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Evaluation of the Effectiveness of a School-Based Smoking Prevention Program Among Young Adolescents in Central Greece

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Abstract

Background: Smoking remains a major global public health challenge. Given that smoking often begins in early adolescence, early preventive programs are essential. This study aimed to measure smoking prevalence, assess knowledge and attitudes toward smoking, and evaluate the impact of a school-based smoking intervention program among students aged 12–13 years in Larissa, Greece. Methods: A total of 769 students participated in the study, yielding an overall response rate of 75.5%. All participants' knowledge, attitudes, and smoking prevalence were assessed at baseline. The intervention group (n = 316) was then exposed to audiovisual and printed materials, and both intervention and control group participants were followed up at three- and twelve-months post-intervention. Multivariable linear mixed-effects models and generalized estimating equations models were used to evaluate the effects of the intervention. Results: Baseline characteristics of the study participants were balanced between groups. A statistically significant stage × group interaction was observed for both outcomes, indicating improvements in smoking-related knowledge and attitudes ($p < 0.001$) and a reduction in smoking prevalence ($p = 0.026$). Conclusions: This school-based intervention effectively improved smoking-related knowledge and attitudes and reduced smoking prevalence among participants. These findings support the integration of early prevention programs into school curricula as a potentially effective approach to improving smoking-related outcomes.

Keywords: smoking prevention; school-based intervention; adolescents

1. Introduction

Smoking, a global epidemic and a major public health threat, is responsible for the death of 7 million people each year (World Health Organization, Dai, Gakidou and Lopez, 2022). Tobacco use is widespread globally but unevenly distributed, with 80% of the 1.3 billion tobacco users currently living in low- and middle-income countries (World Health Organization, 2025). Smoking is responsible for 90% of lung cancer cases, about 85–90% of all chronic obstructive pulmonary disease (COPD) cases and is a major risk factor for ischemic heart disease, stroke, asthma, and other conditions (American Lung Association 2025, Reitsma et al. 2021). Smoking has a cumulative harmful effect, and therefore the risk associated with smoking increases with earlier age of initiation, longer

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duration of smoking, and higher average cigarette consumption (Barrington-Trimis et al., 2020). Given this, adolescents and young adults are particularly vulnerable to the risks of smoking due to the longer expected duration of tobacco use (National Center for Chronic Disease Prevention, Health Promotion Office on Smoking, & Health, 2012).

Despite some conflicting evidence, school-based smoking prevention programs have, in many cases, demonstrated effectiveness in achieving both short- and long-term outcomes (Flay, 2009; Thomas & Perera, 2006; Thomas et al., 2013; Song & Park, 2021; de Kleijn et al, 2015). More specifically, these programs have been reported to prevent adolescent cigarette use, reduce smoking prevalence, and lower the likelihood of smoking initiation among this group (Cremers et al., 2015; de Josselin de Jong et al., 2014; Thomas et al., 2013, 2015; Veeranki et al., 2014; Song & Park, 2021). Evidence suggests that school-based programs can influence smoking-related attitudes, beliefs, and behaviors by promoting healthy lifestyle choices, increasing awareness of the dangers of tobacco use, and equipping students with the skills to resist social pressures to smoke (Cuijpers et al., 2002). In addition, school-based interventions have been also conducted for other reasons except smoking prevention with promising results, like internet misuse, physical activity, and substance use (Cadri et al., 2024; Cohen et al., 2024; Martínez-Hernández and Lloret-Irles, 2024; Moeller et al., 2024;).

In Greece, no studies on smoking prevalence among primary school students are available, while only limited data exist for adolescents aged 13–15 (Kyrlesi et al., 2007). According to this study, which was conducted during the 2004–2005 academic year, 32.1% of students reported having tried tobacco in the past, while 16.2% reported being current users of tobacco products (Kyrlesi et al., 2007). In addition, approximately 25% of ever-smokers reported initiating smoking before the age of 10 (Kyrlesi et al., 2007). A Greek study published in 2021 implemented an experiential learning intervention among students with a mean age of 13 (Mpousiou et al. 2021). According to this study, compared to the control group, students in the intervention group were more likely to improve their knowledge of smoking's harmful effects, develop negative attitudes toward smoking, and report intentions not to smoke during the first year after the program (Mpousiou et al. 2021).

Given the aforementioned evidence, the aim of the present study was to assess the prevalence of smoking, as well as participants' knowledge and attitudes toward smoking, and to evaluate the effectiveness of a school-based intervention in reducing the likelihood of smoking initiation and improving knowledge and attitudes among the participants. Specifically, this study sought to address the following research questions:

1. What is the prevalence of smoking among participants before the intervention?
2. What are the levels of knowledge and attitudes toward smoking among participants before the intervention?
3. Is the school-based intervention effective in reducing the likelihood of smoking initiation and improving knowledge and attitudes toward smoking among participants?

2. Materials and Methods

2.1. Population – Inclusion Criteria

The present study was a quasi-experimental, longitudinal intervention study with control group, conducted among 6th-grade students in Larisa, Greece, during the 2017–2018 academic year. In that year, the total number of 6th-grade students in the city was 1,667. Eligibility criteria for participation included enrolment in the 6th grade during the 2017–2018 academic year and provision of parental consent.

2.2. Sampling

The sample size was calculated using the standard formula for comparing two independent proportions, based on the expected prevalence of smoking at the end of the study: 8% in the intervention group and 16% in the control group (Malone, Nicholl, & Coyne, 2016). The calculation assumed a power of 80%, a 95% significance level, a response rate of 90%, a design effect of 1.5 to account for clustering,

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and an allocation ratio of 1:2 (intervention: control). The study employed a two-stage sampling design. In the first stage, schools were selected through probability sampling, and in the second stage, students were chosen using non-probability methods. For the school sample, stratified random sampling was applied to capture differences in geographical context (urban, semi-urban, and rural). Within each stratum, a unique random number was assigned to every school in the sampling frame, and schools were then sorted according to these random numbers. Participation was voluntary, and students were selected based on their availability during the researcher's visits. Participation of the students in the study required written informed consent from their parents or legal guardians

2.3. Questionnaire

A questionnaire with closed-ended questions was developed based on a review of relevant literature and by appropriately adapting previously validated instruments to the specific context of this study (de Vries et al., 2003; Vasilopoulos et al., 2015). The questionnaire comprised three thematic sections: (1) sociodemographic characteristics, (2) knowledge and attitudes toward smoking and (3) tobacco use (see Supplementary materials).

2.4. Pilot Study

Initially, the process of organizing the research was evaluated through a pilot study, focusing on the method of distributing and completing the questionnaire. The purpose of this pilot study was to identify potential comprehension problems by observing respondents' reactions and reviewing their answers. These issues could relate to the form and language of the questionnaire or to unclear or confusing points. The pilot study was conducted with a total of 20 students. Afterwards, the students were asked to provide feedback on the clarity of the questions and to report any difficulties encountered while answering. Cronbach's alpha was calculated to assess the internal consistency of the knowledge–attitude scale and was found to be 0.73, indicating acceptable internal consistency.

2.5. Intervention

Participants in the intervention group received a two-hour educational session, with a baseline assessment of their attitudes and smoking habits conducted prior to the intervention. Follow-up assessments were carried out three months after the intervention and again one year later, resulting in a total of three measurement points: at baseline, three months post-intervention (in the sixth grade), and one-year post-intervention (in the first grade of middle school).

In the first phase, sixth-grade students from both intervention and control schools completed a baseline questionnaire assessing their knowledge, attitudes, and practices regarding smoking prior to the educational intervention. Immediately afterward, the intervention group received a two-hour educational session based on the HEART II program and the "I Learn the Truth – I Say No to Cigarettes" initiative of the Institute of Public Health of the American College of Greece, incorporating audiovisual and printed materials as well as age-appropriate questionnaires (Smoke free Greece, 2025). In the second phase, approximately three months later, the same students completed the questionnaire again to evaluate changes in their smoking-related knowledge, attitudes, and practices. During the third phase, about one year after the intervention, the students were followed up in Larissa high schools to assess these outcomes, allowing comparison between the intervention and control groups over time.

2.6. Data Collection

After securing the necessary approvals, the researcher visited the school premises and distributed the questionnaires. Each questionnaire was accompanied by a letter providing the researcher's details, the purpose of the study, and assurances of anonymity, confidentiality, and voluntary participation. The distribution and collection of the questionnaires took place in the

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presence of the researcher, both before and after the intervention. Completion of the questionnaire required no more than 30 minutes.

2.7. Independent Variables

As independent variables in the multivariable model, we included age, sex, and variables derived from the first section of the questionnaire regarding the smoking habits of participants' family members and friends. Specifically, students were asked whether their mother, father, or any siblings smoke, as well as whether any of their friend's smoke. The possible responses for each question were "Yes," "No," "I don't know," or "I don't have / does not live with me."

2.8. Dependent Variables

The 16 items in the second section, which assessed participants' attitudes and knowledge about smoking, were combined in a logical manner (from negative to positive attitudes and from low to high knowledge) to create a continuous variable, "smoking knowledge–attitudes," ranging from 0 to 80.

Although three distinct questions on smoking prevalence were included in the questionnaire (see Supplementary materials), a measure of smoking in the past 30 days was used for the analysis, in accordance with the Global Youth Tobacco Survey (GYTS) definition (World Health Organization, 2023). Smoking prevalence during the past 30 days was assessed with the question: "Have you smoked at all during the past month (even a single puff)?".

2.9. Statistical Analysis

All statistical analyses were performed with SPSS version 29.

Age is presented in years along with the corresponding standard deviation (SD), while categorical variables are presented as frequencies with corresponding percentages. To evaluate baseline imbalances between the control and intervention groups, we calculated standardized differences for means and prevalence for all variables. Standardized differences values were interpreted using Cohen's rule of thumb, with 0.2 indicating a small difference, 0.5 a medium difference, and 0.8 a large difference (Luo, Funada, et al., 2022). Baseline standardized differences were calculated according to the formulas described by Peter C. Austin (Austin, P.C., 2009).

The knowledge–attitudes scale was treated as a continuous variable and is presented as the mean with the corresponding SD, while smoking prevalence is presented as a percentage. The effect of the intervention was assessed using a multivariable linear mixed-effects regression model for the knowledge–attitudes scale and a multivariable Generalized Estimating Equations (GEE) model for smoking prevalence. Both models included the stage × group interaction as an independent variable, along with the same covariates: group, stage, sex, age, maternal smoking, paternal smoking, and smoking by any sibling. Correlations arising from repeated measures and clustering were accounted for using a two-level random effect in the mixed-effects model, with participants nested within clusters, and robust standard errors in the GEE model.

2.10. Ethical Issues

Participation of the students in the study required written informed consent from their parents or legal guardians. The protocol of the study has been approved by the Ministry of Education, Religious Affairs and Sports (57683/12-04-2018), the Institute of Educational Policy (4073/12-04-2018), as well as the General Assembly of the Faculty of Medicine of the University of Thessaly (5262/11-10-2017).

3. Results

In total, 769 students aged 11–12 years participated in the study, yielding an overall response rate of 75.5%. Between stages 1 and 3, loss to follow-up occurred in 21% of participants in the intervention group and 28% in the control group.

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Baseline characteristics of study participants are presented in Table 1. Overall, the groups were well balanced, with only minor differences observed for paternal and maternal smoking, which were slightly more prevalent in the intervention group.

Table 1. Baseline characteristics of study participants.

Variable	Intervention Group	Control Group	ASD*
Gender			0.088
no. (%) male	161 (50.9%)	211 (46.6%)	
no. (%) female	155 (49.1%)	242 (53.4%)	
Age in years (SD)	11.24 (0.43)	11.29 (0.46)	0.11
Smoking of the mother, no. (%) yes	144 (36.9%)	147 (32.5%)	0.27
Smoking of the father, no. (%) yes	170 (43.5%)	171 (37.7%)	0.33
Smoking of any sibling, no. (%) yes	15 (3.8%)	17 (3.8%)	0.05
Smoking of any friend, no. (%) yes	10 (2.6%)	16 (3.5%)	0.02

* ASD: Absolute Standardized Difference; values of 0.2, 0.5, and 0.8 indicate small, medium, and large differences, respectively.

Table 2 presents the scores of the smoking knowledge-attitude scale across the three stages of the intervention in both the control and intervention groups. A slight improvement was observed in the intervention group, with scores increasing from 60.36 at baseline to 62.27 at stage 3, while no notable changes were observed in the control group.

Table 2. Summary statistics of scores of the smoking knowledge-attitude scale between the three stages of the intervention.

Stage	Mean ± SD	
	Intervention group	Control group
1	60.36 ± 6.90	62.91 ± 5.90
2	62.88 ± 7.31	62.91 ± 6.85
3	62.27 ± 7.58	62.46 ± 6.45

According to the mixed-effects multivariable linear regression model, the interaction between stage and group was statistically significant ($p < 0.001$), indicating that changes over time in knowledge and attitudes toward smoking differed between the two groups (Table 3). Sex and age were also significantly associated with smoking prevalence ($p = 0.003$ and $p = 0.011$, respectively).

Table 3. Mixed-effects multivariable linear regression results for baseline variables and the smoking knowledge–attitudes scale, including the time × group interaction.

Variable	F-Statistic	P-Value
Group	0.487	0.493
Stage	5.945	0.003
Stage x group	8.432	<0.001
Sex	8.828	0.003
Age	6.435	0.011
Smoking of the mother	3.613	0.057
Smoking of the father	0.084	0.772
Smoking of any sibling	0.033	0.856
Smoking of any friend	0.582	0.445

Table 4 presents the prevalence of smoking at the three stages of the study in both the intervention and non-intervention groups. Although participants in the control group started with a lower baseline prevalence compared to the intervention group (0.22% and 0.51%, respectively), by stage 3 the smoking prevalence was 2.68% in the control group and 1.81% in the intervention group.

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Table 4. Smoking prevalence (%) during baseline (stage 1), 3 months post-intervention (stage 2) and 12 months post-intervention (stage 3).

Stage	Prevalence (%)	
	Intervention Group	Control Group
1	0.51	0.22
2	0.51	0.44
3	1.81	2.68

According to the GEE multivariable model, a significant interaction between stage and group was observed ($p = 0.026$), indicating that the change in smoking prevalence over time differed between the two groups (Table 5). Other baseline variables significantly associated with smoking prevalence were group ($p < 0.001$), stage ($p = 0.004$), and smoking by any sibling ($p = 0.010$).

Table 5. Results of the multivariable GEE model examining the associations of baseline variables with smoking prevalence, as well as the effect of the stage × group interaction on changes in prevalence over time.

Variable	Wald Chi- Square	P-Value
Group	39.164	<0.001
Stage	14.187	0.004
Stage x group	7.301	0.026
Sex	0.043	0.837
Age	1.130	0.288
Smoking of the mother	3.549	0.060
Smoking of the father	1.686	0.194
Smoking of any sibling	6.657	0.010
Smoking of any friend	3.241	0.072

4. Discussion

The present study demonstrated a statistically significant interaction between stage and group, indicating that the intervention was effective in improving scores on the knowledge–attitude scale, and in controlling smoking initiation among the participants who experienced the intervention in comparison to the control group.

There are meta-analytic lines of evidence suggesting that smoking intervention programs significantly improved smoking behaviors and prevented smoking initiation among young adolescents with both short- and long-term effects taken into account (Song & Park, 2021; Thomas et al., 2013). The most effective interventions were school-based programs, particularly those delivered by trained teachers (Song & Park, 2021). High-intensity programs, also resulted in a significant reduction in smoking use (Song and Park, 2021). In addition, X:IT intervention a large prospective study in Denmark the X:IT intervention included also core systematic features of an antismoking campaign like smoke-free school grounds, a smoke-free curriculum, and parental involvement, which collectively contributed to the control and decrease of smoking use among adolescents (Bast et al, 2016). Mpousiou et al. in a school-based interventional study in Athens, Greece used ancient Greek myths to convey anti-smoking messages to middle-school students (Mpousiou et al. 2021). Among 351 participants, those in the intervention group showed better knowledge, stronger anti-smoking attitudes, and less intention to smoke after 3 months, in comparison to the control group (Mpousiou et al. 2021).

The results of the present study may have several implications for early smoking prevention policy in Greece. Although smoking initiation often occurs during adolescence, our findings show that preventive education can be effective even before most students begin experimenting with tobacco. Implementing school-based interventions at the primary level may therefore serve as a key strategy for the primary prevention of smoking. This is of importance since Greece continues to report one of the highest adult smoking rates in Europe (Rachiotis, 2017). Integrating structured, evidence-based prevention modules into national curricula could enhance the primary prevention of

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tobacco use at an early age. Early prevention also aligns with Greece's National Action Plan for Public Health (Ministry of Health, 2021). Expanding programs like the one implemented in this study—and ensuring that teachers are trained and supported to deliver them—could contribute to a sustained reduction in smoking prevalence and associated chronic diseases morbidity over time

The observed improvements in students' knowledge and attitudes toward smoking and prevalence of smoking may be interpreted through the optic of Bandura's Social Cognitive Theory (Bandura, 1999), and the Theory of Planned Behavior (Ajzen, 1991) which focus on three independent determinants of intention (attitudes towards the behavior under study; subjective form which is reflects the perceived social pressure to accept or reject the behavior; and also the degree of perceived behavioral control (self-efficacy). The educational intervention— e.g. by providing audiovisual material, guided discussion, and peer interaction— may have created opportunities for observational learning, where students could model anti-smoking behaviors and recognize positive social norms associated with tobacco refusal. Through exposure to persuasive messages and the use of relatable examples, the program likely enhanced students' self-efficacy—their belief in their ability to resist social pressure to use tobacco and nicotine products. The above-mentioned mechanisms collectively help explain why knowledge and attitudes substantially improved, and why the intervention was able to effectively control the prevalence of smoking over time.

It is a strength of our study that in statistical analysis we accounted for the effect of time and the interaction between stage and group of participants. Further, our students belonged to the elementary school and to the best of our knowledge, it is the first interventional study for smoking prevention in Greece among adolescents of this age. Moreover, our study sample was well balanced between the intervention and control groups in terms of key sociodemographic factors (sex and age) and the additional covariates, thereby minimizing the risk of confounding in the analysis. However, the present study has several limitations. First, as it relies on questionnaires, there is a risk of information bias. This is particularly relevant for outcomes related to smoking behavior and attitudes toward smoking, as responses might be influenced by social desirability bias. Additionally, we did not utilize biomarkers to verify participants' smoking exposure status. Moreover, interventions that include digital material might be more appealing to students (Ausems et al., 2002; Prokhorov et al., 2008). Additionally, our participants come from the region of Thessaly. Consequently, the generalizability of study's results should be approached with caution. The relatively high and differential loss to follow-up between groups represents a potential source of attrition bias and should be considered when interpreting the results. Finally, a limitation of this study is that it did not examine the use or impact of novel tobacco products, such as e-cigarettes or heated tobacco devices. As these products are increasingly prevalent, future research should include them to provide a more comprehensive understanding of tobacco use behaviors.

5. Conclusions

In conclusion, the results of the present interventional study showed significant improvements in the level of knowledge and attitudes of young adolescents towards smoking, as well as in the control of smoking initiation in the intervention group. Our findings support that integration of similar early prevention programs in school curricula could be beneficial for improving the above-mentioned outcomes and highlight the importance of continuous evaluation and adaptation for sustained impact. Integrating structured smoking prevention modules into elementary and early secondary school curricula could support long-term tobacco control efforts in Greece by enhancing positive anti-smoking behaviors from an early age.

Supplementary Materials: The English translation of the original questionnaire used in the study can be downloaded at: https://www.mdpi.com/article/doi/s1, Figure S1: title; Table S1: title; Video S1: title.

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Informed Consent Statement: Participation of the students in the study required written informed consent from their parents or legal guardians.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

COPD	Chronic obstructive pulmonary disease
GYTS	Global Youth Tobacco Survey
GEE	Generalized Estimating Equations

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