excluded. Firstly, Pearson's chi-squared tests of independence were conducted to examine the associations between e-cigarette expenditure and demographic, knowledge, and awareness variables. Next, given that the dependent variable was ordinal, an ordered probit model was estimated to analyse factors affecting various levels of e-cigarette expenditure. Marginal effects of each independent variable were computed and interpreted. Since the data used in the present analysis had a large number of observations, the distribution of sample means approximated a normal distribution. Hence, an ordered probit model with a standard normal cumulative distribution function and normally distributed residuals was suitable for this study (Wooldridge 2010).

The ordered probit model can be expressed as follows:

$$y_i^* = \alpha + x_i'\beta + u_i \quad (1)$$

where x is the vector of independent variables, α is the constant term, β represents the vector of coefficients, and u is the error term. The latent variable is unobservable, but when y_i^* crosses a threshold τ_j, j = 1, 2, 3, and 4, the dependent variable is given by:

$$y_i = j \text{ if } \tau_{j-1} < y_i^* \leq \tau_j \quad (2)$$

where j = 1 represents 'RM 0', j = 2 represents 'RM 1 to RM 49', j = 3 represents 'RM 50 to RM 300', and j = 4 represents 'RM 301 and above'. The probability that observation i will select alternative j is given by:

$$\begin{aligned}
&\Pr(y_i = 1|x_i) = \Phi(\tau_1 - \alpha - x_i'\beta) \\
&\Pr(y_i = 2|x_i) = \Phi(\tau_2 - \alpha - x_i'\beta) - \Phi(\tau_1 - \alpha - x_i'\beta) \\
&\Pr(y_i = 3|x_i) = \Phi(\tau_3 - \alpha - x_i'\beta) - \Phi(\tau_2 - \alpha - x_i'\beta) \\
&\Pr(y_i = 4|x_i) = 1 - \Phi(\tau_4 - \alpha - x_i'\beta) \quad (3)
\end{aligned}$$

where Φ is the standard normal cumulative distribution function.

To determine the best model for the data, researchers developed three ordered probit models. Model 1 regressed e-cigarette expenditure levels on demographic variables. In Model 2, the independent variables included demographic factors and cigarette- and e-cigarette-related knowledge variables. The awareness of cigarette and e-cigarette variables was added to Model 3, the comprehensive model. Researchers compared these three models using information on pseudo R-squared, log likelihood, and Akaike's information criterion (AIC). Additionally, two likelihood ratio (LR) tests were conducted. Model 1 was nested within Model 2 in the first LR test, while Model 2 was nested within Model 3 in the second LR test. Furthermore, researchers computed variance inflation factors (VIFs) to assess potential multicollinearity in the models. P-values less than 0.05 were considered significant.

RESULTS

Descriptive statistics of the variables are presented in Table 1. The total sample consisted of 12,844 respondents, with 95.2%, 2.3%, 1.9%, and 0.6% spending RM 0, RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes, respectively. Many respondents were aged 13 to 15 years (40.1%). The majority of respondents were urban residents (58.5%), females (50.5%), Malays (70.1%), and non-smokers (90.8%). Nearly half of the respondents received RM 2–4 pocket money per day (48.2%), 75% of respondents were taught about the dangers of smoking, 71.2% and 65.8% thought that quitting both cigarette smoking and e-cigarette use was difficult, respectively, and 18.9% perceived e-cigarettes as less risky compared with ordinary cigarettes. Approximately 86.7%, 72.9%, and 58.2% of respondents were aware of anti-tobacco advertisements, health-related texts and images on cigarette packs, and posters or pamphlets on the dangers of e-cigarettes, respectively.

TABLE 1. Summary statistics of variables (n = 12844)

Variables	Total	Expenditure on e-cigarettes (RM)				*p*-value
		0	1–49	50–300	≥301	
Expenditure on e-cigarettes (RM)						
0	12230 (95.2)	–	–	–	–	–
1–49	298 (2.3)	–	–	–	–	
50–300	248 (1.9)	–	–	–	–	
≥301	68 (0.6)	–	–	–	–	
Age (years)						
10–12	4106 (32)	3972 (96.7)	77 (1.9)	45 (1.1)	12 (0.3)	<0.001
13–15	5155 (40.1)	4890 (94.9)	115 (2.2)	124 (2.4)	26 (0.5)	
16–19	3583 (27.9)	3368 (94)	106 (3)	79 (2.2)	30 (0.8)	
Locality						
Urban	7516 (58.5)	7158 (95.2)	172 (2.3)	145 (1.9)	41 (0.6)	0.983
Rural	5328 (41.5)	5072 (95.2)	126 (2.4)	103 (1.9)	27 (0.5)	
Gender						
Male	6358 (49.5)	5819 (91.5)	262 (4.1)	216 (3.4)	61 (1)	<0.001
Female	6486 (50.5)	6411 (98.8)	36 (0.6)	32 (0.5)	7 (0.1)	
Ethnicity						
Malay	9005 (70.1)	8516 (94.6)	241 (2.7)	200 (2.2)	48 (0.5)	<0.001
Chinese	1755 (13.7)	1720 (98)	12 (0.7)	15 (0.8)	8 (0.5)	
Indian	733 (5.7)	708 (96.6)	11 (1.5)	10 (1.4)	4 (0.6)	
Others	1351 (10.5)	1286 (95.2)	34 (2.5)	23 (1.7)	8 (0.6)	
Pocket money (RM)						
≤1	1690 (13.1)	1609 (95.2)	46 (2.7)	28 (1.7)	7 (0.4)	<0.001
2–4	6186 (48.2)	5943 (96.1)	131 (2.1)	85 (1.4)	27 (0.4)	
5–9	4177 (32.5)	3943 (94.4)	95 (2.3)	115 (2.8)	24 (0.6)	
≥10	791 (6.2)	735 (92.9)	26 (3.3)	20 (2.5)	10 (1.3)	
Smoking						
Yes	1185 (9.2)	863 (72.8)	133 (11.2)	147 (12.4)	42 (3.5)	<0.001
No	11659 (90.8)	11367 (97.5)	165 (1.4)	101 (0.9)	26 (0.2)	
Being taught on the danger of smoking						
Yes	9640 (75)	9227 (95.7)	202 (2.1)	167 (1.7)	44 (0.5)	<0.001
No	3204 (25)	3003 (93.7)	96 (3)	81 (2.5)	24 (0.8)	
Quitting smoking is difficult						
Yes	9141 (71.2)	8745 (95.7)	184 (2)	172 (1.9)	40 (0.4)	<0.001
No	3703 (28.8)	3485 (94.1)	114 (3.1)	76 (2.1)	28 (0.8)	
Quitting e-cigarette use is difficult						
Yes	8445 (65.8)	8196 (97.1)	104 (1.2)	117 (1.4)	28 (0.3)	<0.001
No	4399 (34.2)	4034 (91.7)	194 (4.4)	131 (3)	40 (0.9)	
E-cigarettes are less harmful						
Yes	2428 (18.9)	2183 (89.9)	120 (4.9)	102 (4.2)	23 (0.9)	<0.001

No	10416	10047	178	146	45	
	(81.1)	(96.5)	(1.7)	(1.4)	(0.4)	
Exposure to anti-tobacco advertisements						
Yes	11132	10612	244	218	58	0.091
	(86.7)	(95.3)	(2.2)	(2)	(0.5)	
No	1712	1618	54	30	10	
	(13.3)	(94.5)	(3.2)	(1.8)	(0.6)	
Exposure to health warning messages and pictures						
Yes	9359	8836	254	209	60	<0.001
	(72.9)	(94.4)	(2.7)	(2.2)	(0.6)	
No	3485	3394	44	39	8	
	(27.1)	(97.4)	(1.3)	(1.1)	(0.2)	
Exposure to posters or pamphlets on dangers of e-cigarettes						
Yes	7472	7178	133	127	34	<0.001
	(58.2)	(96.1)	(1.8)	(1.7)	(0.5)	
No	5372	5052	165	121	34	
	(41.8)	(94)	(3.1)	(2.3)	(0.6)	

Note: The entries refer to frequencies. For the total sample, column percentages are shown in parentheses. For respondents with different levels of e-cigarette expenditure, row percentages are shown in parentheses. *P-values* for Pearson's chi-squared tests of independence.
Source: TECMA 2016

Regarding Pearson's chi-squared tests, age, gender, ethnicity, pocket money, smoking, being taught about the dangers of smoking, holding the thought that quitting cigarette smoking and use of e-cigarettes was difficult, holding the view that e-cigarettes had a lower risk than cigarettes, being aware of health labels on cigarette packs, and exposure to posters or pamphlets on the dangers of e-cigarettes were significantly associated with expenditure on e-cigarettes. Specifically, the prevalence of spending RM 7 301 on e-cigarettes rose with age and pocket money. It was also higher among adolescents who were males, non-Malays, smokers, not educated about the dangers of smoking, thinking that quitting cigarette smoking and e-cigarette consumption was not difficult, having the perception that e-cigarettes were less harmful compared to ordinary cigarettes, exposed to health-related texts and images on cigarette packs, and unaware of posters or pamphlets on the dangers of e-cigarettes.

Results of the ordered probit models are shown in Table 2. Model 3 was considered the best model explaining expenditure on e-cigarettes because it had a significant LR test, the highest values of pseudo R-squared and log likelihood, as well as the lowest score on AIC. Also, multicollinearity was not a concern because the maximum VIF in Model 3 was below the generally accepted threshold of 10 (Wooldridge 2010). Therefore, researchers used Model 3 to make statistical inferences.

TABLE 2. Estimated coefficients for the ordered probit models (n = 12844)

Variables	Model 1	Model 2	Model 3
Age (years)			
10–12	Ref.	Ref.	Ref.
13–15	0.113*	0.116*	0.119*
	(0.054)	(0.056)	(0.056)
16–19	0.190*	0.164*	0.161*
	(0.058)	(0.059)	(0.059)
Locality			
Urban	0.073	0.065	0.065
	(0.045)	(0.046)	(0.046)
Rural	Ref.	Ref.	Ref.
Gender			
Male	0.608*	0.535*	0.527*
	(0.055)	(0.056)	(0.056)
Female	Ref.	Ref.	Ref.
Ethnicity			
Malay	Ref.	Ref.	Ref.
Chinese	-0.315*	-0.354*	-0.353*
	(0.084)	(0.086)	(0.087)
Indian	-0.090	-0.130	-0.113
	(0.099)	(0.101)	(0.101)
Others	-0.044	-0.021	-0.019
	(0.074)	(0.075)	(0.075)
Pocket money (RM)			
≤1	Ref.	Ref.	Ref.
2–4	-0.244*	-0.212*	-0.206*
	(0.067)	(0.069)	(0.069)
5–9	-0.078	-0.061	-0.053
	(0.072)	(0.073)	(0.073)
≥10	0.040	0.064	0.072
	(0.095)	(0.096)	(0.096)
Smoking			
Yes	1.077*	1.050*	1.032*
	(0.051)	(0.052)	(0.053)
No	Ref.	Ref.	Ref.
Being taught on the danger of smoking			
Yes	–	-0.209*	-0.192*
		(0.048)	(0.050)
No	–	Ref.	Ref.
Quitting smoking is difficult			
Yes	–	0.001	0.006
		(0.050)	(0.050)

No	–	Ref.	Ref.
Quitting e-cigarette use is difficult			
Yes	–	-0.305*	-0.297*
		(0.047)	(0.047)
No	–	Ref.	Ref.
E-cigarettes are less harmful			
Yes	–	0.336*	0.329*
		(0.047)	(0.047)
No	–	Ref.	Ref.
Exposure to anti-tobacco advertisements			
Yes	–	–	-0.047
			(0.064)
No	–	–	Ref.
Exposure to health warning messages and pictures			
Yes	–	–	0.184*
			(0.055)
No	–	–	Ref.
Exposure to posters or pamphlets on dangers of e-cigarettes			
Yes	–	–	-0.088*
			(0.046)
No	–	–	Ref.
Maximum VIF	2.660	2.670	2.670
Log likelihood	-2548.314	-2479.599	-2472.069
Pseudo R^2	0.166	0.189	0.191
AIC	5124.628	4995.197	4986.167
LR chi-square	–	137.430	15.060
p-value	–	<0.001	<0.002

Note: Ref. refers to reference groups. VIF refers to the variance inflation factor. AIC refers to Akaike's information criterion. LR refers to likelihood ratio. Robust standard errors in parentheses. *p<0.05.
Source: TECMA 2016

Estimated marginal effects of all the independent variables are shown in Table 3. Adolescents aged 13–15 and 16–19 years were 0.4–0.5%, 0.2–0.4%, and 0.1% more likely to spend RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes, respectively, compared to those aged 10 12 years. This is mainly because older adolescents know more about e-cigarettes and have greater exposure to e-cigarette products than their younger counterparts. Boys were 1.6%, 1.1%, and 0.2% more likely to spend RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes, respectively, than girls. This may be due to females generally having better health awareness than males. Compared to Malays, Chinese were 0.1–0.9% less likely to spend RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes, highlighting significant cultural differences in preference for e-cigarettes.

TABLE 3. Estimated marginal effects of the independent variables (n = 12844)

Variables	Expenditure on e-cigarettes (RM)			
	0	1–49	50–300	≥301
Age (years)				
10–12	Ref.	Ref.	Ref.	Ref.
13–15	-0.007*	0.004*	0.002*	0.001*
	(0.003)	(0.002)	(0.001)	(0.001)
16–19	-0.009*	0.005*	0.004*	0.001*
	(0.004)	(0.002)	(0.001)	(0.001)
Locality				
Urban	-0.003	0.002	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)
Rural	Ref.	Ref.	Ref.	Ref.
Gender				
Male	-0.030*	0.016*	0.011*	0.002*
	(0.003)	(0.002)	(0.001)	(0.001)
Female	Ref.	Ref.	Ref.	Ref.
Ethnicity				
Malay	Ref.	Ref.	Ref.	Ref.
Chinese	0.015*	-0.009*	-0.005*	-0.001*
	(0.003)	(0.002)	(0.001)	(0.001)
Indian	0.006	-0.003	-0.002	-0.001
	(0.004)	(0.003)	(0.002)	(0.001)
Others	0.001	-0.001	-0.001	-0.001
	(0.004)	(0.002)	(0.001)	(0.001)
Pocket money (RM)				
≤1	Ref.	Ref.	Ref.	Ref.
2–4	0.011*	-0.006*	-0.004*	-0.001*
	(0.004)	(0.002)	(0.001)	(0.001)
5–9	0.003	-0.002	-0.001	-0.001
	(0.004)	(0.002)	(0.001)	(0.001)
≥10	-0.004	0.002	0.002	0.001
	(0.006)	(0.003)	(0.002)	(0.001)
Smoking				
Yes	-0.125*	0.058*	0.053*	0.015*
	(0.012)	(0.005)	(0.006)	(0.003)
No	Ref.	Ref.	Ref.	Ref.
Being taught on the danger of smoking				
Yes	0.011*	-0.006*	-0.004*	-0.001*
	(0.003)	(0.002)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.

Quitting smoking is difficult				
Yes	-0.001	0.001	0.001	0.001
	(0.003)	(0.002)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.
Quitting e-cigarette use is difficult				
Yes	0.018*	-0.010*	-0.007*	-0.001*
	(0.003)	(0.002)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.
E-cigarettes are less harmful				
Yes	-0.022*	0.012*	0.008*	0.002*
	(0.004)	(0.002)	(0.002)	(0.001)
No	Ref.	Ref.	Ref.	Ref.
Exposure to anti-tobacco advertisements				
Yes	0.003	-0.001	-0.001	-0.001
	(0.004)	(0.002)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.
Exposure to health warning messages and pictures				
Yes	-0.009*	0.005*	0.003*	0.001*
	(0.003)	(0.001)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.
Exposure to posters or pamphlets on dangers of e-cigarettes				
Yes	0.005*	-0.003*	-0.002*	-0.001*
	(0.003)	(0.001)	(0.001)	(0.001)
No	Ref.	Ref.	Ref.	Ref.

Note: Ref. refers to reference groups. Robust standard errors in parentheses. *p<0.05.
Source: TECMA 2016

The probabilities of spending RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes increased by at least 1.5% if respondents smoked cigarettes, whereas being taught about the dangers of smoking elevated the probability of not spending on e-cigarettes by 1.1%, thereby concluding that ordinary cigarettes are complementary goods to e-cigarettes, and that smoking-related knowledge is a protective factor for e-cigarette use. Respondents with the perception that quitting e-cigarette use was difficult were 1%, 0.7%, and 0.1% less likely to spend RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes, respectively, compared with those without this perception. Having the belief that e-cigarettes were less risky compared to ordinary cigarettes increased the probabilities of spending RM 1–49, RM 50–300, and RM ⁷ 301 on e-cigarettes by 1.2%, 0.8%, and 0.2%, respectively. These findings emphasise that the perception of e-cigarettes plays a significant role in determining demand for e-cigarettes because it can modify consumer preference. Being aware of health-related texts and images on cigarette packs reduced the probability of spending on e-cigarettes by 0.9%. Perhaps this is because adolescents view e-cigarettes as a substitute for ordinary cigarettes. Exposure to posters or pamphlets on the dangers of e-cigarettes increased the probability of having zero expenditure on e-cigarettes by 0.5%, underscoring the vital role of education in protecting adolescents from using e-cigarettes.

DISCUSSION

This study found that older adolescents had a higher probability of spending money and spent more on e-cigarettes than their younger counterparts. This finding did not support the theory proposed by Grossman (2000) but agreed with the evidence from numerous empirical studies. For instance, Vogel et al. (2018) found the rate of e-cigarette use to be higher among older than younger adolescents, Camenga et al. (2018) observed that the odds of using e-cigarettes increased with age, and Wills et al. (2015) found students at higher grade levels to have a greater tendency than students at lower grade levels to engage in e-cigarette use. Two reasons were cited by Jeon et al. (2016) and Park et al. (2017). First, the time spent exposed to peers using e-cigarettes was longer among older adolescents; thus, e-cigarettes may be more familiar to them. Second, older adolescents were more aware of e-cigarette products and had better access to them than younger adolescents. Nationwide anti-vaping policies are therefore suggested to focus more on improving awareness of the harmful effects of e-cigarettes among students at higher grade levels, especially those aged 16–19 years.

In line with the present study's hypothesis, male adolescents not only had a higher likelihood of spending money on e-cigarettes but also spent more than female adolescents. Similar results were observed in past studies, which showed being male to be correlated with increased odds of consuming e-cigarettes (Gali et al. 2022; Doherty et al. 2022; Benny et al. 2023). Health awareness and cultural factors may explain these outcomes. As discussed by Cheah et al. (2019) and Cheah et al. (2022), female smoking is culturally unacceptable in Malaysian society, and females are usually more concerned about their health compared to males. In terms of policy implications, school authorities could collaborate with public health administrators on conveying the adverse effects of e-cigarettes on gender-specific health at schools. Integrating an anti-e-cigarette campaign into the School Health Service provided by the Ministry of Health Malaysia could be a desirable strategy.

While the empirical studies related to the ethnic correlate of e-cigarette consumption among adolescents span the US and Canada (Moustafa et al. 2021; Benny et al. 2023; Sun et al. 2023), little attention has been paid to countries in SEA. In the present study, adolescents who were from the Malay ethnic group had higher levels of expenditure on e-cigarettes compared with their Chinese counterparts. Surprisingly, however, there were no differences in the expenditure levels between Malays and Indians, and those of other ethnicities. Why e-cigarette expenditure was higher among Malays than

Chinese was not well understood, but differences in culture and parental roles in educating children may be plausible explanations. It is also plausible that Malays are more likely to be dual users than the Chinese. An empirical study by Azagba et al. (2023) discussed the possibility that cultural factors had a significant impact on the consumption of e-cigarettes among youths. Therefore, to acquire a deeper understanding of the reasons for ethnic differences in the preference for e-cigarettes, a comprehensive qualitative study can be carried out. Based on the present study's findings, policymakers are urged to pay more attention to Malay adolescents than to Chinese. Meanwhile, the key role of parents in curbing e-cigarette use should not be overlooked.

The association between smoking and use of e-cigarettes was widely evidenced in previous studies (Camenga et al. 2018; Moustafa et al. 2021; Gali et al. 2022). Lindstrom and Rosvall (2018) found that cigarette users had higher odds of consuming e-cigarettes than non-users. Chang and Seo (2021) also observed a strong positive correlation between smoking and e-cigarette use within a large sample of school-going adolescents. Apart from current use, the history of cigarette smoking was found to be a factor affecting e-cigarette consumption (Chapman & Wu 2014). These prior findings were supported by the current study, which showed that adolescents who allocated a moderate or large amount of money to e-cigarettes were more likely to be smokers rather than non-smokers. This is attributable to nicotine addiction (Vogel et al. 2018). Another reason may be related to dual use (Lim et al. 2022). Therefore, an intervention aimed at reducing the incidence of cigarette consumption among adolescents is suggested to be integrated with e-cigarette control policies.

The findings obtained provide new insight into the relationships between cigarette- and e-cigarette-related knowledge and levels of expenditure on e-cigarettes. These findings lend support to the hypothesis that adequate information reduces demand for e-cigarettes. In the present study, adolescents who had been taught about the dangers of smoking were less likely to spend a large or moderate amount of money on e-cigarettes than those who had not, which aligns with the finding of Kelder et al. (2020) that schools implementing e-cigarette prevention programmes tended to show a low prevalence of e-cigarette use because the programmes could improve knowledge regarding e-cigarettes among students. Furthermore, consistent with the evidence of Pulvers et al. (2020), adolescents who perceived that quitting e-cigarette use was difficult spent less and were less likely to spend on e-cigarettes compared with those without such a perception. In addition, the current study observed that the probability of having moderate to high expenditure on e-cigarettes increased significantly if adolescents thought that e-cigarettes were less risky compared to ordinary cigarettes. Similarly, Moustafa et al. (2021) found that 9th-grade adolescents who had positive expectations of e-cigarette consumption had a higher likelihood of indulging in e-cigarette use compared to those without such positive expectations. Tercyak et al. (2021) also identified that the likelihood of consuming e-cigarettes was lower among 7th, 9th and 11th grade students who perceived a high risk of e-cigarette consumption compared to those with low-risk perception. Based on the present study's findings, policymakers could consider the important role of knowledge in reducing e-cigarette use among Malaysian adolescents. Educational strategies should ensure that the existing classroom-based anti-drug education programmes conducted at schools in Malaysia include information on the risks of both cigarettes and e-cigarettes. This may, in turn, safeguard students from becoming e-cigarette consumers.

In this study, the influence of information on e-cigarette use was explained by the associations between awareness of cigarettes and e-cigarettes, and e-cigarette expenditure levels. It is interesting to find that adolescents who were exposed to health-related texts and images on cigarette packs had a higher likelihood of allocating a large amount of money to e-cigarettes than those without this kind of exposure. There are two plausible explanations for this outcome. First, most e-cigarette users are dual users. Hence, cigarette pack warnings are very common to them (Sweet et al. 2019). Second, e-cigarettes are usually seen as a healthier substitute for ordinary cigarettes (Rom et al. 2014). Therefore, adolescents who are aware of the adverse effects of ordinary cigarettes may have a high preference for e-cigarettes. The current study also found that adolescents who were aware of posters or pamphlets on the dangers of e-cigarettes were less likely to spend and spent less on e-cigarettes compared to those who were unaware. This finding emphasises the important role of print media in influencing adolescents' decisions to consume e-cigarettes. It appears, therefore, that increasing awareness of the dangers of e-cigarettes is crucial. School authorities could make information pertaining to e-cigarettes more easily accessible and ensure that students do not possess misconceptions about e-cigarettes.

This study extends past studies by examining how pocket money, a proxy for income, affected e-cigarette expenditure. This is important in the sense that it provides policymakers and researchers with information about whether demand for e-cigarettes is largely influenced by income. Although a negative relationship existed between pocket money and e-cigarette expenditure, the relationship was weak, as only one category (RM 2–4) was significant. It can, therefore, be concluded that the role of income in adolescent e-cigarette expenditure is less important. Moreover, the lack of significant rural-urban variations in e-cigarette expenditure was worthy of note. One may expect that urban dwellers spend more on e-cigarettes than rural dwellers because e-cigarettes are more accessible in urban areas, but that may not be the case in Malaysia.

It is apparent that the use of large nationwide data that consists of a wide range of key variables and a rigorous analytical approach is the main strength of the current study. Nonetheless, the present study possesses a few limitations. First, although the data are comprehensive and able to generate important findings, they are somewhat obsolete and thus cannot reflect the most recent scenario in Malaysia. Second, owing to the nature of cross-sectional data, causality between variables cannot be firmly established. Third, all the information was self-reported by respondents. Since e-cigarette consumption and smoking among students are prohibited and considered unethical behaviours, minor social desirability bias and self-report bias may exist. Last, pocket money may not be a suitable proxy for socioeconomic status.

CONCLUSION

The present study illuminates the correlates of e-cigarette expenditure among Malaysian adolescents. Findings indicated that age, gender, ethnicity, smoking, as well as knowledge and awareness regarding cigarettes and e-cigarettes, were significantly associated with different levels of expenditure on e-cigarettes. In particular, adolescents were more likely to spend and spent a moderate to large amount of money on e-cigarettes if they were older, males, Malays, smokers, not instructed on the dangers of smoking, holding the belief that quitting e-cigarette use was not difficult and e-cigarettes were less harmful compared to ordinary cigarettes, being exposed to health warning messages and pictures on cigarette packages, and unaware of posters or pamphlets on dangers of e-cigarettes.

Although this study did not investigate the effectiveness of policies, its findings are important to attract policymakers' attention. Promising interventionist strategies aimed at reducing expenditure on e-cigarettes in the school-going adolescent population can be implemented based on the present study's results. Additionally, since the present study is a rigorous health economic research paper focusing on factors affecting consumer health behaviours, it makes a significant contribution to the objective of Jurnal Ekonomi Malaysia, that is, developing economic theories of various disciplines and providing important policy implications. With the availability of data, an in-depth investigation into the mediating effects of e-cigarette use on the relationships between demographic factors and health outcomes is recommended as a direction for future study. Up-to-date longitudinal data can also be collected to examine the causal effects of knowledge and awareness on e-cigarette spending.

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