ORIGINAL ARTICLE

Effectiveness of "Duet Me": a quasi-experimental study assessing the impact of a mobile phone mini-game on enhancing tobacco knowledge among Thai adolescents

Phitchasuda Detboon[1], Chitlada Areesantchai[2], Usaneya Perngparn[2], Apichet Jumneansuk[3]

[1]Ph.D. student in College of Public Health Sciences Chulalongkorn University, Bangkok, Thailand
[2]College of Public Health Sciences Chulalongkorn University, Bangkok, Thailand
[3]Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani, Thailand

Corresponding Author: Chitlada Areesantchai **Email:** Chitlada.A@chula.ac.th

Received: 15 December 2023 **Revised:** 13 February 2024 **Accepted:** 22 February 2024 **Available online:** May 2024
DOI: 10.55131/jphd/2024/220202

ABSTRACT

Tobacco use poses a significant health risk to the Thai population, contributing to serious illnesses such as cancer and lung disease while also increasing the risk of tuberculosis. This six-month quasi-experimental study, conducted in Phrae Province, Thailand, aims to assess the effectiveness of the mobile phone mini-game, "Duet Me," with its engaging design and HBM alignment in enhancing tobacco knowledge among adolescents. A sample of 99 fifteen-year-olds participated, with the focus on a two-month intervention period and a four-month follow-up. Data were collected through self-administered questionnaires. Demographic analysis revealed that the intervention group comprised 51% females, and the comparison group comprised 54% females. Approximately 23.2% of participants reported prior tobacco use. Both groups initiated the study with a low level of knowledge (p-value>0.05). The intervention group exhibited a significant increase in tobacco knowledge at both the two-month post-intervention and four-month follow-up, outperforming the comparison group (p-value<0.05) . Repeated measures ANOVA revealed a significant difference in the mean knowledge scores between the two groups over time, supporting the game's effectiveness (p-value<0.0001) . Pairwise comparison confirmed sustainable knowledge improvement in the intervention group (p-value<0.0001) . The findings suggest that innovative interventions play a positive role in promoting health education among adolescents, potentially contributing to fostering informed decision-making toward tobacco consumption.

Key words:
adolescent; tobacco knowledge; mobile phone game; risky health behavior; health education

Citation:
Phitchasuda Detboon, Chitlada Areesantchai, Usaneya Perngparn, Apichet Jumneansuk. Effectiveness of "Duet Me": a quasi-experimental study assessing the impact of a mobile phone mini-game on enhancing tobacco knowledge among Thai adolescents. J Public Hlth Dev. 2024;22(2):13-25
(https://doi.org/10.55131/jphd/2024/220202)

INTRODUCTION

Due to the impact of political tension and uncertainty in 2010, Thailand is facing a decline in the overall birth rate.[1] Thailand's population crisis has resulted in a rapid growth in the number of elderly people while the birth rate and proportion of children have dropped. According to the National Statistical Office of Thailand, in 2019, the population aged 0–14 years, 15–24 years, and 65 years and over equated to 16.45%, 13.02%, and 11.82% respectively. While in 2020, the number of those aged 0–14 years, 15–24 years, and 65 years and over equated to 16.49%, 12.73%, and 12.57%, respectively.[2]

Despite the decline in the percentage of adolescents, it remains imperative to prioritize this demographic, considering their pivotal role as the future workforce and potential contribution to the economic system. Consequently, amidst the challenges posed by demographic shifts, focusing on adolescents becomes crucial not only for their physical and social development but also for fostering a healthy lifestyle. Healthy living is an essential factor for adolescents, while lifestyle and behaviors influence their quality of life. Given that adolescence is a time of intimate personal development and increasing independence, it is essential to recognize the impact of lifestyle and behaviors on their overall quality of life. This heightened independence exposes adolescents to various risk factors that can lead to sexually risky behavior, substance abuse, alcohol use, and tobacco use. Addressing these common behavioral risks is crucial for promoting a healthier and more resilient adolescence.

Tobacco use refers to the inhalation of smoke from burning tobacco, including cigarettes, pipes, and cigars. Smoking increases the risk of health problems such as stroke and coronary heart disease, damages blood vessels, threatens eyesight, and causes skin to dry out and lose elasticity. Furthermore, smoking can cause cancer in practically every part of the body, including the mouth and throat, kidneys and renal pelvis, liver, stomach, and lungs.[3] As time progresses, the severity of the smoking problem becomes increasingly critical, particularly in adolescents. Over 19% (10.7 million) of the Thai population aged ≥15 years are estimated to be smokers, with 7.8% of these being 15–18 years old. Almost 1 in 10 Thai students is a current tobacco user, with about 20% of these students initiating cigarette smoking before their 10th birthday.[4] As previously mentioned, there has been a notable increase in smoking habits. The average age of smoking initiation has been decreasing annually. Moreover, it is widely recognized that smoking is detrimental to health, irrespective of age. There is compelling evidence to indicate that the commencement of alcohol use or smoking before the age of 21 may rapidly progress into habituation and addiction.[5] Furthermore, smoking during childhood and adolescence can lead to notable health issues, such as heightened respiratory illness and reduced physical fitness, while also potentially impacting lung growth and function.[6]

Tobacco use among adolescents remains a significant health problem for this demographic group. Therefore, this study focuses primarily on strategies for the prevention of alcohol consumption and smoking among adolescents, one such strategy being educating them about the risks involved. According to a study by Harvey and Chadi,[7] there is adequate evidence to recommend interventions to prevent smoking through healthcare, including providing printed materials in person, by mail, or email, while computer applications or internet sources are also known to be effective. Consistent with the studies by Jungsomjatepaisal[8] and Jewpattanakul Y et al.,[9] enhancing tobacco knowledge is a pivotal component of prevention activities, with a particular focus

on the early stages before adolescents initiate smoking.

A survey on tobacco consumption in Phrae Province in 2017 revealed that 16.05% of the population aged 15 years old and above had smoked.[10] In addition, the results of a survey on the quality of life in Phrae Province revealed that the compliant indicator is the percentage of individuals in a household who smoked. A total of 36,229 people were surveyed, constituting 6.16%. This criterion ranked second among all 31 indicators, aligning with the data from the Provincial Health Office in Phrae, which found an increasing trend in tobacco use, particularly among young people aged 15 and older, irrespective of gender.[11]

Despite the evident need for research on tobacco use in Phrae Province, there is a notable gap in studies and preventive activities for adolescents. To address this gap, a quasi-experimental study was proposed to evaluate the effectiveness of a mini mobile phone game in enhancing tobacco knowledge among adolescents in Phrae Province. This study adopts the Health Belief Model (HBM) as a theoretical framework. By integrating the HBM into the development of the mini mobile game, this study aims to leverage technology as an innovative approach to educate adolescents about the risks associated with tobacco use. Through a comprehensive evaluation of the game's impact, the research seeks to contribute valuable insights into ongoing efforts toward tobacco prevention and health promotion in Phrae Province.

METHODS

Study Design

This quasi-experimental study covered a period of six months and was conducted in 2021, with two months being dedicated to the intervention period and four months for follow-up.

Respondents and sample size calculation

The calculated sample size was initially calculated by the G-power program using a confidence level of 95% (Type I error = 0.05) and a power (1-α) of 80%, resulting in a sample of 96 participants. To account for potential data collection errors and attrition, the sample size was adjusted by 10%. Consequently, the final sample size for the study consisted of 106 participants, divided evenly into an intervention group (53 participants) and a comparison group (53 participants).

The recruitment of participants followed a multi-stage sampling approach. The inclusion criteria stipulated that the respondent must attend a public school, be 15 years old, have been living in Phrae Province for at least one year, be fluent in the Thai language, and have obtained parental informed consent to participate in the study. Adolescents with any vision or hearing problems were allowed to participate; however, those who failed to complete more than 10% of their gaming assignments were excluded.

At the initiation of the intervention, 106 participants were recruited for the study. However, during the implementation, some participants lost connection, withdrew from the study, or failed to complete more than 10% of the mini-game. Consequently, the final analysis was conducted with 99 participants (Intervention group = 50 participants, Comparison group = 49 participants).

Procedure

The intervention group participants received instruction in a regular classroom and were provided access to a mobile phone mini-game. The game application focuses on enhancing tobacco knowledge through reading and learning by seamlessly integrating these game elements.

Mini-game: Duet Me

The mini-game was crafted to incentivize participants to enhance their tobacco knowledge through a question-and-answer contest. This mini-game features two distinct modes: solo-player and competitive.

In the solo-player mode, participants engage in a random question-and-answer contest to test their tobacco knowledge. Each round is strategically designed with a time limit of three minutes. The game aims to provide immersive experiences that effectively impart and reinforce tobacco knowledge. In addition, the competitive mode offers a two-player setting, creating a vibrant environment where participants compete in answering questions. This mode not only adds a layer of friendly competition but also encourages social interaction among players, elevating the overall gaming experience. In both modes, participants who make the correct choices receive rewards representing extra characters in-game, while incorrect choices lead to character damage and score reduction.

Incorporating the principles of HBM theory, the formulation of the question bank with the Duet Me mini-game has been systematically designed to address foundational knowledge on tobacco, patterns of tobacco use, the impact of tobacco on the adolescent brain, and its overarching influence on overall health, and association with chronic diseases. Through the application of the HBM, the questions are intended to instill awareness among participants regarding the dangers of tobacco and elucidate the severity of its impact on health.

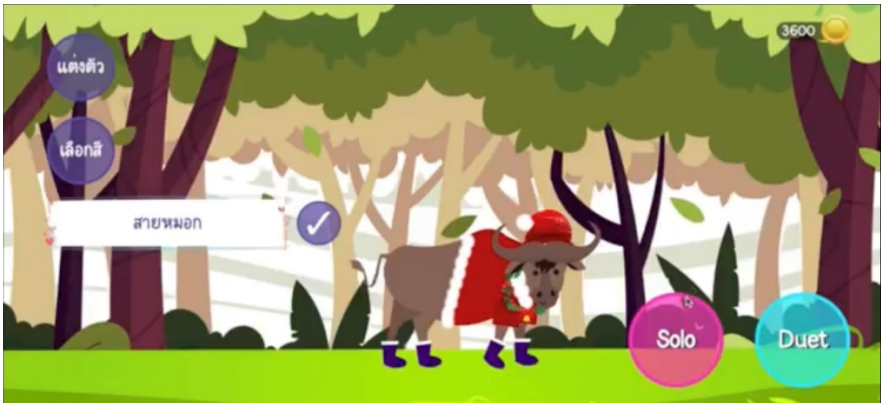

Figure 1. Screenshot of Duet Me mini-game

The comparison group, who were not permitted to participate in the mini-game, received regular classroom instruction at their school throughout the entire intervention period.

Research Instruments

Data were collected through a self-administered questionnaire, which was divided into two parts:

1) Characteristic factors

This self-administered measurement consisted of six items relating to adolescent characteristics: gender, weight, height, tobacco use experience, parental tobacco use, and time the parent spends with the adolescent.

2) Tobacco knowledge assessment

This self-administered tobacco knowledge assessment was developed through a comprehensive literature review. This assessment comprised 40 items. Each question was associated with a correct answer, contributing to a total score ranging from 0 to 40. Example questions included: 1) To what extent do you think smoking during adolescence contributes to long-term health issues? 2) What are the primary

components found in tobacco smoke that pose health risks to individuals? 3) How does nicotine affect brain development in adolescents? and 4) Which chronic respiratory condition is strongly associated with long-term cigarette smoking?

The following scores were revealed: low level of tobacco knowledge (0–24), moderate level of tobacco knowledge (25–31), and high level of tobacco knowledge (32 or above).

To ascertain the construct validity of the tobacco knowledge assessment, three experts were involved in the evaluation process. The resulting validity coefficient obtained for the instrument was 0.86. Additionally, internal consistency yielded a score of 0.81, indicating reliability.

Statistical analysis

1) Descriptive statistics

The demographic data of the participants were analyzed using descriptive statistics, namely frequency, percentage, mean, and standard deviation.

2) Analytical statistics

2.1 The independent t-test was used to compare tobacco knowledge among 15-year-old adolescents between the intervention group and the comparison group. The significance level for this study was defined as 0.05.

2.2 Repeated measures ANOVA was used to determine the effectiveness of a mini mobile phone game on tobacco knowledge among 15-year-old adolescents in Phrae Province, Thailand. The significance level for this study was defined as 0.05.

Ethical consideration

This study was approved by the Research Ethics Review Committee for Research Involving Human Subjects, Chulalongkorn University. Project number: 100.1/64. Date of approval: July 1, 2021.

RESULTS

Characteristics of the respondents

Table 1 shows the total number of respondents in this study, namely 99 adolescents aged 15 years old living in Phrae Province. The results for characteristics indicate the distribution of participants based on their tobacco use experience within the past three months. The findings highlight that the majority of participants in both groups (76% in each) have never experienced tobacco use. In both study groups, a minority of participants (24% in each group) reported recent experience with tobacco use within the last three months. Notably, all individuals within this subset continued smoking during this period.

The baseline characteristics of the intervention and comparison groups show no statistically significant difference in terms of gender, weight, height, tobacco use experience, parental tobacco use experience, and parental time spent with adolescents (p-value>0.05), as presented in Table 1.

Table 1. Characteristics of the respondents (n=99)

Factors	Intervention group (n=50)	Comparison group (n=49)	p-value
Gender			0.250[a]
- Male	23 (46.0%)	25 (51.0%)	
- Female	27 (54.0%)	24 (49.0%)	
Weight (kilograms)			0.541[b]
Mean± SD	56.12±12.89	54.54±12.74	
Min, Max	40, 95	33, 85	
Height (centimeters)			0.516[b]
Mean± SD	163.22±5.88	164.14±8.01	
Min, Max	149, 178	145, 185	
Tobacco use experience (3 months previously)			0.974[a]
- Never	38 (76.0)	38 (76.0)	
- Has been experienced	12 (24.0)	11 (24.0)	
Parental tobacco use			0.821[a]
- Neither of the parents smoke	36 (72.0)	34 (69.4)	
- Father smokes	12 (24.0)	13 (26.5)	
- Mother smokes	2 (4.0)	2 (4.1)	
Time the parent spends with the adolescent (hours per day)			0.919[b]
Mean± SD	2.42±0.79	2.40±0.76	
Min, Max	1.5, 4.0	1.5, 4.5	

Note: [a]Chi-square test, [b]Independent t-test with the significance level set at p-value< 0.05

Tobacco knowledge assessment

These descriptive statistics provide an overview of the knowledge scores at different time points. Both groups started with a low baseline knowledge level (p-value>0.05). After two months, the intervention group showed significant improvement (mean=32.48, SD.=3.524), with a majority achieving a high knowledge level, while the comparison group mostly remained at a low level (mean=14.06, SD.=3.165). During the follow-up period, the intervention group maintained a high knowledge level (mean=32.70,SD.=3.477), whereas the comparison group still predominantly exhibited a low level (mean=14.06, SD.=3.139), as displayed in Table 2.

Table 2. Tobacco knowledge assessment (n=99)

Tobacco knowledge assessment	Intervention group (n=50)	Comparison group (n=49)	p-value
Baseline			
- Low level	50 (100.00%)	49 (100.00%)	
Mean± SD	13.62± 2.602	12.48± 2.953	0.164[a]
Min, Max	9, 20	8, 20	
Post-intervention (two months)			
- Low level	1 (2.00%)	48 (98.00%)	
- Average level	20 (40.00%)	1 (2.00%)	
- High level	29 (58.00%)	0 (0.00%)	
Mean± SD	32.48± 3.524	14.06± 3.165	<0.0001[a]
Min, Max	24, 40	9, 27	

Table 2. Tobacco knowledge assessment (n=99) (cont.)

Tobacco knowledge assessment	Intervention group (n=50)	Comparison group (n=49)	p-value
Follow-up period (four months)			
- Low level	0 (0.00%)	48 (98.00%)	
- Average level	19 (38.00%)	1 (2.00%)	
- High level	31 (62.00%)	0 (0.00%)	
Mean± SD	32.70± 3.477	14.06± 3.139	<0.0001[a]
Min, Max	25, 40	9, 27	

Note:[a]Independent t-test with the significant level set at p-value< 0.05

Enhancing Adolescent Tobacco Knowledge: The Effectiveness of a Mobile Phone Mini-Game

The repeated measures ANOVA was employed to assess the intervention impact on tobacco knowledge, by comparing the intervention group with the comparison group across multiple time points.

The within-subjects analysis revealed that time had a highly significant effect on knowledge scores (F= 1332.645, p< 0.0001), indicating a significant variation in knowledge across different time intervals. Additionally, the interaction effect between intervention and time was also highly significant (F= 1029.051, p< 0.0001), suggesting that the change in knowledge scores over time differed between the intervention and comparison groups.

The between-subjects analysis demonstrated a substantial difference in mean knowledge scores between the intervention and comparison groups (F= 474.384, p< 0.0001), supporting the efficacy of the intervention in influencing knowledge outcomes. These results collectively indicate that the intervention had a significant and differential impact on the change in tobacco knowledge scores over time compared to the comparison group, emphasizing its effectiveness in enhancing participants' understanding of tobacco-related information (Table 3).

Table 3 An analysis of tobacco knowledge by repeated measures ANOVA between the intervention group and comparison group (n=99)

Variables	Sum of squares	df	Mean square	*F*-test	p-value
Within subjects					
Time	6728.900	1.043	6452.811	1332.645	<0.0001*
Intervention x time	5195.970	1.043	4982.779	1029.051	<0.0001*
Error (within-group error)	489.780	101.150	4.842		
Between subjects					
Intervention	11812.196	1	11812.196	474.384	<0.0001*
Error (between-group error)	2415.306	91	24.900		

Note: significant level at 0.05.

Pairwise comparison analysis utilizing Bonferroni adjustment was conducted to assess the differences in tobacco knowledge between the intervention and comparison groups at various time points.

Baseline: At the baseline, there was no statistically significant mean difference in knowledge scores between the intervention and comparison groups (p=0.162).

Post-intervention (two months): Following the intervention, a statistically significant mean difference was observed in knowledge scores between the two groups (p<0.0001). The 95% confidence interval for the difference ranged from -0.223 to 0.003. This suggests that, on average, the intervention group exhibited a significant increase in knowledge compared to the comparison group at the two-month post-intervention assessment.

Four-month Follow-up: Even at the 4-month follow-up, a statistically significant mean difference persisted in knowledge scores between the intervention and comparison groups (p< 0.0001). The 95% confidence interval for the difference ranged from -0.003 to 0.223, indicating that the intervention group maintained a significantly higher level of knowledge compared to the comparison group (Table 4).

Table 4 Pairwise comparison of the difference measurement in tobacco knowledge between the intervention group and comparison group (n=99)

Variables	Group		Mean difference	SE	*p*	95% confidence interval for difference[a]	
	i	j	i-j			Lower	Upper
Baseline	Intervention	Comparison	-10.152	0.273	0.162[a]	-10.819	-9.486
Post-intervention	Intervention	Comparison	-0.110	0.046	<0.0001[a]	-0.223	0.003
Four-month follow-up	Intervention	Comparison	0.110	0.046	<0.0001[a]	-0.003	0.223

Note: [a]Adjustment for multiple comparisons: Bonferroni, significance level at 0.05.

DISCUSSION

Tobacco use poses a crucial health risk with profound implications for both individual well-being and public health in Thailand. Smoking is intricately linked to a plethora of diseases and disabilities, including cancer, heart disease, stroke, lung diseases, diabetes, and chronic obstructive pulmonary disease (COPD)[12]. Despite ongoing efforts to reduce tobacco consumption, the prevalence of tobacco use remains noteworthy, particularly in terms of the decreasing average age of smoking initiation. Results from the 2015 Global Youth Tobacco Survey[13] revealed that overall, 15% of students currently used tobacco, with the prevalence of current cigarette smoking being 11.3%. These statistics highlight the significant issue of tobacco use among adolescents, with approximately 1 in 10 Thai students currently using tobacco and initiating smoking before the age of 15[4]. Given these alarming trends, it is imperative that tobacco research and intervention efforts focus attention on adolescents.

In the study area of Phrae Province, an obvious dearth of research on tobacco use persists despite its recognized significance as a crucial quality of life indicator[11]. This evident gap in the literature underscores a critical deficiency

in society's comprehension of local tobacco consumption trends and their ramifications for public health. According to the study analysis, approximately 24% of participants reported past and current smoking habits. This finding underscores the urgency for addressing tobacco use in Phrae Province and emphasizes the pressing need for targeted interventions to mitigate its adverse effects and promote healthier behaviors.

Previous studies have suggested that education and the implementation of knowledge represent potential strategies to deter smoking initiation among adolescents[7,8,9]. For instance, intervention programs like school-based prevention[14,15] and internet-based prevention[16] have shown promise in enhancing adolescents' awareness of the risks associated with tobacco use. These interventions aim to equip adolescents with the necessary information and skills to make informed decisions regarding tobacco consumption. While education-based programs have shown promise, there is a burgeoning interest in exploring alternative approaches, such as game-based interventions. Previous studies suggest that gaming interventions may have the potential to effectively augment adolescents' understanding of tobacco products. Pentz et al.[17] implemented a videogame intervention for tobacco product use prevention in adolescents, demonstrating significant improvements in knowledge toward e-cigarettes and other tobacco products (p's<0.001). Similarly, a study by Hieftje et al.[18] investigated the effectiveness of a videogame intervention on the beliefs and knowledge of young adolescents concerning tobacco, revealing significant differences in knowledge levels before (pre-survey) and after (post-survey) the intervention across all six knowledge questions ($p < 0.0001$). Therefore, the "Duet Me" mini-game intervention was selected for this study to enhance adolescents' knowledge of tobacco in Phrae Province.

At the baseline, both the intervention and comparison groups displayed a propensity toward lower levels of knowledge (p-value>0.05). However, after the intervention, noteworthy disparities in knowledge scores emerged between the two groups during the two-month and four-month follow-up periods. The intervention group demonstrated a marked improvement (p-value>0.05), indicating the potential effectiveness of the mini-game in augmenting knowledge related to tobacco smoking. These findings are consistent with those of a study by Bteddini et al.[19], wherein intervention participants exhibited significant enhancements in their general tobacco-related knowledge (post-pre = 16.21-12.92 = 3.3, $p < .01$).

Several factors may have potentially contributed to the observed improvement in knowledge scores. Firstly, it is likely that the mini-game's capacity to deliver an engaging learning experience played a significant role. By offering both solo and competitive modes, the game may have encouraged active participation from adolescents, who are known to potentially retain information more effectively in a gamified and enjoyable format. Additionally, the strategic inclusion of timed rounds with a three-minute limit may have introduced a sense of challenge, potentially heightening players' overall engagement and attention. This approach aligns with Gee's work[20], which provides valuable insights into the potential synergy between gaming and education, advocating for the integration of gaming principles into educational practices. Similarly, the findings from a study by Parisod et al.[21] suggest that the intervention with embedded game elements, such as the health game Fume, may be more feasible as

a tobacco-related health education intervention than non-gamified websites among early adolescents, potentially in light of demand and acceptability.

Furthermore, the strategic alignment of the game with the HBM principles adds depth to its effectiveness[22]. The deliberate integration of HBM into the game's question bank reflects a nuanced understanding of behavioral change theories. By addressing the fundamental aspects of tobacco, including basic knowledge and its impact on the adolescent brain, the mini-game not only imparts information but may also influence perceptions and attitudes. This alignment with psychological and behavioral theories may significantly contribute to the game's success in positively shaping participants' understanding of tobacco-related issues. Therefore, the mini-game, rooted in the principles of the HBM, may emerge as a potent tool for enhancing tobacco knowledge among adolescents compared to traditional classroom instruction alone[23].

Overall, while this study might provide insights into the effectiveness of the intervention in the context of Phrae Province, it is essential to acknowledge its limitations and interpret the findings accordingly. Firstly, although a quasi-experimental design was employed to facilitate comparison between intervention and comparison groups, the absence of participant randomization poses a limitation. Randomization helps to minimize biases and confounding variables, thereby enhancing the internal validity of the study. A randomized controlled trial would have provided stronger evidence as to the effectiveness of the intervention. Moreover, the generalisability of the findings in this study may be limited beyond the specific population of adolescents in Phrae Province, Thailand. Cultural, socioeconomic, and contextual factors unique to this region may influence the effectiveness of the intervention. Thus, caution is advised when extrapolating the results to other populations or settings. Therefore, future research endeavors could address these limitations by employing more rigorous study designs and considering diverse populations to enhance the generalisability of the findings.

CONCLUSION

The mini mobile phone game, "Duet Me," presents a promising avenue for tobacco prevention efforts among adolescents in Phrae Province. The study's findings contribute valuable insights to the broader discourse on the use of innovative and technology-driven approaches to address critical public health issues. The sustained impact observed over the four-month follow-up period underscores the potential of gamified interventions to instill lasting knowledge and promote healthier behaviors among adolescents.

By adopting these recommendations, policymakers, educators, and healthcare professionals can work collaboratively to improve tobacco knowledge among adolescents in Phrae Province and contribute to the overall health and well-being of the younger population.

RECOMMENDATIONS

Based on the findings of this study, several recommendations can be made to address the issue of tobacco knowledge among adolescents in Phrae Province. Firstly, the study highlights the alarming decrease in the average age of smoking initiation. Therefore, preventive measures should be initiated at an early age, possibly even before adolescence. Integrating tobacco education into primary school curricula and community-based awareness campaigns can contribute to building a foundation of knowledge and resistance against tobacco use. In addition, the

effectiveness of the mini mobile phone game in enhancing tobacco knowledge among adolescents suggests the potential of leveraging technology for educational purposes. The development of more interactive and educational mobile applications or games can be explored to make learning about tobacco more engaging and effective.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this work.

ACKNOWLEDGMENT

The authors would like to acknowledge the generous support of the Graduate School Chulalongkorn University for Graduate Studies for providing the Student Research Support Grant [Student Research Support Grant 3/2564. Date: September 17, 2021] for this research. The authors would like to thank the public schools in Phrae Province for permitting the collection of data, the respondents for dedicating time to answering the questions, and the parents of respondents for allowing their children to participate in this study. The authors are also grateful to all those who have supported and contributed to this study.

REFERENCES

1. UNICEF Thailand Country Office. A situation analysis of adolescents in Thailand 2015-2016. [Internet]. [Cited 2020 Dec 20]. Available from: https://www.unicef.org/thailand/sites/unicef.org.thailand/files/2018-08/adolescent-situation-analysis-thailand-en.pdf.
2. National Statistical Office of Thailand. Number and percentage population from registration record by age group (child age, working age, old age) sex region and province year: 2012–2021. [Internet]. [Cited 2020 Dec 20]. Available from: http://statbbi.nso.go.th/staticreport/page/ sector/en/01.aspx.
3. West R, Shiffman S. Smoking cessation. Third edition. Abingdon: Health Press. 2016.
4. Ninkron P, Yau S, Noosorn N. Predictors of smoking initiation among Thai adolescents from low-income backgrounds: A case study of Nakhon Pathom low-cost housing estates. Tob Induc Dis. 2022;20:21. doi: 10.18332/tid/145143.
5. Ali FRM, Agaku IT, Sharapova SR, Reimels EA, Homa DM. Onset of Regular Smoking Before Age 21 and Subsequent Nicotine Dependence and Cessation Behavior Among US Adult Smokers. Prev Chronic Dis. 2020;17:E06. doi: 10.5888/pcd17.190176.
6. Centers for Disease Control and Prevention. Preventing tobacco use among young people: a report of the Surgeon General (Executive Summary). MMWR. 1994;43(4):4–6.
7. Harvey J, Chadi N. Preventing smoking in children and adolescents: Recommendations for practice and policy. Paediatr Child Health. 2016; 21(4):209-21. doi: 10.1093/pch/21.4.209. PMID: 27429575; PMCID: PMC4934164.
8. Jungsomjatepaisal P, Tuaymeerit S. Prevention of Smoking among High School Students in the Situation of the Coronavirus Disease 2019 Epidemic, Nakhon Ratchasima Province. J Health Sci. 2022;31(6):997–1007.
9. Jewpattanakul Y. et al. Complete Report Research Project on the Development of Guidelines for

Preventing and Reducing Smoking in Adolescents through Family and Community Involvement. [Internet]. [Cited December 11, 2020]. Available from: https://www.trc.or.th/trcresearch/pdffiles/ ART%2012/cat12%20(1).pdf
10. National Library of Thailand Cataloging in Publication Data. Report on the situation of tobacco consumption in Thailand 2019. Bangkok: Sintaveekit Printing Limited Partnership. 2020.
11. Community Information Development Group. (BE2561). Quality of Life Report of Phrae People in 2018. Phrae: Phrae Provincial Community Development Office.
12. U.S. Department of Health and Human Services. The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. 2014.
13. Chotbenjamaporn P, Haruhansapong V, Jumriangrit P, Pitayarangsarit S, Agarwal N, Garg R. Tobacco use among thai students: Results from the 2015 global youth tobacco survey. Indian J Public Health. 2017;61(Suppl 1):S40-s6. doi: 10.4103/ijph.IJPH_234_17.
14. Tahlil T, Woodman RJ, Coveney J, Ward PR. The impact of education programs on smoking prevention: a randomized controlled trial among 11 to 14 year olds in Aceh, Indonesia. BMC Public Health. 2013;13:367. doi: 10.1186/1471-2458-13-367.
15. Guo SE, Chen MY, Okoli C, Chiang YF. Effectiveness of Smoking Prevention Programs on the Knowledge, Attitudes, and Anti-Smoking Exposure Self-Efficacy among Non-Smoking Rural Seventh-Grade Students in Taiwan. Int J Environ Res Public Health. 2022;19(15). doi: 10.3390/ijerph19159767.
16. Palacheewa N, Tiansawad S, Srisuphan W, Whattananarong K, Duffy SA. Development of an Internet-based Smoking Prevention Program for Young Male Adolescents in Thailand. PRIJNR 2014;18(3):228–43.
17. Pentz MA, Hieftje KD, Pendergrass TM, Brito SA, Liu M, Arora T, et al. A videogame intervention for tobacco product use prevention in adolescents. Addict Behav. 2019;91:188-92. doi: 10.1016/j.addbeh.2018.11.016.
18. Hieftje KD, Fernandes CF, Lin IH, Fiellin LE. Effectiveness of a web-based tobacco product use prevention videogame intervention on young adolescents' beliefs and knowledge. Subst Abus. 2021;42(1):47-53. doi: 10.1080/08897077.2019.1691128.
19. Bteddini DS, LeLaurin JH, Chi X, Hall JM, Theis RP, Gurka MJ, et al. Mixed methods evaluation of vaping and tobacco product use prevention interventions among youth in the Florida 4-H program. Addict Behav. 2023;141:107637.
20. Gee J.P. What video games have to teach us about learning and literacy. Palgrave Macmillan. 2007.
21. Parisod H, Pakarinen A, Axelin A, Löyttyniemi E, Smed J, Salanterä S. Feasibility of mobile health game "Fume" in supporting tobacco-related health literacy among early adolescents: A three-armed cluster randomized design. Int J Med Inform. 2018;113:26-37. doi: 10.1016/j.ijmedinf.2018.02.013.
22. Rosenstock IM The health belief model: Explaining health behavior through expectancies. In:Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: Theory, Research, and Practice. Jossey-Bass. 1990.

23. Champion VL, Skinner CS. The health belief model. In: Glanz K, Rimer BK, Viswanath K, editors. Health behavior and health education: Theory, Research, and Practice. 4th ed. Jossey-Bass. 2008.