

Original Article

Use of Electronic Cigarettes Among High School Students in Sorowako: Prevalence, Safety Perceptions, and Health Education Impact

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DOI:**ABSTRACT**

Introduction: Rising adolescent e-cigarette use is largely driven by perceptions of safety. This study assessed the prevalence, knowledge, and safety perceptions of e-cigarettes among high school students in Sorowako, Indonesia, and evaluated the short-term impact of a school-based health education session. **Methods:** A cross-sectional survey of 601 students was conducted in November 2025, followed by a one-group pretest–posttest evaluation. Self-administered questionnaires assessed e-cigarette use, knowledge, and perceptions. Chi-square tests compared user and non-user perceptions. Pretest–posttest changes among 315 students were evaluated using Stuart–Maxwell and McNemar's tests. **Results:** Current and ever-use rates were 2.2% and 9.5%, respectively. Widespread knowledge gaps existed: over 40% of students were unsure if e-cigarettes contain carcinogens, and 55.1% were unsure if they lack tar and carbon monoxide. Ever-users more frequently perceived e-cigarettes as safer than conventional cigarettes compared to non-users (29.3% vs. 8.6%; $P < 0.001$). Post-intervention, recognition of carcinogenic compounds increased from 52.4% to 68.9%, and the perception of e-

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*cigarettes as a safer alternative decreased from 12.4% to 8.9%. However, significant uncertainty regarding aerosol composition persisted (43.5%). **Conclusion:** Despite low e-cigarette use among Sorowako students, misconceptions regarding composition and safety are prevalent. A single educational session significantly improved risk awareness but did not eliminate uncertainty. Future interventions should evaluate repeated, interactive educational models using controlled study designs.*

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1. INTRODUCTION

Tobacco and nicotine use remains a major public health problem in Indonesia, particularly among adolescents. Law No. 17 of 2023 on Health, implemented through Government Regulation No. 28 of 2024, now regulates electronic cigarettes alongside conventional tobacco products.(1,2) Among other provisions, Article 434 of the regulation prohibits selling tobacco products and electronic cigarettes to persons under 21 years of age and within a 200 m radius of educational facilities and children's play areas.(2) Despite these measures, electronic cigarettes present a distinct challenge for youth tobacco control.

Electronic cigarettes (e-cigarettes) are battery-powered devices that heat a liquid, typically containing nicotine, flavorings, and humectants, into an aerosol that the user inhales. Since their introduction in the early 2000s, they have been marketed as a "safer" alternative to conventional cigarettes because they do not burn tobacco (3). This claim has contributed to their popularity among adolescents, many of whom do not fully understand the associated health risks.

National surveys show that e-cigarette use in Indonesia has grown substantially. In the Global Adult Tobacco Survey (GATS), current e-cigarette use among adults aged 15 years and older increased tenfold, from 0.3% in 2011 to 3.0% in 2021 (4). In the 2019 Global Youth Tobacco Survey (GYTS), a nationally representative school-based survey of students aged 13–15 years, 19.2% of students currently used tobacco products, and 41.5% had learned about e-cigarettes from a friend; among students who used e-cigarettes, more than half (56.3%) obtained them from another person rather than from a shop. The 2023 Indonesian Health Survey (SKI), a national household survey, reported an e-cigarette use prevalence of 0.13% among adolescents aged 10–18 years, higher than among persons aged 15 years and older (5). School-based studies report current use of approximately 11% among Indonesian students and identify perceived safety, peer influence, and easy access as the main motivations (6,7).

The perception that e-cigarettes are harmless is not supported by evidence. E-cigarette aerosol contains carbonyl compounds such as formaldehyde and acetaldehyde, volatile organic compounds, metals released from the heating coil (including lead, nickel, and chromium), and ultrafine particles that can deposit deep in the lungs (8–10). Nicotine exposure during adolescence can disrupt development of brain regions that govern attention, learning, and impulse control, and it increases the risk of long-term dependence (11). E-cigarette use has also been associated with acute

increases in heart rate and blood pressure, endothelial dysfunction, and airway inflammation (9). The 2019 outbreak of e-cigarette or vaping product use–associated lung injury (EVALI) demonstrated that serious lung damage can occur even in young, otherwise healthy individuals (12).

Evidence from other Indonesian cities shows that use patterns and their determinants vary by setting (13,14). However, the prevalence of e-cigarette use among adolescents in Sorowako, East Luwu Regency, has not been documented. Without local data, schools and pediatric health workers lack a basis for designing targeted prevention. Studies also indicate a gap between knowledge and behavior: many adolescents continue to use e-cigarettes even when they recognize that the products are not safe (14). Understanding adolescents' knowledge and risk perceptions, and testing whether education can correct misconceptions, is therefore a necessary first step toward effective school-based interventions (15,16).

This study aims to determine the prevalence of e-cigarette use and the knowledge and safety perceptions of high school students in Sorowako, to compare perceptions between users and non-users, and to assess changes in knowledge and perceptions after a school-based health education intervention.

2. METHODS

Study Design and Setting

This study combined a cross-sectional baseline survey with a quasi-experimental one-group pretest–posttest evaluation of a health education intervention. It was conducted in November 2025 in three senior high schools in Sorowako, East Luwu Regency (Luwu Timur), South Sulawesi, Indonesia. Reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for the cross-sectional component (17,18) and the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statement for the intervention evaluation (19).

Participants

All students enrolled in grades 10, 11, and 12 at three senior high schools in Sorowako, East Luwu Regency, South Sulawesi, Indonesia, were invited to participate in the study. Of the 650 eligible students, 601 completed the baseline questionnaire, yielding a response rate of 92.5%. Participation was voluntary, and the questionnaire link was distributed through class communication groups by homeroom teachers. All 601 respondents were included in the cross-sectional analysis.

For the pretest–posttest analysis, 315 students (52.4% of baseline respondents) completed both assessments and could be matched using their identification codes. The remaining 286 students were excluded from the paired analysis because they were absent during the posttest or submitted incomplete posttest responses. These students remained included in the baseline cross-sectional analysis. Accordingly, the cross-sectional analysis included 601 students, whereas the intervention analysis was restricted to the 315 students with complete paired data.

Instrument

Data were collected with a structured, self-administered online questionnaire (Google Forms). It covered demographic characteristics, smoking and e-cigarette use status, sources of e-cigarettes, knowledge (eight items), and perceptions (four items). Knowledge and perception items were rated on a five-point Likert scale (strongly agree, agree, unsure, disagree, strongly disagree). For analysis, responses were collapsed into three categories: agree (strongly agree + agree), unsure, and disagree (disagree + strongly disagree). The questionnaire was adapted from the GYTS core questionnaire (20) and administered in Indonesian. Two senior pediatricians independently reviewed it for content validity, assessing the relevance, clarity, and accuracy of each item. Discrepancies between the reviewers were resolved by discussion until consensus was reached.

Smoking status was assessed with a single item offering five mutually exclusive categories: current e-cigarette user, current conventional cigarette user, former e-cigarette user, former conventional cigarette user, and non-smoker. Consistent with the GYTS, current use was defined as use on at least one day in the past 30 days (20). Former use was defined as any lifetime use but no use in the past 30 days. Ever-use of e-cigarettes was defined as current or former e-cigarette use.

Intervention

After the pretest, a structured health education session on e-cigarettes was delivered to each grade in groups of approximately 100 students. Each session consisted of a 20-minute presentation followed by a 10–20-minute question-and-answer discussion. Content covered e-cigarette composition and aerosol constituents, health risks (respiratory, cardiovascular, and nicotine dependence), common misconceptions about safety, and prevention strategies. The posttest used the same instrument and was administered immediately after each session.

Statistical Analysis

Categorical variables are presented as frequencies and percentages. Safety perceptions of e-cigarette users and non-users were compared with the chi-square test, or with Fisher's exact test when expected cell counts were below 5. Pretest–posttest changes in the three-category ordinal responses (agree, unsure, disagree) were tested with the marginal homogeneity test, an extension of the McNemar test to more than two categories. Changes in the proportion of correct responses were tested with the McNemar test. Changes are expressed in percentage points, and statistical significance was set at $p < 0.05$. Analyses were performed with IBM SPSS Statistics version 21 (IBM Corp., Armonk, NY, USA).

Ethical Considerations

The study was approved by the Faculty of Medicine, Kurnia Jaya Persada University, Palopo, South Sulawesi, Indonesia. Permission was obtained from the principals of the three participating schools. Because most participants were younger than 18 years, written informed consent was obtained from parents or guardians, and each student provided assent on the first page of the online questionnaire before any items were displayed (consent forms distributed through the schools one week before data collection). Participation was voluntary, and students could withdraw at any time

without consequence. No names were collected. To link pretest and posttest responses, each student entered a self-generated identification code (the last four digits of the student ID number). The research team used this code only for matching and deleted it from the dataset before analysis. Responses were accessible only to the research team and were not shared with teachers or parents.

3. RESULTS

Of the 650 eligible students invited to participate in the study, 601 completed the baseline questionnaire, yielding a response rate of 92.5%. Of these respondents, 315 (52.4%) completed both the pretest and posttest and were included in the paired analysis. The remaining 286 students were excluded from the paired analysis because they were absent during the posttest or submitted incomplete posttest responses. All 601 baseline respondents were retained in the cross-sectional analysis.

Table 1. Participant characteristics, smoking status, and sources of e-cigarettes

Variable	Category	n	%
Sex	Female	334	55.6
	Male	267	44.4
Smoking status	Current e-cigarette user	13	2.2
	Current conventional cigarette user	36	6.0
	Former e-cigarette user	44	7.3
	Former conventional cigarette user	41	6.8
	Non-smoker	467	77.7
Source of e-cigarettes ^a	Specialty vape kiosk	78	13.0
	Minimarket	18	3.0
	Other	38	6.3
	Never obtained	467	77.7

Note: ^a Includes students who obtained e-cigarettes for others or did not report themselves as users.

Knowledge and Perceptions

More than half of the students correctly agreed that e-cigarettes convert nicotine into vapor (57.4%) and deliver nicotine without tobacco smoke (51.1%) (Table 2). Most recognized their addictive potential (67.6%), their effects on the circulatory system (54.4%), the presence of fine particles (52.1%), and the presence of carcinogenic compounds (50.2%). Uncertainty was greatest for items on aerosol chemistry: 55.1% were unsure whether e-cigarettes are free of tar and carbon monoxide, and 51.2% were unsure whether they contain only nicotine. Regarding perceptions, 56.4% disagreed that e-cigarettes are safer than conventional cigarettes, but 12.8% agreed and 30.8% were unsure. Fewer than half (45.9%) disagreed that e-cigarettes help smokers quit, and 39.1% agreed that e-cigarette vapor smells better than tobacco smoke.

Table 2. Knowledge and perceptions of e-cigarettes among students

Statement	Correct answer	Agree ^a n (%)	Unsure n (%)	Disagree ^b n (%)
Knowledge				

Statement	Correct answer	Agree ^a n (%)	Unsure n (%)	Disagree ^b n (%)
E-cigarettes are devices that convert nicotine into vapor	Agree	345 (57.4)	178 (29.6)	78 (13.0)
E-cigarettes deliver nicotine without tobacco smoke	Agree	307 (51.1)	211 (35.1)	83 (13.8)
E-cigarettes do not contain tar and carbon monoxide	Agree	86 (14.3)	331 (55.1)	184 (30.6)
E-cigarettes contain only nicotine compounds	Disagree	116 (19.3)	308 (51.2)	177 (29.5)
E-cigarettes contain carcinogenic compounds	Agree	302 (50.2)	242 (40.3)	57 (9.5)
E-cigarette vapor contains fine particles that easily enter the lungs	Agree	313 (52.1)	231 (38.4)	57 (9.5)
E-cigarettes can cause addiction	Agree	406 (67.6)	132 (22.0)	63 (10.5)
Nicotine in e-cigarettes affects the circulatory system	Agree	327 (54.4)	222 (36.9)	52 (8.7)
Perception				
E-cigarettes are safer than conventional cigarettes	—	77 (12.8)	185 (30.8)	339 (56.4)
E-cigarettes can help someone quit conventional cigarettes	—	74 (12.3)	251 (41.8)	276 (45.9)
E-cigarettes pose a risk of battery explosion	—	343 (57.1)	196 (32.6)	62 (10.3)
E-cigarette vapor smells better than tobacco smoke	—	235 (39.1)	212 (35.3)	154 (25.6)

Note: Responses were collected on a five-point Likert scale. ^a Agree = agree + strongly agree. ^b Disagree = disagree + strongly disagree.

Safety Perception by E-cigarette Use Status

Ever-users were more likely than non-users to agree that e-cigarettes are safer than conventional cigarettes (29.3% vs. 8.6%), whereas disagreement was more common among non-users (59.7% vs. 46.6%) (Table 3). The response distribution differed significantly between the two groups ($\chi^2(2) = 22.94$, $p < 0.001$).

Table 3. Perception that e-cigarettes are safer than conventional cigarettes, by e-cigarette use status

	Ever-users (n = 58) n (%)	Non-users (n = 467) n (%)	p-value
Agree ^a	17 (29.3)	40 (8.6)	< 0.001 ^c
Unsure	14 (24.1)	148 (31.7)	
Disagree ^b	27 (46.6)	279 (59.7)	

Note: Responses were collected on a five-point Likert scale. ^a Agree = agree + strongly agree. ^b Disagree = disagree + strongly disagree. ^c Chi-square test, $\chi^2(2) = 22.94$. Students who were current or former conventional cigarette users and had never used e-cigarettes (n = 76) were excluded.

Changes After the Educational Intervention

Among the 315 students with paired data, the proportion of “unsure” responses decreased for every item after the intervention, and responses shifted toward more definite and more accurate views (Table 4). Disagreement that e-cigarettes are safer than conventional cigarettes increased from 56.2% to 65.7% (+9.5 percentage points). Recognition that e-cigarettes contain carcinogenic compounds increased from 52.4% to 68.9% (+16.5 percentage points). Recognition that the aerosol contains fine particles

that reach the lungs increased from 50.5% to 63.5% (+13.0 percentage points), and awareness of battery explosion risk increased from 57.8% to 73.7% (+15.9 percentage points). The tar and carbon monoxide item showed the least improvement. Correct agreement rose from 14.6% to 19.4% (+4.8 percentage points), but 43.5% of students remained unsure and 37.1% still believed that these combustion products are present.

Table 4. Knowledge and perceptions before and after the educational intervention (n = 315)

Statement	Response	Pretest (%)	n Posttest (%)	n Change, (percentage points)	n p-value
E-cigarettes are safer than conventional cigarettes	Agree ^a	39 (12.4)	28 (8.9)	-11 (-3.5)	0.003 ^c
	Unsure	99 (31.4)	80 (25.4)	-19 (-6.0)	
	Disagree ^b	177 (56.2)	207 (65.7)	+30 (+9.5)	
E-cigarettes do not contain tar and carbon monoxide	Agree ^a	46 (14.6)	61 (19.4)	+15 (+4.8)	0.021 ^c
	Unsure	170 (54.0)	137 (43.5)	-33 (-10.5)	
	Disagree ^b	99 (31.4)	117 (37.1)	+18 (+5.7)	
E-cigarettes contain carcinogenic compounds	Agree ^a	165 (52.4)	217 (68.9)	+52 (+16.5)	<0.001 ^c
	Unsure	126 (40.0)	84 (26.7)	-42 (-13.3)	
	Disagree ^b	24 (7.6)	14 (4.4)	-10 (-3.2)	
E-cigarette vapor contains fine particles that can enter the lungs	Agree ^a	159 (50.5)	200 (63.5)	+41 (+13.0)	0.002 ^c
	Unsure	133 (42.2)	98 (31.1)	-35 (-11.1)	
	Disagree ^b	23 (7.3)	17 (5.4)	-6 (-1.9)	
E-cigarettes may pose a battery explosion risk	Agree ^a	182 (57.8)	232 (73.7)	+50 (+15.9)	<0.001 ^c
	Unsure	106 (33.7)	59 (18.7)	-47 (-14.9)	
	Disagree ^b	27 (8.6)	24 (7.6)	-3 (-1.0)	

Note: Responses were collected on a five-point Likert scale. ^a Agree = agree + strongly agree. ^b Disagree = disagree + strongly disagree. ^c Stuart–Maxwell test of marginal homogeneity for paired three-category data.

4. DISCUSSIONS

In this study, 2.2% of high school students in Sorowako currently used e-cigarettes and 9.5% had ever used them. Active use was therefore uncommon, but a meaningful minority had experimented with the products. These figures are lower than those reported elsewhere. A global meta-analysis estimated ever-use among children and adolescents at approximately 16–17% and current use at 4–5%, with wide regional variation (21). In Southeast Asia, a systematic review reported current adolescent use ranging from 3.3% to 11.8%, depending on the country and survey design (22). National Indonesian studies also report higher current use among adolescents and young adults than we observed (6,23). A national school-based study in Saudi Arabia similarly found higher ever-use and current use and emphasized that use is unevenly distributed across adolescent subgroups.

Several factors may explain the lower prevalence in Sorowako, including its small-town setting, lower urbanization, and possibly more limited exposure to e-

cigarette retail and marketing. Social desirability bias in a school-administered survey may also have led to underreporting. Nevertheless, low current use does not eliminate risk. Experimentation in adolescence is associated with continued use later in life, so these findings support early prevention before use becomes more widespread.

Although most students recognized that e-cigarettes are addictive and harmful, a substantial proportion agreed or were unsure that e-cigarettes are safer than conventional cigarettes. The largest gaps concerned aerosol chemistry. Over half of the students were unsure whether e-cigarettes contain only nicotine or whether they are free of tar and carbon monoxide, and nearly one-third incorrectly believed that these combustion products are present. This pattern suggests that students conflate e-cigarettes with conventional smoking rather than understanding how the aerosol is produced and what it contains. The distinction matters: e-cigarettes produce no combustion products such as tar, yet their aerosol still contains carbonyls, metals, and ultrafine particles (8–10).

These findings are consistent with a systematic review and meta-analysis showing that adolescents who perceive e-cigarettes as less harmful or less addictive are more likely to use them (24). Survey evidence likewise shows that misperceptions about nicotine and the relative harms of e-cigarettes remain common among young people (25). Health messages should therefore explain not only that e-cigarettes are not harmless but also why their risks differ from those of conventional cigarettes.

Ever-users were more than three times as likely as non-users to agree that e-cigarettes are safer than conventional cigarettes (29.3% vs. 8.6%). Studies of Italian and U.S. adolescents report the same pattern, with users perceiving e-cigarettes as lower-risk products (26,27). Longitudinal data from the Population Assessment of Tobacco and Health (PATH) Study show that adolescents who perceive e-cigarettes as less harmful and less addictive initiate use at a younger age (28). In Indonesia, perceived safety and the belief that e-cigarettes aid smoking cessation are among the main determinants of youth use (7). Users also tend to emphasize the positive aspects of e-cigarettes and minimize their health risks, which may reflect a justification of their own behavior (29).

The cross-sectional design does not allow us to establish the direction of this association. Low risk perception may promote initiation, and use may in turn reinforce favorable beliefs. Evidence that risk perceptions can change partly supports the second possibility. After the EVALI outbreak, adolescents whose risk perceptions increased reported fewer positive expectations about e-cigarettes, whereas those who maintained low risk perceptions were more likely to continue use (30).

Following the educational intervention, responses shifted toward greater recognition of several potential risks associated with e-cigarette use, although the magnitude of change varied across topics. The proportion of students who disagreed that e-cigarettes were safer than conventional cigarettes increased from 56.2% to 65.7%, representing an increase of 9.5 percentage points. Recognition that e-cigarettes contain carcinogenic compounds increased from 52.4% to 68.9% (+16.5 percentage points), while recognition of the risk of battery explosions increased from 57.8% to 73.7% (+15.9 percentage points). Agreement that e-cigarette aerosol contains fine particles that can enter the lungs also increased from 50.5% to 63.5% (+13.0 percentage points). However, improvement was limited for the item concerning tar and

carbon monoxide. Although agreement that e-cigarettes do not contain these combustion products increased from 14.6% to 19.4% (+4.8 percentage points), 43.5% of students remained unsure after the intervention. This persistent uncertainty suggests that the distinction between combustion and aerosolization may require more explicit explanation than a single 20-minute presentation can provide.

These findings are broadly consistent with previous evidence suggesting that school-based educational programs can improve knowledge and risk perceptions in the short term. A single-session curriculum in Alabama increased knowledge and perceived addictiveness and reduced intentions to try e-cigarettes (31). A multisession program, CATCH My Breath, improved knowledge and reduced intentions to use e-cigarettes among middle school students (32). A recent meta-analysis concluded that school-based interventions have positive short-term effects on knowledge and attitudes, whereas their effects on behavior are weaker and less consistent (33). Reviews of existing programs have identified interactive curricula, refusal-skills training, and education about industry marketing as components associated with greater effectiveness (16,34).

The delivery format may partly explain the variation in observed changes. Sessions were delivered to groups of approximately 100 students, which may have limited individual participation and interaction. Indonesian school-based health education programs have reported improvements in knowledge following interactive educational approaches delivered in smaller groups (35–37). Future programs in Sorowako could therefore incorporate smaller-group discussions, interactive learning activities, and repeated sessions. Particular emphasis should be placed on aerosol chemistry and misconceptions regarding the role of e-cigarettes in smoking cessation. These approaches should be evaluated in future studies to determine whether they produce more sustained improvements in knowledge and risk perceptions.

To our knowledge, this is the first study of e-cigarette use among adolescents in Sorowako. It invited all students in three schools and combined a prevalence survey with an intervention evaluation. Several limitations should be noted. First, all data were self-reported, and e-cigarette use, a stigmatized behavior among adolescents, may have been underreported, particularly because the survey was administered in a school setting. Second, the one-group pretest–posttest design without a control group cannot exclude testing effects, secular trends, or regression to the mean. Third, only 315 of 601 students (52.4%) completed both measurements. Baseline perceptions of completers and non-completers were largely similar, but attrition bias cannot be excluded. Fourth, the posttest measured only immediate changes in knowledge and perceptions, not sustained effects or behavior. Fifth, the questionnaire was adapted from the GYTS and reviewed for content validity, but its reliability was not formally tested. Sixth, smoking-status categories were mutually exclusive, so dual users of e-cigarettes and conventional cigarettes could not be identified; because dual use is common among adolescents and may shape safety perceptions, this may have affected the comparison of users and non-users. Seventh, the small number of e-cigarette users limited the precision of comparisons and precluded adjustment for confounders such as sex and grade. Finally, Sorowako is an industrial mining town with a distinctive socioeconomic profile, and the findings from its three schools may not be generalizable to other Indonesian settings. In particular, the lower prevalence observed

here should be interpreted with caution when compared with national survey data. Furthermore, because the intervention was evaluated without a control group and the posttest was administered immediately after the educational session, the observed changes cannot be attributed exclusively to the intervention, and their persistence over time remains unknown.

5. CONCLUSION

E-cigarette use among high school students in Sorowako is low, but experimentation has occurred, and misconceptions about e-cigarette safety and aerosol chemistry are common. Students who had used e-cigarettes were considerably more likely to perceive them as safer than conventional cigarettes. A single large-group education session improved knowledge and perceptions, but the changes were modest, and uncertainty about tar and carbon monoxide persisted. We recommend school-based programs that use smaller, interactive, repeated sessions, evaluated with a control group and longer follow-up.

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Conflict of Interest Statement:

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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