Original Article

Why High Income Fails to Reduce E-Cigarette Use: The Knowledge-Attitude Paradox in the SMOKES Study

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Abstract:

Background: Electronic cigarette (e-cigarette) use and vaping tobacco have increased rapidly worldwide, raising concerns about their health effects, social acceptability, and regulatory challenges. In many countries, e-cigarettes are more commonly used by individuals from higher socioeconomic status (SES) backgrounds, who, in theory, should have greater knowledge about e-cigarettes and their associated risks. However, it remains unclear why a group with more knowledge about e-cigarette risks would also hold more positive attitudes toward vaping and exhibit higher usage rates — a phenomenon that may represent a knowledge-behavior paradox. Understanding this paradox, along with the complex relationships between e-cigarette knowledge, attitudes, and behaviors, is critical for informing effective public health interventions, campaigns, social media messaging, and regulatory policies. **Objectives:** This study aimed to evaluate the complex relationship between SES, e-cigarette knowledge, pro-vaping attitudes, and e-cigarette use. **Methods:** The SMOKES Study (Study of Measurement of Knowledge and Examination of Support for Tobacco Control Policies) used a multi-center, cross-sectional design, collecting data from 2,403 college and university students across 15 provinces in Iran (covering nearly half of the country's provinces). The survey measured family income, age, sex, ethnicity, e-cigarette use, knowledge, and attitudes. Structural Equation Modeling (SEM) was employed to examine the interrelations between SES, knowledge, attitudes, and behavior, while adjusting for age, sex, and ethnic minority status. **Results**: SEM analysis confirmed the hypothesized paradox. Although greater knowledge about e-cigarettes was linked to less favorable attitudes toward vaping and lower use, pro-vaping attitudes emerged as the strongest predictor of vaping behavior, while knowledge played a weaker protective role. Notably, individuals with higher SES simultaneously showed higher knowledge and, paradoxically, more pro-e-cigarette attitudes and greater usage. Female students and ethnic minority students reported higher correct knowledge and lower pro-vaping attitudes and use. Although age and higher family income were associated with more favorable attitudes, they did not directly predict vaping behavior. These results suggest that for higher SES individuals, poor knowledge is not the main driver of e-cigarette use; rather, their pro-e-cigarette attitudes, which seem to outweigh the influence of knowledge, play a key role. **Conclusions:** Although individuals from higher SES backgrounds report greater correct knowledge about e-cigarettes, this knowledge does not necessarily translate into reduced positive attitudes or lower usage. This study highlights the complexity of these paradoxical effects and suggests that public health strategies need to go beyond simple education and knowledge-based interventions. Targeted approaches should address industry messaging, challenge misconceptions, and strengthen regulatory efforts to reduce e-cigarette use among young adults, including those from higher SES backgrounds.

Keywords: Tobacco, College and University Students, Knowledge, Attitude, Electronic Cigarette

1. Background

Electronic cigarette (e-cigarette) use has become increasingly common and continues to grow globally, particularly among young adults [1-4]. Market expansion, targeted advertising, and evolving perceptions of vaping as a harm reduction tool have contributed to its rising popularity. E-cigarettes are often framed as a safer alternative to combustible cigarettes [5,6], leading to widespread experimentation and regular use among college students [7,8]. However, the increasing prevalence of vaping has raised significant concerns regarding its health risks, potential for nicotine addiction, and long-term effects [9,10], necessitating a deeper understanding of the psychological and cognitive factors influencing e-cigarette use.

One of the key determinants of vaping behavior is knowledge about e-cigarettes [11,12], which can be either correct or incorrect [13,14]. Both accurate information and misinformation/misconceptions about electronic cigarettes are widespread [15,16]. Additionally, attitudes toward e-cigarettes, which can range from pro-vaping to anti-vaping [17], play a crucial role in shaping use patterns. While it is commonly assumed that greater knowledge about health risks would discourage e-cigarette use, the relationship is not necessarily straightforward. Individuals may hold attitudes that endorse the use of electronic cigarettes or opposite attitudes that disapprove such use [18-21]. While knowledge may influence attitudes, which in turn may affect behavior, it remains unclear whether attitudes mediate the relationship between knowledge and e-cigarette use. This uncertainty presents a gap in literature, as existing studies often treat knowledge and attitudes as independent predictors rather than examining their potential interaction in influencing behavior.

Another important, yet underexplored, issue is the relationship between socioeconomic status (SES), ethnicity, and e-cigarette use [22]. Research has shown that vaping is more prevalent among individuals from higher SES backgrounds and among ethnic majority groups. However, given that higher SES is generally associated with greater access to health information and higher levels of education, it is difficult to expect lower knowledge among those who use e-cigarettes more frequently. This creates a paradox where individuals with higher correct knowledge about e-cigarettes may simultaneously have a greater tendency to use them [23,24]. The complex relationship between knowledge, attitudes, and use has not been extensively studied, and understanding these interactions is crucial for informing targeted interventions.

In addition to knowledge [25] and attitudes [26], demographic factors such as age, sex, and ethnic minority status are known to predict e-cigarette use and must be accounted for [27,28]. These variables also influence knowledge and attitudes, further complicating their relationship with vaping behavior [29]. Women tend to have lower e-cigarette use rates, possibly due to greater risk aversion and different social norms surrounding vaping. Additionally, SES is positively associated with e-cigarette use, meaning that individuals from wealthier backgrounds may have greater exposure to vaping-related marketing and peer influences that encourage experimentation [22,30]. Thus, controlling for demographic differences is essential to accurately assessing the interplay between knowledge, attitudes, and behavior [31,32].

This study aims to examine the direct and indirect relationships between family SES, measured by household income, accurate e-cigarette knowledge, pro-vaping attitudes, and actual e-cigarette use in a large and diverse sample of Iranian college and university students. One of the main goals is to assess whether pro-vaping attitudes mediate the relationship between knowledge and behavior. Additionally, the study explores how these relationships may vary across demographic groups by examining the role of income in shaping knowledge, attitudes, and use. We hypothesize that individuals with higher SES will have greater knowledge about e-cigarettes yet will also hold more favorable attitudes toward vaping and engage in higher levels of use — a paradoxical pattern. To

accurately assess these relationships, the analyses control for age, sex, and ethnic minority status. Based on previous research, we also expect that greater correct knowledge about e-cigarettes will be associated with less use, although it may be linked to more favorable attitudes. Furthermore, pro-vaping attitudes are anticipated to be strong predictors of actual use, while women and ethnic minority students are expected to report lower rates of vaping. By investigating these questions, this study aims to offer new insights into the complex and sometimes contradictory role of knowledge in shaping e-cigarette behavior, contributing to a more nuanced understanding of the social, cognitive, and demographic factors that influence vaping among college students.

2. Methods

2.1. Design and Setting

The SMOKES Study (Study of Measurement of Knowledge and Examination of Support for Tobacco Control Policies) [33] is a multi-center, cross-sectional research project conducted in Iran between 2024 and 2025, focusing on college and university students. The survey was distributed online, with invitation links shared through student groups on social media platforms affiliated with each university. Since social media is the primary communication tool for students in Iran—more commonly used than email for news, updates, and general interactions—it was chosen as the most effective method for participant recruitment.

2.2. Sample and Sampling

To ensure ethnic, geographic, and institutional diversity, the study included 15 provinces, selecting at least one college or university from each province using random sampling. While the sample composition broadly reflects the demographic characteristics of Iranian college and university students, the findings should not be considered nationally representative.

Participants were eligible to take part if they were actively enrolled in a college or university within the selected provinces at the time of data collection, regardless of their academic discipline. Individuals who had already graduated, non-Iranian students, and those providing invalid responses, such as inconsistent, unrealistic, or incomplete data, were excluded from the final analysis.

2.3. Measurement Tool

The study utilized an online survey designed to capture a broad spectrum of variables across multiple domains, including socio-demographic characteristics, university-related factors, tobacco use behaviors, knowledge, and attitudes regarding e-cigarettes and tobacco control policies. The questionnaire incorporated items from previously validated measure [34-36] while also integrating newly developed questions based on input from experts in public health, pulmonology, and health policy. The survey was conducted in Farsi, ensuring accessibility for participants. By including a diverse range of variables, the study aimed to create a comprehensive multi-dimensional profile of the participants, facilitating a detailed examination of the relationships between tobacco use behaviors and attitudes toward tobacco control policies. The survey included nominal, dichotomous, continuous, and ordinal measures, allowing for both behavioral and attitudinal analyses to provide deeper insights into personal tobacco use and policy support within this population.

To contextualize the sample, the survey collected university-related variables such as province, academic discipline, student level, university type, and year of study. These variables were recorded using nominal scales, distinguishing participants based on geographic region, institutional type, and academic background. Demographic variables included sex (categorical), age (continuous), and ethnicity (categorical). Marital status was

recorded for both students and their parents, while additional socio-demographic indicators, such as place of residence, type of housing, employment status, and income level (both for the student and their family), were included to provide further contextual information. The survey also assessed exercise frequency, which was measured on an ordinal scale, to capture participants' physical activity levels. Tobacco use behaviors were assessed through questions differentiating between lifetime and current use. For instance, cigarette use was measured using two single items indicating whether a participant had ever smoked and whether they were currently smoking. A similar approach was applied to hookah use, which included additional questions on frequency of use. E-cigarette use was measured through three key variables: ever use, current use, and frequency of use. To evaluate knowledge about e-cigarettes, the survey included eight items assessing participants' understanding of vaping-related risks. A sample question was: *"Electronic cigarettes are addictive."* Responses were scored as True (2), False (0), or I don't know (1), providing a structured way to assess accuracy and uncertainty in participants' knowledge. Pro-e-cigarette attitudes were measured using 10 Likert-scale items that assessed perceptions related to vaping. A representative question was: *"Using electronic cigarettes makes a person look modern and attractive."* Responses were recorded on a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The use of a Likert scale allowed for a nuanced assessment of how strongly participants agreed or disagreed with various vaping-related statements. For further details on the measurements used in the SMOKES study, additional information can be found in related documentation.

2.4. Ethical considerations

This study adhered to the ethical guidelines set forth in the Declaration of Helsinki and received approval from the Ethics Committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran (Ethics Code: IR.SSU.MEDICINE.REC.1403.159). Participation in the study was entirely voluntary, and informed consent was obtained prior to data collection. At the start of the online questionnaire, participants were provided with detailed information about the study's objectives and procedures. Before proceeding, they were required to confirm their willingness to participate, ensuring that their involvement was based on informed consent and their own voluntary decision.

2.5. Statistical analysis

All statistical analyses were conducted using Stata 18 [37-40]. The analysis followed a structured approach, including descriptive statistics, confirmatory factor analysis (CFA), structural equation modeling (SEM), and robustness checks to examine the relationships between e-cigarette knowledge, attitudes, and use while controlling for demographic factors. Descriptive statistics were used to summarize sample characteristics, including demographic variables (age, sex, ethnic minority status, and family income), knowledge levels, attitudes toward e-cigarettes, and vaping behaviors. Continuous variables were presented as means and standard deviations (SD), while categorical variables were reported as frequencies and percentages. Differences in e-cigarette use across demographic groups were tested using t-tests for continuous variables and chi-square tests for categorical variables. A Structural Equation Model (SEM) [41-45] was used to examine the relationships between correct e-cigarette knowledge, pro-vaping attitudes, and e-cigarette use, while accounting for demographic covariates. The primary paths of interest included the effect of correct knowledge on pro-vaping attitudes, the effect of pro-vaping attitudes on e-cigarette use, and the direct effect of knowledge on e-cigarette use. Additional covariates—age, sex, ethnic and minority status—were included in the model to control for potential confounding effects. To test whether attitudes mediate the relationship between knowledge and e-cigarette use, mediation analysis was conducted by estimating indirect and total effects in SEM. This analysis allowed for an assessment of whether knowledge influences behavior primarily through its effect on attitudes, or

whether knowledge has an independent direct effect on vaping behavior. Model fit was assessed using standard goodness-of-fit indices, including the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA). Model fit was considered acceptable if CFI and TLI were above 0.90 and RMSEA and SRMR were below 0.08[46].

In this study, we utilized latent variables to represent key constructs—knowledge, attitudes, and behavior—by aggregating multiple observed indicators for each construct. Using Confirmatory Factor Analysis (CFA), we created latent variables that captured the underlying dimensions of correct knowledge about e-cigarettes, pro-vaping attitudes, and e-cigarette use behaviors, allowing for a more accurate and reliable measurement of these psychological and behavioral factors. A latent variable is a theoretical construct that cannot be measured directly but is inferred from multiple observed variables. For example, knowledge about e-cigarettes was measured using multiple survey items assessing factual understanding, while attitudes were derived from responses reflecting perceptions of e-cigarette risks and benefits. Similarly, behavior was constructed based on self-reported e-cigarette use indicators such as ever use, current use, and frequency of use. Latent variables are essential in social and behavioral research because they reduce measurement error and enhance construct validity. By incorporating multiple observed indicators, they provide a more stable and comprehensive assessment of complex psychological traits, avoiding the limitations of single-item measures. In this study, the use of latent variables ensured a more precise estimation of the relationships between knowledge, attitudes, and e-cigarette use, allowing for a deeper understanding of the underlying mechanisms driving vaping behavior among college students.

3. Results

A total of 2,405 university and college students participated in this study, with an equal representation of male and female students (1:1 ratio). The average age of participants was 22.30 years (SE = 0.07; 95% CI = 22.16 to 22.44), with ages ranging from 15 to 60 years. Regarding institution type, the majority (76.12%, n = 1,826) were enrolled in government-funded universities, while 23.88% (n = 573) attended private or non-governmental institutions.

In terms of academic disciplines, students from medical fields constituted the largest proportion, accounting for 43.38% (n = 1,036) of the sample. This was followed by those majoring in Engineering and Technology Sciences (13.32%, n = 318) and Humanities and Social Sciences (9.76%, n = 233). Additional academic fields included Dentistry (8.88%, n = 212), Allied Health Sciences (8.12%, n = 194), Nursing (4.94%, n = 118), Basic Sciences (3.77%, n = 90), Architecture and Arts (3.69%, n = 88), Pharmacy (2.85%, n = 68), Veterinary Medicine (0.84%, n = 20), and Agriculture and Natural Resources (0.46%, n = 11).

Participants represented a diverse geographical distribution across 15 provinces, with the highest number of students from Yazd (14.61%, n = 350), followed by Mazandaran (10.93%, n = 262) and Tehran (10.64%, n = 255). Other provinces included Esfahan (9.22%, n = 221), Razavi Khorasan (8.76%, n = 210), Kermanshah (6.93%, n = 166), Fars (5.68%, n = 136), East Azerbaijan (5.63%, n = 135), Gilan (5.76%, n = 138), Kerman (4.97%, n = 119), Khuzestan (4.97%, n = 119), Sistan and Balouchestan (4.92%, n = 118), Semnan (3.05%, n = 73), Alborz (2.17%, n = 52), and Hamedan (1.75%, n = 42).

The ethnic composition of the sample was predominantly Fars (57.75%, n = 1,356), followed by Turk (11.29%, n = 265), Kurd (6.81%, n = 160), Lur (5.79%, n = 136), and Mazani (5.88%, n = 138). Smaller ethnic groups included Gilak (4.77%, n = 112), Balouch (2.00%, n = 47), Bakhtiari (1.75%, n = 41), Arab (1.19%, n = 28), and other ethnicities (2.26%, n = 53), with 0.51% (n = 12) identifying with unlisted ethnic backgrounds.

Regarding academic level, the largest proportion of students were pursuing a Doctorate or higher degree (52.19%, n = 1,253), followed by those enrolled in Bachelor's

degree programs (38.57%, n = 926). Additionally, Master's degree students comprised 6.66% (n = 160) of the sample, while Associate's degree students made up 2.58% (n = 62).

Table 1. Participants in the Study

	n	%
University Major		
Humanities and Social Sciences	233	9.76
Basic Sciences	90	3.77
Engineering and Technology Sciences	318	13.32
Medicine	1,036	43.38
Dentistry	212	8.88
Pharmacy	68	2.85
Nursing	118	4.94
Allied Health	194	8.12
Agriculture and Natural Resources	11	0.46
Architecture and Arts	88	3.69
Veterinary Medicine	20	0.84
Province		
Tehran	255	10.64
Khorasan Razavi	210	8.76
Fars	136	5.68
East Azerbaijan	135	5.63
Esfahan	221	9.22
Yazd	350	14.61
Khouzestan	119	4.97
Kerman	119	4.97
Sistan and Balouchestan	118	4.92
Kermanshah	166	6.93
Mazandaran	262	10.93
Gilan	138	5.76
Semnan	73	3.05
Alborz	52	2.17
Hamedan	42	1.75
Residence		
Living with Family	1,198	49.9
Dormitory	970	40.4
Private Housing (Without Family)	228	9.5
Other	5	0.21
Sex		
Male	1,201	50
Female	1,201	50
Ethnicity		
Fars	1,356	57.75
Turk	265	11.29
Lur	136	5.79
Kurd	160	6.81

Mazani	138	5.88
Arab	28	1.19
Balouch	47	2
Gilak	112	4.77
Bakhtiari	41	1.75
Other	53	2.26
Any	12	0.51
University Level		
Associate's Degree	62	2.58
Bachelor's Degree	926	38.57
Master's Degree	160	6.66
Doctorate or Higher	1,253	52.19
University Type		
Governmental	1,826	76.12
Non-Governmental/Private	573	23.88

Table 2 summarizes the findings from the SEM analysis examining the direct and indirect relationships between family SES, correct knowledge about e-cigarettes, pro-vaping attitudes, and actual e-cigarette use.

Predictors of Correct E-Cigarette Knowledge

Higher correct knowledge of e-cigarette risks was significantly associated with older age (B = 0.178, SE = 0.016, 95% CI [0.147, 0.209], p < 0.001), higher family income (B = 0.247, SE = 0.018, 95% CI [0.212, 0.282], p < 0.001), ethnic minority status (B = 0.481, SE = 0.015, 95% CI [0.451, 0.511], p < 0.001), and being female (B = 0.363, SE = 0.016, 95% CI [0.331, 0.396], p < 0.001). These results suggest that individuals who are older, female, from higher-income families, and ethnic minorities tend to have greater awareness of e-cigarette risks.

Predictors of Pro-Vaping Attitudes

Pro-vaping attitudes were significantly negatively associated with correct e-cigarette knowledge (B = -0.031, SE = 0.001, 95% CI [-0.032, -0.030], p < 0.001), indicating that greater knowledge of harms is linked to less favorable views of vaping. However, age (B = 0.204, SE = 0.015, 95% CI [0.175, 0.233], p < 0.001), higher family income (B = 0.145, SE = 0.022, 95% CI [0.102, 0.187], p < 0.001), and ethnic minority status (B = 0.103, SE = 0.022, 95% CI [0.061, 0.146], p < 0.001) were all associated with more favorable attitudes toward e-cigarettes. Notably, sex (female) was not a significant predictor of pro-vaping attitudes (B = -0.013, SE = 0.022, 95% CI [-0.056, 0.029], p = 0.544).

Predictors of E-Cigarette Use

E-cigarette use was positively associated with pro-vaping attitudes (B = 0.330, SE = 0.027, 95% CI [0.276, 0.383], p < 0.001), confirming that favorable attitudes strongly predict higher use. Interestingly, correct knowledge was also positively associated with e-cigarette use (B = 0.072, SE = 0.001, 95% CI [0.070, 0.075], p < 0.001), revealing a paradox in which greater awareness of harms is linked to more use. Ethnic minority status (B = -0.078, SE = 0.019, 95% CI [-0.115, -0.041], p < 0.001) and female sex (B = -0.182, SE = 0.019, 95% CI [-0.219, -0.145], p < 0.001) were both negatively associated with e-cigarette use, suggesting that women and ethnic minority students were less likely to use e-cigarettes. In contrast, age (B = -0.009, SE = 0.019, 95% CI [-0.045, 0.028], p = 0.643) and high family income (B =

0.029, SE = 0.019, 95% CI [-0.008, 0.067], p = 0.125) were not significantly associated with use in the final model.

Measurement Model

All measurement items for the latent constructs (correct knowledge, pro-vaping attitudes, and e-cigarette use) had strong and statistically significant factor loadings (all p < 0.001), indicating that the indicators reliably captured their respective constructs. For correct knowledge, item loadings ranged from 0.379 to 0.693. Measurement items for pro-vaping attitudes loaded between 0.161 and 0.740, and e-cigarette use, which was modeled as a latent factor, was measured using ever use (loading = 0.782), current use (loading = 0.811), and frequency of use (loading fixed at 1.000).

Table 2. Summary of structural equation model

			B	SE	95%	CI	p
Structural							
Age (Yr)	→	Correct Electronic Cigarette Knowledge	0.178	0.016	0.147	0.209	< 0.001
High Family Income	→	Correct Electronic Cigarette Knowledge	0.247	0.018	0.212	0.282	< 0.001
Ethnic Minority	→	Correct Electronic Cigarette Knowledge	0.481	0.015	0.451	0.511	< 0.001
Sex (Female)	→	Correct Electronic Cigarette Knowledge	0.363	0.016	0.331	0.396	< 0.001
Correct Electronic Cigarette Knowledge	→	Pro- Electronic Cigarette Attitude	-0.031	0.001	-0.032	-0.030	< 0.001
Age (Yr)	→	Pro- Electronic Cigarette Attitude	0.204	0.015	0.175	0.233	< 0.001
High Family Income	→	Pro- Electronic Cigarette Attitude	0.145	0.022	0.102	0.187	< 0.001
Ethnic Minority	→	Pro- Electronic Cigarette Attitude	0.103	0.022	0.061	0.146	< 0.001
Sex (Female)	→	Pro- Electronic Cigarette Attitude	-0.013	0.022	-0.056	0.029	0.544
Correct Electronic Cigarette Knowledge	→	Electronic Cigarette Use	0.072	0.001	0.070	0.075	< 0.001
Pro- Electronic Cigarette Attitude	→	Electronic Cigarette Use	0.330	0.027	0.276	0.383	< 0.001
Age (Yr)	→	Electronic Cigarette Use	-0.009	0.019	-0.045	0.028	0.643
High Family Income	→	Electronic Cigarette Use	0.029	0.019	-0.008	0.067	0.125
Ethnic Minority	→	Electronic Cigarette Use	-0.078	0.019	-0.115	-0.041	< 0.001
Sex (Female)	→	Electronic Cigarette Use	-0.182	0.019	-0.219	-0.145	< 0.001
Measurement							
Correct Electronic Cigarette Knowledge							
Item 1			0.693	0.006	0.682	0.704	< 0.001
Item 2			0.379	0.027	0.326	0.432	< 0.001
Item 4			0.636	0.010	0.616	0.656	< 0.001
Item 5			0.388	0.004	0.380	0.396	< 0.001
Item 6			0.667	0.010	0.648	0.686	< 0.001
Item 7			0.495	0.005	0.484	0.505	< 0.001
Item 8			0.437	0.005	0.428	0.445	< 0.001
Pro - Electronic Cigarette Attitude							

Item 1	0.740	0.008	0.725	0.756	< 0.001
Item 2	0.564	0.008	0.548	0.580	< 0.001
Item 3	0.671	0.009	0.653	0.688	< 0.001
Item 4	0.672	0.008	0.657	0.688	< 0.001
Item 5	0.551	0.011	0.528	0.573	< 0.001
Item 6	0.539	0.012	0.515	0.563	< 0.001
Item 7	0.433	0.006	0.421	0.444	< 0.001
Item 8	0.161	0.007	0.147	0.174	< 0.001
E-Cig Use					
Ever Use	0.782	0.009	0.765	0.799	< 0.001
Current Use	0.811	0.007	0.798	0.824	< 0.001
Frequency of Use	1.000	0.000	1.000	1.000	< 0.001
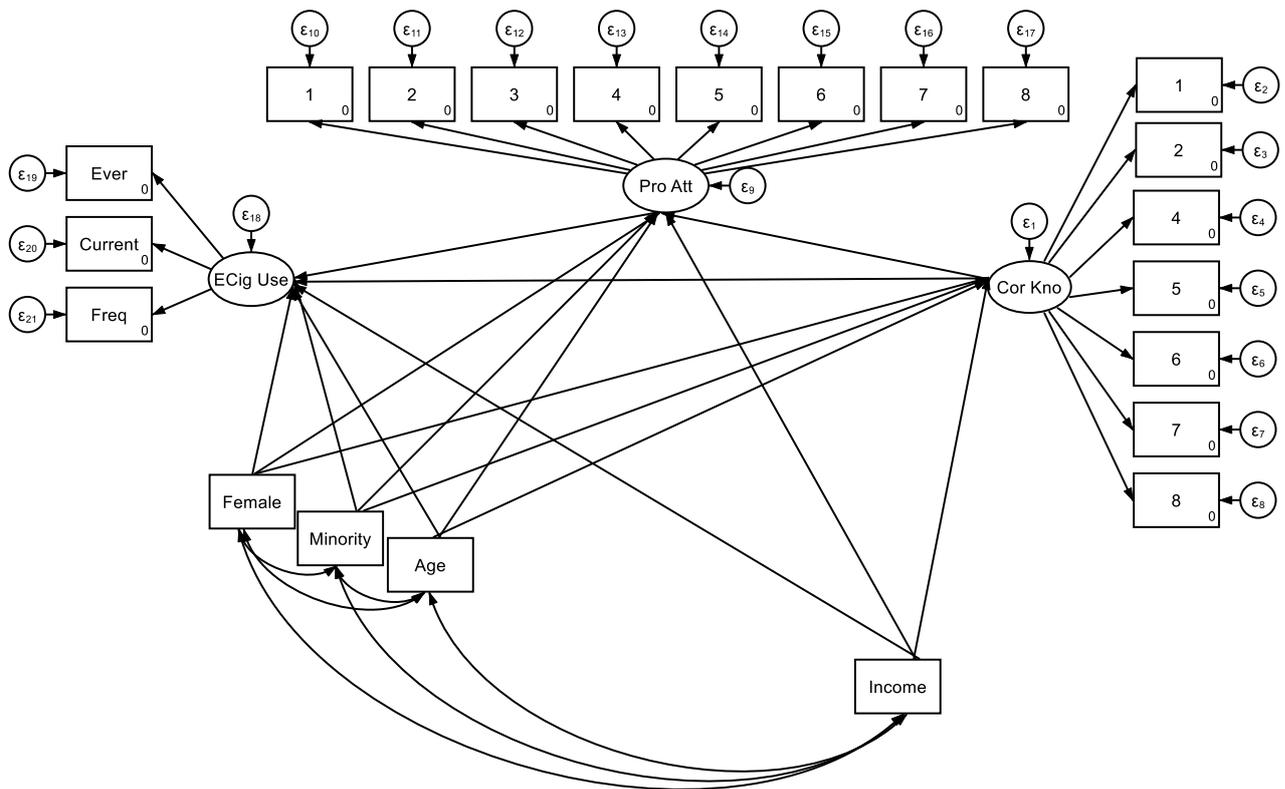
Figure 1. Association between family income, e-cig knowledge, e-cig attitude, and electronic cigarette use (**Note:** Pro Att= Cor Kno= Correct Electronic Cigarette Knowledge; Pro - Electronic Cigarette Attitude)

4. Discussion

This study examined the relationships between SES, measured by family income, e-cigarette knowledge, pro-vaping attitudes, and actual e-cigarette use among college and university students. The study had several key objectives. First, it aimed to determine whether higher levels of accurate knowledge about e-cigarettes are associated with pro-vaping attitudes and increased use. Another goal was to explore why individuals with higher SES, despite having greater awareness of e-cigarette risks—awareness that would

typically be expected to discourage favorable perceptions—still hold more pro-vaping attitudes and report higher e-cigarette use. In other words, this study aimed to investigate how accurate knowledge and positive attitudes toward vaping can coexist in high-SES individuals and contribute to their elevated use of e-cigarettes, highlighting a paradoxical pattern of behavior. To address these questions, the study analyzed both the direct and indirect effects of knowledge on e-cigarette use, with pro-vaping attitudes examined as a potential mediator in this complex relationship.

The results revealed a counterintuitive pattern: individuals with higher SES had more accurate knowledge about the harms of e-cigarettes yet held more pro-vaping attitudes and reported higher rates of e-cigarette use. In other words, knowledge about risks of e-cigarettes did not translate into lower use. This paradox suggests that while high-SES individuals possess greater awareness of the harms of e-cigarette use, they still perceive vaping more positively— a perception that seems to override the influence of knowledge on behavior. The strong association observed between pro-vaping attitudes and actual use further indicates that the higher rate of e-cigarette use among high-SES individuals is less about being uninformed and more about their favorable views of vaping. These findings highlight a complex and paradoxical dynamic, where having accurate knowledge about risks is not sufficient to reduce use — suggesting that attitudes may play a stronger role than knowledge in influencing behavior among high-SES populations.

The Health Belief Model (HBM) [47-49] suggests that individuals with higher knowledge about a risky substance should exhibit lower usage rates, aligning with the observed negative association between knowledge and vaping behavior. However, theory of reasoned action [50] and theory of planned behavior [51-55] suggest that attitudes are key determinants of behavior, reinforcing the finding that pro-vaping attitudes strongly predict e-cigarette use. The challenge, then, lies in explaining why knowledge fosters pro-vaping attitudes while simultaneously discouraging actual use.

4.1. Why Does Knowledge Increase Pro-Vaping Attitudes?

A potential explanation for this unexpected association lies in the way vaping knowledge is framed, particularly in the context of harm reduction narratives. Public health messaging often highlights the relative safety of e-cigarettes compared to traditional cigarettes, leading individuals to perceive vaping as a less harmful alternative. While this framing is intended to inform smokers about harm reduction strategies, it may inadvertently foster more positive attitudes toward vaping, even among those who do not smoke. This phenomenon reflects the broader challenge of knowledge dissemination, where factual information can shape attitudes in unintended ways.

Although harm reduction is a crucial element of tobacco control strategies [56], it may contribute to the perception that e-cigarettes are generally safe rather than being a tool primarily for smoking cessation. This underscores the importance of balanced public health messaging that not only communicates potential benefits for smokers but also emphasizes the risks for non-smokers, particularly young adults. Ensuring that knowledge is framed appropriately may help prevent misinterpretations that lead to pro-vaping attitudes among those who might otherwise avoid e-cigarette use.

Despite its association with pro-vaping attitudes, knowledge still functioned as a protective factor against actual use. This suggests that while individuals with greater awareness may acknowledge the perceived benefits of vaping, they are also more informed about its risks, leading them to make more cautious decisions regarding use. This aligns with behavioral health theories emphasizing the role of risk perception, self-regulation, and external influences in shaping behaviors.

Knowledge alone does not necessarily determine behavior; instead, it interacts with individual risk awareness, social influences, and regulatory knowledge. In this study, participants with higher knowledge levels may have had greater awareness of nicotine

addiction risks, long-term health uncertainties, and regulatory restrictions, all of which contribute to hesitancy toward e-cigarette use. This dual role of knowledge—promoting positive attitudes while simultaneously discouraging use—reinforces the need for nuanced public health strategies that go beyond simple education-based interventions.

Ethnic minority students were also less likely to endorse pro-vaping attitudes, which may reflect cultural differences in smoking norms, lower exposure to e-cigarette marketing, or differing social environments that shape perceptions of nicotine use. Research has shown that the tobacco industry has historically targeted specific racial and ethnic groups with marketing strategies, while others may have had less direct exposure, influencing their attitudes toward vaping. Minority students may also have had reduced access to vaping products due to social or economic factors, further lowering the likelihood of favorable perceptions and use. Understanding these differences is crucial for tailoring public health interventions that address social, cultural, and economic factors influencing vaping behavior.

4.2. Implications

These findings underscore the need for public health interventions to go beyond simply increasing knowledge, particularly when addressing high-SES individuals. E-cigarette use among high-SES individuals is unlikely to stem from a lack of awareness or misunderstanding of risks; rather, it appears to be driven by favorable attitudes and narratives that frame e-cigarettes in a positive light. Therefore, the challenge lies more in reshaping how e-cigarettes are perceived and discussed rather than filling a knowledge gap. While educational efforts remain essential, especially for low-SES individuals who may benefit from improved risk awareness and correction of misinformation, interventions for high-SES populations must directly confront the industry-driven narratives promoting e-cigarettes as harm reduction tools and as lifestyle products for youth and young adults. Public health campaigns should be carefully designed to avoid unintentionally reinforcing pro-vaping attitudes, particularly among younger audiences. Tailored approaches that consider the differing needs of high- and low-SES groups may be necessary to effectively address e-cigarette use across diverse populations.

An important area for intervention involves countering the influence of vaping industry marketing, particularly on social media platforms that target middle-class youth. These marketing efforts often portray e-cigarettes as modern, socially acceptable, and fashionable products, contributing to their appeal. Regulations that limit misleading or glamorized advertisements on social media, coupled with public awareness campaigns that highlight the long-term risks of vaping, can help shift public perceptions toward a more realistic understanding of e-cigarette use. Additionally, given that female and ethnic minority students were less likely to endorse vaping, prevention messages may need to be tailored when targeting males and majority populations, who may be more vulnerable to pro-vaping narratives. Developing nuanced, targeted interventions that address both the cultural and social drivers of vaping can enhance the effectiveness of public health strategies.

Another critical implication is that reducing e-cigarette use cannot rely solely on increasing correct knowledge, as the pathway from knowledge to behavior is not linear. The paradox observed in this study suggests that while correct knowledge discourages vaping, it does not do so by reducing pro-vaping attitudes. Instead, students with higher knowledge levels may still perceive e-cigarettes favorably, particularly if they accept harm reduction claims or see vaping as a safer alternative to smoking. However, this knowledge simultaneously raises awareness of risks, which may ultimately deter use.

The study also revealed significant gender and ethnic disparities in e-cigarette perceptions and behaviors. Females were significantly less likely to have pro-vaping attitudes or to use e-cigarettes. This may be attributed to gender differences in risk perception [57-60], as prior research suggests that women tend to be more risk-averse and

more concerned about long-term health effects. Additionally, marketing strategies and social influences surrounding e-cigarettes have historically targeted male audiences more aggressively, potentially explaining lower vaping prevalence among females [61,62]. Social norms may also play a role, as tobacco-related behaviors are often more stigmatized for women in many cultural contexts.

4.3. Limitations

This study has several limitations. First, its cross-sectional design limits the ability to draw causal inferences, making it unclear whether knowledge shapes attitudes over time or if attitudes influence knowledge. Second, the sample was not randomly selected, which restricts the generalizability of the findings to all Iranian college and university students. Third, the reliance on self-reported data may introduce social desirability bias or recall errors, and no biomarker validation was conducted to confirm the accuracy of self-reports in a subsample. Additionally, this study did not explore whether these associations vary by gender, ethnicity, university type, or academic major.

4.4. Future Research

Future research should explore how factors such as regulatory policies, misinformation on social media, peer influence, cultural norms, product appeal (including taste), subjective norms, advertising, and mental health contribute to pro-e-cigarette attitudes and behaviors, particularly among high-income populations. Understanding how interventions like advertising restrictions, sales limitations, social media regulation, peer-led initiatives, and campus bans influence these attitudes and behaviors is critical for addressing the disproportionately high rates of e-cigarette use among individuals with higher SES. Additionally, future studies should employ longitudinal designs to better establish causal relationships and incorporate objective measures of vaping behavior, such as biochemical verification of nicotine exposure, to enhance the accuracy and reliability of findings.

5. Conclusion

This study highlights the complex interplay between family socioeconomic status (SES), knowledge, attitudes, and behavior related to e-cigarette use in a large and diverse sample of Iranian college and university students. Individuals from higher SES backgrounds were found to have greater knowledge about e-cigarettes but also more favorable attitudes toward their use and higher actual use. These findings underscore the need for public health efforts that go beyond simple educational approaches. Interventions should address deeper cultural factors that shape interest in e-cigarettes among high-SES individuals, while also challenging industry narratives and accounting for demographic differences in vaping behaviors.

Authors Contribution:

Conceptual design: SA, MM, MP, FA; Data Collection: MM, MP; IRB Approval: FA, MM; Data Entry: MM, MP; Data Cleaning: MM, MP, SA; Analysis: SA; First Draft: SA; Revision: SA, JP, MM, MP, FA; Approval: SA, MM, MP, FA, JP.

Conflict of interests:

The authors declared no conflict of interests.

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