Journal of Public Health and Pharmacy
2775-4952 (Online - Elektronik)
Research Articles Open Access

Factors Influencing Electronic Cigarette use among Young Adults in Sarawak, Malaysia: A Hierarchical Analysis

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ARTICLE INFO

Manuscript Received: 01 Jan, 2025
Revised: 17 Mar, 2025
Accepted: 10 Apr, 2025
Date of publication: 02 Oct, 2025
Volume: 5
Issue: 3
DOI: 10.56338/jphp.v5i3.6765

KEYWORDS

Electronic Cigarettes;
Smoking;
Psychosocial Factors;
Sarawak

ABSTRACT

Introduction: The rapid global rise in electronic cigarette (e-cigarette) use has led to increasing research interest, yet factors influencing its adoption remain underexplored in Malaysia. This study investigates sociodemographic and psychosocial determinants of e-cigarette use in the Samarahan and Kuching divisions of Sarawak, Malaysia.
Methods: A cross-sectional study was conducted among smokers aged 18 and above. A total of 474 participants were recruited using cluster sampling. Data collection was performed through face-to-face interviews using a structured questionnaire. Hierarchical multinomial logistic regression was applied to identify key predictors of e-cigarette use.
Results: Among participants, 27.8% were e-smokers, 25.8% were switchers, and 46.4% were dual smokers. The analysis revealed that females were more likely to be e-smokers (AOR = 5.889, $p < .001$) and switchers (AOR = 2.647, $p = .021$) than males. Additionally, degree holders were more likely to be e-smokers than dual smokers (AOR = 4.106, $p = .025$). Psychosocial factors, such as subjective norms (AOR = 1.435, $p = .023$) and perceived usefulness (AOR = 1.616, $p = .016$), were significant predictors of e-cigarette use.
Conclusion: Sociodemographic and psychosocial factors, such as gender and education, influence e-cigarette use in Sarawak. These findings provide valuable insights for designing targeted public health strategies to regulate e-cigarette use and support smoking cessation efforts in Malaysia.

Publisher: Pusat Pengembangan Teknologi Informasi dan Jurnal Universitas Muhammadiyah Palu

INTRODUCTION

The introduction of electronic cigarettes (e-cigarettes) in the mid-2000s has significantly altered the tobacco landscape, particularly among young adults. Marketed as modern and technologically advanced alternatives to conventional cigarettes, e-cigarettes have gained popularity due to their perceived ability to facilitate smoking cessation and provide a customizable smoking experience (1,2). Unlike traditional tobacco products, these devices allow users to control nicotine levels, flavors, and vapor production, further enhancing their appeal. While some evidence suggests that daily e-cigarette users exhibit higher smoking cessation rates compared to intermittent users, the overall effectiveness of e-cigarettes as a cessation aid remains contentious (3,4). Concerns persist regarding their long-term safety, potential to perpetuate nicotine addiction, and rising popularity among individuals who may not have previously engaged in tobacco use (5,6). The dual role of e-cigarettes as both a harm reduction tool and a potential public health risk underscores the need for further research to inform evidence-based policies.

In Malaysia, the increasing prevalence of e-cigarette use among young adults presents a growing public health challenge. The country is already grappling with high smoking rates, and the concurrent rise in e-cigarette consumption further complicates tobacco control efforts (7,8). Although e-cigarettes are often perceived as a less harmful alternative to conventional smoking, their widespread use, particularly among adolescents and young adults, raises concerns about nicotine dependence and the risk of transitioning to conventional cigarette smoking. Despite the expanding body of research on e-cigarette usage, significant knowledge gaps remain regarding the sociodemographic and psychosocial determinants influencing adoption patterns (7). The absence of comprehensive and standardized regulatory measures has further contributed to the normalization of e-cigarette use, potentially undermining existing tobacco control strategies (9, 10). In addition, aggressive marketing tactics, the accessibility of e-cigarettes, and peer influence have played a role in shaping perceptions and behaviors related to their consumption, particularly among young populations (2,11-13).

This study aims to examine the sociodemographic and psychosocial factors associated with e-cigarette use among smokers in Sarawak, focusing on the Samarahan and Kuching divisions. Sarawak represents a unique context where cultural, social, and economic factors may influence smoking behaviors differently from other regions in Malaysia. By addressing an understudied population within Southeast Asia, this research seeks to fill a critical gap in understanding the motivations and behavioral patterns underlying e-cigarette use. The findings from this study will provide valuable insights that can inform the development of targeted smoking cessation programs, policy interventions, and public health campaigns. A more nuanced understanding of the predictors of e-cigarette adoption will contribute to the broader discourse on tobacco control and harm reduction strategies, guiding policymakers in formulating regulations that balance potential benefits with the risks associated with e-cigarette consumption. Ultimately, this research aims to support evidence-based public health measures that mitigate the growing challenges posed by both traditional tobacco use and the increasing prevalence of e-cigarette consumption in Malaysia.

METHOD

Study design

We employed an observational cross-sectional design using a quantitative research approach. We chose a cross-sectional design because it is particularly suitable for investigating the patterns and determinants of electronic cigarette (e-cigarette) use among young adult smokers. In this design, we simultaneously assessed both the exposure (factors influencing e-cigarette use) and the outcome (use of e-cigarettes) at a single point in time.

Population and Sample

The study population comprised smokers or vapers aged 18 years and above, regardless of gender, residing in the Samarahan and Kuching divisions of Sarawak. Individuals with pre-existing mental illnesses or cognitive impairments were excluded. Data collection was conducted from October 2022 to August 2023. A cluster sampling technique was used to determine the sample size. The initial sample size was estimated using a single proportion formula, assuming a base prevalence of e-cigarette use at 5% (14). This resulted in a required sample size of 200. To account for the clustering effect, the sample size was multiplied by a design effect of 1.95 (based on 20 respondents per cluster), yielding 395 participants. To adjust for potential non-response, the sample was further inflated by 15%, resulting in a final required sample size of 474 participants. This adjustment ensures sufficient statistical power and minimizes biases associated with incomplete responses.

Research Location

Participants were recruited from vape outlets using a two-tier sampling approach, targeting key locations where e-cigarette users purchase and consume these products. Seven vape shops in Samarahan and fifteen in Kuching were selected based on accessibility, user traffic, and relevance to the target population. Systematic sampling was applied at these locations, where customers were recruited until the required sample size was achieved. While this method ensured efficient access to e-cigarette users, the potential bias of relying on vape shop customers was acknowledged as a limitation, as it may not fully represent the broader population of e-cigarette users.

Instruments

Data collection was conducted using a structured questionnaire adapted from established sources (15-17) and administered through face-to-face interviews. The questionnaire assessed multiple domains, including sociodemographic characteristics, smoking and vaping behaviors, knowledge of e-cigarettes and related policies, attitudes and beliefs toward e-cigarette use, and constructs from the Technology Acceptance Model. It also incorporated behavioral components from the Theory of Reasoned Action, evaluating personal control and decision-making processes. Responses were recorded using multiple-choice questions, knowledge-based scoring, and Likert scales ranging from four to seven points, ensuring a comprehensive assessment of user perceptions and behaviors.

Measures

Smoking status is classified into three categories. According to the Global Adult Tobacco Survey (GATS) definition, current smokers are defined as smoking at least 100 cigarettes in their lifetimes and currently everyday smoking. Former smokers smoked at least 100 cigarettes in their lifetimes but currently do not smoke. A non-smoker is defined as having not smoked 100 cigarettes in their lifetime (18).

E-cigarettes use is classified by respondents who answer yes for using e-cigarettes in the past 30 days or anytime before that period were considered e-cigarette users. Respondents who try e-cigarettes even once define it as never trying e-cigarettes (19). The e-smokers were further classified into e-smokers, switchers to e-smokers and dual smokers. **E-smokers**: Individuals who have used an e-cigarette at least once in the last 30 days **Switchers**: These people previously smoked conventional cigarettes but have transitioned to solely using e-cigarettes at least once in the past 30 days without returning to traditional/conventional cigarettes. **Dual smokers**: These individuals have consumed conventional cigarettes and e-cigarettes within the past 30 days at least once.

Knowledge: Refers to the understanding and awareness of facts, information and skills related to e-cigarettes. This includes being informed about the health effects and regulations of the different brands and types available in the market. It is closed-ended, with respondents could answer "Yes", "No", or "I don't know".

Attitude, Motivation, Subjective Norm, Usefulness and Ease of Use questions were ranked from 1 (strongly disagree) to 7 (strongly agree) using a Likert scale.

Attitude: This pertains to an individual's evaluation of using e-cigarettes. It encompasses their preferences, opinions and emotional responses towards using them.

Motivation: Represents the drive or incentives that lead individuals to use conventional or e-cigarettes. This can include factors like wanting to quit smoking, peer influence or perceiving benefits such as taste/flavour or convenience.

Subjective Norm: Refers to the perceived pressures or societal expectations regarding the use of e-cigarettes. It encompasses opinions from family and friends, its norms, and how society views electronic cigarette usage.

Usefulness: Relates to the perceived benefits or utility derived from using cigarettes. This can include aspects such as perceived health benefits, economic advantages or fulfilling a desire for novelty.

Ease of Use: Focuses on how easy and accessible it's to use e-cigarettes. Factors that contribute to this perception include availability, user-friendliness and ease of maintenance.

Intention and behaviour were measured on a 4-point Likert scale (1= Definitely not, 2= Probably not, 3= Probably yes, 4= Definitely yes).

Intention: Represents an individual's self-predicted likelihood or conscious plan to use e-cigarettes. This intention is shaped by their attitudes towards the norms they perceive from others around them and their perceptions regarding usefulness and ease of use.

Behaviour: Refers to using e-cigarettes and can be evaluated by considering factors such as how curious they are used, their intention towards law and regulation and individual flavour preferences regarding usage.

Data collection procedure

The data collection procedure for this study was comprehensive and methodically executed. Respondents were fully briefed on the study's purpose and provided written informed consent before participating. Face-to-face interviews were conducted using a structured questionnaire, primarily at vape shops. A pilot study involving 45 eligible participants was conducted to assess the instrument's reliability in the local context. These participants were not included in the main study to avoid interaction effects. The pilot aimed to evaluate questionnaire clarity, language comprehensibility and identify areas for refinement. The study achieved an internal reliability level of 0.65 to 0.75, considered acceptable in social science research.

Data Analysis

Data entry and analysis for this study followed a systematic and comprehensive approach. Initially, all collected data was manually verified by the researcher for completeness. The data was then entered into Microsoft Office Excel 365 for preliminary entry and validation. Subsequently, it was exported to IBM SPSS version 28.0 for in-depth analysis. Descriptive statistics were employed to calculate frequencies and percentages for all variables. Quantitative variables were described using means, standard deviations, minimums, and maximums, while qualitative variables were presented as percentages. The core analytical method used was hierarchical multinomial logistic regression. This approach was chosen to identify determinants of e-smoking, with smoking status (e-smokers, switchers, and dual smokers) as the dependent variable. This method allowed us to systematically examine the contribution of each level of predictors while controlling for confounding variables and understanding their relative importance in shaping e-cigarette use behavior. Independent variables included sociodemographic characteristics, behavioural attributes, and various psychosocial factors such as knowledge, attitude, motivation, subjective norms, perceived utility, ease of use, intention, and behaviour. A p-value less than .05 was considered statistically significant.

Ethical Approval

This study adhered to strict ethical standards, with approval obtained from the Ethical Committee of University Malaysia Sarawak (UNIMAS) (Ref: UNIMAS/TNC(PI)/09 – 65/02 (27)). All respondents were thoroughly briefed on the study's objectives, procedures, and expected outcomes before participation. They were informed about the potential benefits of the research, both to themselves and others. The research emphasized the absolute confidentiality of all information collected and explicitly communicated the participants' right to withdraw from the study at any time without any consequences. Written informed consent was obtained from each participant.

RESULTS

Table 1 illustrates the sociodemographic characteristics of the study participants. For age, participants fell within an 18 to 49-year age range (M = 24.79, SD = 5.88). The median age was 23 years. The largest age group was individuals between 20 to 24 years, making up 49.3% of the sample, followed by individuals aged less than 20 years (13.5%), those aged 25 to 29 (18.6%), and 30 years or older (18.6%). Regarding gender, most participants identified as male (83.4%), with a smaller proportion identifying as female (16.6%). The racial distribution of the sample was diverse, with Malay (45.1%) being the predominant race, followed by Iban (18.8%), Bidayuh (18.4%), other races (9.0%), Chinese (7.0%), and Indian (1.8%). In terms of religion, Islam was the most commonly reported (50.7%), followed by Christianity (44.2%), Buddhism (4.0%), and Hinduism (1.1%). For education, the majority of the participants reported having either a diploma (32.5%) or a degree (29.4%). This was followed by secondary school (30.7%), others (5.2%), primary school (2.0%), and only one participant reported having no formal education (.2%). Family sizes ranged from 1 to 15 members (M = 5.35, SD = 2.182), with a median size of 5. The largest segment of the sample lived in families with 4 to 6 members (57.0%), followed by families with seven or more members (24.9%) and families with three or fewer members (18.2%). Monthly income ranged from RM800 to RM8500 (M = 2086.15, SD = 1046.792), with a median income of 1780. The largest income group earned between 1001 and 2000 (79.1%), followed by those earning between 2001 and 3000 (10.3%), those earning 3001 to 4000 (4.9%), and those earning more than 4001 (4.5%). Only 5 participants reported earning less than 1000 (1.1%). In terms of working status, the

largest group were students (37.0%), followed by those employed in the private sector (33.2%), workers (12.8%), government employees (7.0%), self-employed (5.8%), and business owners (4.3%).

Table 1 Characteristics of the respondents (N=446)

Variables	Frequency	%	Statistics
Age in years			
< 20	60	13.5	Mean= 24.79 (SD=5.877)
20 - 24	220	49.3	Median=23.00
25 - 29	83	18.6	Min=18, Max=49
≥30	83	18.6	
Gender			
Male	372	83.4	
Female	74	16.6	
Ethnicity			
Malay	201	45.1	
Iban	84	18.8	
Bidayuh	82	18.4	
Others bumi	40	9.0	
Chinese	31	7.0	
Indian	8	1.8	
Religion			
Islam	226	50.7	
Christian	197	44.2	
Buddhist	18	4.0	
Hindhu	5	1.1	
Level of education			
No formal education	1	.2	
Primary school	9	2.0	
Secondary school	137	30.7	
Diploma	145	32.5	
Degree	131	29.4	
Others	23	5.2	
Family size			
≤3	81	18.2	Mean=5.35 (SD=2.182)
4 - 6	254	57.0	Median=5.00
≥7	111	24.9	Min, 1, Max, 15
Monthly income			
<1000	5	1.1	Mean=2086.15
1001-2000	353	79.1	(SD= 1046.792)
2001-3000	46	10.3	Median= 1780.00
3001-4000	22	4.9	Min,800, Max, 8500
>4001	20	4.5	
Working status			
Student	165	37.0	
Private	148	33.2	
Workers	57	12.8	
Government	31	7.0	
Self-employed	26	5.8	
Business	19	4.3	

Table 2 provides a detailed account of the respondents' smoking habits, including their smoking patterns, age at starting e-smoking and conventional smoking, and daily frequency of smoking both types of cigarettes. Regarding smoking patterns, 27.8% of respondents identified as e-smokers, 25.8% had switched to e-smoking from conventional

smoking, and 46.4% were dual smokers (conventional and e-cigarettes). For those who e-smoked (n=446), the mean age of initiation was 20.5 years (SD=5.6, Median=19, Range 12-45 years). Nearly half (49.6%) started between the ages of 15-19, 27.1% at 20-24 years, and the remainder began at 25 years or later. The average number of e-cigarettes smoked per day was approximately 9 (SD=4.2, Median=8, Range 1-28). Most e-smokers (63.7%) reported smokes 6-10 puffs of e-cigarettes daily. Regarding conventional smoking among those who had ever smoked (n=322), the mean age of initiation was lower at 15.3 years (SD=3.1, Median=15, Range 10-30 years). A large proportion (41.9%) began smoking before age 15, and half (50.0%) started between 15-19 years. The average frequency of smoking conventional cigarettes per day was approximately 5 (SD=5.4, Median=3, Range 1-50) among dual smokers (n=207). The majority (75.4%) smoked 5 or fewer conventional cigarettes daily.

Table 2 Pattern of smoking, age at starting and frequency of smoking

Variables	Frequency	%	Statistics
Pattern of smoking			
E-smoker	124	27.8	
Switch to e-smoking (Switcher)	115	25.8	
Dual smoker	207	46.4	
Age at starting e-smoking (yrs) (n=446)			
< 15	22	4.9	Mean =20.5
15 - 19	221	49.6	SD=5.6
20 - 24	121	27.1	Median=19.0
25 - 29	38	8.5	Min 12;
30 - 34	25	5.6	Max= 45
≥35	19	4.3	
Frequency of smoking E-cigarettes per day (n=446)			
≤5	63	14.1	Mean =9.04 (Sd=4.2)
6 - 10	284	63.7	Median= 8.0
11 - 15	53	11.9	Min=1
≥16	46	10.3	Max=28
Age at starting conventional smoking (yrs) (n=322)			
< 15	135	41.9	Mean=15.3(Sd=3.1)
15 - 19	161	50.0	Median= 15.0
≥20	26	8.1	Min=10; Max=30
Frequency of smoking conventional cigarettes per day (n=207)			
≤5	156	75.4	Mean = 4.67(Sd= 5.4)
6 - 10	38	18.4	Median= 3.0
≥11	13	6.3	Min=1; Max=50

Table 3 provides the hierarchical multinomial logistic regression analysis examined factors influencing electronic cigarette use, comparing e-smokers and switchers to dual smokers (reference category). Two models were constructed: Model 1 included sociodemographic variables (age, gender, education level, working status) and drug use, while Model 2 added psychosocial factors (knowledge, attitude, motivation and beliefs, subjective norms, perceived usefulness, perceived ease of use, intention to use, and actual use). This approach allowed for a comprehensive examination of both demographic and psychological predictors of e-cigarette use patterns.

Both models demonstrated good fit, with Model 1 showing a significant improvement over the null model ($\chi^2 = 93.530$, df = 18, $p < .001$; R^2 McF = 6.8%, R^2 N = 13.3%). Model 2, incorporating psychosocial variables, further improved the fit ($\chi^2 = 137.785$, df = 34, $p < .001$; R^2 McF = 9.8%, R^2 N = 19.3%). The increase in explained variance from Model 1 to Model 2 suggests that psychosocial factors contribute additional explanatory power beyond sociodemographic characteristics in predicting e-cigarette use patterns.

Key findings revealed that gender was a significant predictor, with females more likely to be e-smokers (AOR = 5.889, p < .001) or switchers (AOR = 2.647, p = .021) compared to dual smokers. Education level was also significant, with degree holders more likely to be e-smokers than dual smokers (AOR = 4.106, p = .025). Interestingly, drug use was associated with lower odds of being an e-smoker compared to a dual smoker (AOR = 0.159, p = .018). Among psychosocial factors, subjective norms significantly increased the likelihood of being an e-smoker (AOR = 1.435, p = .023), while perceived usefulness was associated with higher odds of being a switcher (AOR = 1.616, p = .016). Age groups 20-24 and 25-29 were more likely to be switchers compared to those 30 and above (AOR = 2.868, p = .007 and AOR = 3.043, p = .006, respectively).

Table 3 Factors affecting the use of electronic cigarettes: Hierarchical multinomial logistic regression analysis

	E-smoker - Dual smoker						Switcher - Dual smoker					
Predictors	**Estimate**	**SE**	**p-value**	**AOR**	**LL**	**UL**	**Estimate**	**SE**	**p-value**	**AOR**	**LL**	**UL**
Intercept	-1.651	1.256	0.189	0.192	0.016	2.25	-6.939	1.929	< .001	0.001	0	0.043
Age in years												
< 20 – 30+	0.585	0.549	0.287	1.794	0.612	5.265	0.742	0.524	0.156	2.101	0.753	5.862
20 - 24 – 30+	0.767	0.42	0.068	2.154	0.946	4.905	1.054	0.388	**0.007**	2.868	1.341	6.136
25 - 29 – 30+	0.523	0.452	0.247	1.687	0.696	4.092	1.113	0.404	**0.006**	3.043	1.379	6.717
Gender												
Female – Male	1.773	0.364	**< .001**	5.889	2.885	12.023	0.973	0.422	**0.021**	2.647	1.158	6.051
Level of education												
Secondary– Primary	1.294	0.671	0.054	3.648	0.98	13.585	-0.058	0.529	0.913	0.944	0.335	2.662
Diploma – Primary	1.22	0.647	0.059	3.387	0.952	12.048	-0.243	0.515	0.637	0.784	0.286	2.153
Degree – Primary	1.412	0.631	**0.025**	4.106	1.192	14.139	-0.085	0.537	0.874	0.919	0.321	2.631
Working status												
Student – non-student	0.286	0.374	0.444	1.331	0.64	2.77	-0.571	0.361	0.114	0.565	0.278	1.147
Drug used												
Yes – No	-1.836	0.778	**0.018**	0.159	0.035	0.733	-0.023	0.418	0.957	0.978	0.431	2.217
Knowledge	0.003	0.01	0.732	1.003	0.985	1.022	-0.014	0.011	0.184	0.986	0.966	1.007
Attitude	-0.062	0.229	0.787	0.94	0.601	1.471	-0.04	0.278	0.885	0.961	0.558	1.655
Motivation and beliefs	-0.114	0.262	0.663	0.892	0.533	1.491	0.098	0.287	0.732	1.103	0.629	1.936
Subjective norm	0.361	0.159	**0.023**	1.435	1.051	1.961	0.217	0.179	0.226	1.242	0.874	1.765
Perceived usefulness	-0.067	0.191	0.727	0.935	0.643	1.361	0.48	0.199	**0.016**	1.616	1.095	2.385
Perceived ease to use	-0.05	0.146	0.731	0.951	0.715	1.265	-0.051	0.196	0.794	0.95	0.647	1.395
Intention to use	-0.381	0.353	0.281	0.683	0.342	1.365	0.519	0.399	0.193	1.68	0.769	3.673
Behaviour	-0.113	0.242	0.641	0.893	0.556	1.436	0.362	0.278	0.193	1.436	0.833	2.478

LL=Lower limit of 95% confidence interval, UL=Upper limit of 95% confidence interval; AOR= Adjusted Odds Ratio, Dual-smoker as reference category

DISCUSSION

Interpretation of Key Findings

The study findings indicate that 27.8% of participants identified as e-smokers, 25.8% as switchers, and 46.4% as dual smokers. The substantial proportion of dual users suggests that many individuals continue to use both conventional cigarettes and e-cigarettes rather than transitioning fully to vaping as a cessation method. This aligns with prior research indicating that dual use is a common pattern among smokers (20, 21). However, while some studies have suggested that e-cigarettes may facilitate smoking cessation (22), others have raised concerns that they may sustain nicotine dependence rather than reduce overall tobacco use (23). In the Malaysian context, where 46.4% of users are dual smokers, this raises important questions about the role of e-cigarettes in harm reduction. It remains unclear whether dual users are actively attempting to quit smoking or simply incorporating e-cigarettes as an additional nicotine source. These findings underscore the need for targeted smoking cessation programs that address dual users specifically. Public health initiatives should emphasize behavioral support and nicotine replacement therapies alongside regulations to prevent e-cigarette use from reinforcing nicotine addiction rather than reducing harm. Future intervention strategies could also explore the effectiveness of structured e-cigarette tapering programs to assess whether gradual reduction leads to complete cessation. Future research using longitudinal designs is needed to determine whether dual users eventually transition away from conventional smoking or maintain both habits over time.

Findings from the multinomial logistic regression analysis further reveal significant sociodemographic predictors of e-cigarette use. Notably, females were more likely to be e-smokers (AOR = 5.889, $p < .001$) and switchers (AOR = 2.647, $p = .021$) compared to males. (24) reported that only 0.4% of female respondents had ever used e-cigarettes in their hospital-based cross-sectional study conducted in seven public hospitals and health clinics in Malaysia. In contrast, our study, which recruited participants from vape shops, found a significantly higher proportion of female e-cigarette users. This discrepancy may be due to differences in study settings and participant selection methods. A hospital-based study primarily captures individuals seeking healthcare, who may have different smoking behaviors compared to those frequenting vape shops. Additionally, cultural shifts and changing social norms regarding female smoking and vaping behavior could contribute to the increasing presence of female e-cigarette users. Perhaps, as smoking rates of traditional cigarettes decrease, e-cigarette use appears to consolidate its foothold among women globally, suggesting a shift in preferences. Countries like South Korea exhibit rising trends in e-cigarette usage among females, reflecting a broader global movement (25). Given this trend, regulatory frameworks in Malaysia should consider gender-responsive strategies for tobacco control, incorporating messaging tailored to address motivations behind female e-cigarette use. Future studies should examine whether marketing tactics or perceptions of harm reduction influence female uptake and whether specific public health campaigns can effectively counteract these factors.

Education level also emerged as a significant predictor, with degree holders more likely to be e-smokers than dual smokers (AOR = 4.106, $p = .025$). This finding is consistent with research suggesting that individuals with higher education levels may perceive e-cigarettes as a safer alternative and be more inclined to adopt them as a harm-reduction strategy (22, 26). However, given the cross-sectional nature of this study, causality cannot be inferred. It remains uncertain whether education directly influences e-cigarette adoption or if other underlying factors, such as greater health awareness or socioeconomic status, contribute to this association. These findings highlight the importance of integrating e-cigarette education into existing smoking cessation campaigns, particularly in academic institutions and professional settings where higher education levels may drive uptake. Policymakers should consider whether university-based interventions can better inform individuals about the risks of prolonged nicotine dependence, even if e-cigarettes are perceived as less harmful alternatives. Psychosocial factors also played a role in e-cigarette use, with subjective norms (AOR = 1.435, $p = .023$) and perceived usefulness (AOR = 1.616, $p = .016$) emerging as significant predictors. These findings align with existing literature indicating that social influence and perceived benefits shape smoking behaviors (27, 28). However, while these factors contribute to e-cigarette adoption, their long-term impact remains uncertain. It is unclear whether subjective norms lead to sustained e-cigarette use or whether social influences evolve over time to encourage cessation or dual use. Similarly, perceived usefulness may drive initial adoption, but future studies should examine whether users eventually shift to conventional smoking or successfully quit altogether. To address these uncertainties, public health strategies should incorporate behavioral interventions that counteract positive perceptions of e-cigarettes, particularly among youth and first-time users. Public awareness campaigns should specifically target misconceptions regarding harm reduction and ensure that regulations limit misleading advertising that positions e-cigarettes as risk-free alternatives (29, 30).

Theoretical Contributions and Study Originality

While the study identifies key predictors of e-cigarette use, such as gender, education, and psychosocial factors, it relies on established theoretical models namely, the Technology Acceptance Model (31) and the Theory of Reasoned Action (12) which have been widely applied in e-cigarette research (23). Although TAM and TRA effectively explain individual motivations, integrating additional frameworks could enhance the study's novelty. The Health Belief Model (HBM) can provide insights into perceived health risks and benefits influencing e-cigarette adoption (32), while the Social Ecological Model (SEM) contextualizes vaping behavior across individual, community, and policy levels (31, 33). Future research should adopt a multi-theory approach combining TAM, TRA, HBM, and SEM to offer a comprehensive understanding of e-cigarette use dynamics.

Comparison with Previous Studies

Previous studies have highlighted the impact of social norms on smoking initiation and cessation, with individuals more likely to adopt behaviors they perceive as socially acceptable (27, 34, 35). Similarly, perceived usefulness has been shown to influence e-cigarette uptake, as many users believe vaping reduces harm compared to

conventional smoking (28). However, global trends indicate that regulatory scrutiny on e-cigarettes is intensifying, with many countries, including Thailand and Singapore, imposing strict bans on their sale and use. In contrast, countries such as the United Kingdom and New Zealand have integrated e-cigarettes into smoking cessation programs (36). The regulatory landscape in Malaysia remains evolving, and findings from this study must be contextualized within these international frameworks. A comparative approach with other Southeast Asian countries would offer insights into how regulatory differences influence usage patterns and cessation outcomes. Future research should explore these variations to develop more robust, regionally informed policy recommendations.

Limitations of the study

Several limitations must be acknowledged when interpreting these findings. First, the cross-sectional design limits the ability to infer causality, meaning that observed associations should be interpreted with caution. Future longitudinal studies are needed to assess changes in e-cigarette use patterns over time. Second, the reliance on self-reported data introduces the potential for recall bias and social desirability bias, particularly in reporting smoking history and behaviors. This is especially relevant for older participants recalling the onset and frequency of smoking. Additionally, the sampling strategy focused on vape outlets in Samarahan and Kuching, which may not fully represent e-cigarette users across Sarawak. Individuals who purchase e-cigarettes from other sources, such as online platforms or informal vendors, may have different usage patterns that were not captured in this study. This limits the generalizability of the findings to the broader population. Future research should consider more diverse recruitment strategies to obtain a more comprehensive understanding of e-cigarette use across different demographic groups and geographic regions. Despite these limitations, the study provides valuable insights into the sociodemographic and psychosocial factors associated with e-cigarette use in Malaysia. The findings highlight the need for targeted public health interventions that address the complexities of dual-use and evolving smoking behaviors. However, given the increasing global focus on e-cigarette regulation, the study's implications extend beyond the Malaysian context. Understanding how different policy environments shape e-cigarette adoption could offer critical lessons for regulatory decision-making in Malaysia and other Southeast Asian countries. Additionally, the study raises important questions about the long-term effects of psychosocial factors on e-cigarette use. Whether these perceptions lead to permanent smoking cessation or sustained nicotine dependence remains uncertain. Addressing these knowledge gaps would enhance the study's contribution to shaping both local and international public health strategies.

CONCLUSION

This study highlights that e-cigarette usage among smokers in Sarawak is significantly influenced by sociodemographic and psychosocial factors, with females and those holding higher educational qualifications more likely to engage in e-cigarette use. Additionally, subjective norms and perceived usefulness were found to correlate positively with e-cigarette adoption. These findings suggest that e-cigarette use in this population is not only a matter of personal preference but also shaped by social influences and perceived benefits. To address these trends, public health interventions should consider targeting educational campaigns that address the health implications of e-cigarette use, particularly among women and individuals in higher education. Additionally, incorporating social influence factors in smoking cessation programs, such as leveraging positive peer norms and promoting the perceived benefits of quitting, may enhance the effectiveness of these initiatives. Regulatory measures could also be introduced to manage e-cigarette use, ensuring that the public is well-informed about the potential risks and uncertainties associated with e-cigarettes as smoking alternatives.

AUTHOR CONTRIBUTIONS STATEMENT

Both authors contributed to the study conception, design, data collection, analysis, and manuscript preparation. All the authors reviewed and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest that could have influenced the work reported in this study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

Generative AI was used solely for language refinement and formatting support. All study design, data collection, analysis, interpretation, and final manuscript preparation were carried out by the authors, who take full responsibility for the content.

SOURCE OF FUNDING

Self-funded

ACKNOWLEDGEMENTS

We thank the University Malaysia Sarawak (UNIMAS) for their institutional support ethical approval, and all research participants for their invaluable contributions. Our special thanks to the vape shop owners for their cooperation.

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