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Original Research

Enhancing Adolescent Nutrition Knowledge Through Digital Innovation: Evaluating the Effectiveness of E-Pocket Books in Reducing Obesity

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ABSTRACT

Background: Balanced nutrition education is an essential effort in preventing obesity, especially in adolescents who are vulnerable to nutritional problems due to unhealthy diets and a lack of knowledge. This study aims to determine the effectiveness of Android-based e-pocket books in improving the understanding of balanced nutrition among adolescents in Yogyakarta. **Methods:** This study employed an experimental design with control groups, utilizing pre-tests and post-tests. Conducted from February to March 2023 in a high school in Yogyakarta, Indonesia, the research established a minimum sample size of 27 students per group through the Lemeshow formula and multistage sampling. Inclusion criteria required students to have Android phones, to consent to participate, to attend the study, and to complete data collection. The treatment group received education via e-pocket-book media, while the control group used e-leaflets. Knowledge was measured at three points: before the intervention, immediately after (post-test 1), and nine days later (post-test 2). Data analysis was performed using the Wilcoxon and Mann-Whitney tests with SPSS software. **Results:** The knowledge score of the treatment group increased from 76.3 (pre-test) to 93.8 (post-test 1) and 91.3 (post-test 2). The control group increased from 73.8 (pre-test) to 82.5 (post-test 1) and 81.3 (post-test 2). The increase in knowledge was more significant in the treatment group, showing that e-pocket-books were more effective than e-leaflets. **Conclusion:** Android-based e-pocket-books improve adolescents' knowledge of balanced nutrition more than e-leaflets. Digital technology in nutrition education has great potential to be applied in schools. Further research is needed to evaluate the long-term impact on nutritional behavior.

Keywords: Nutritional sciences; adolescent; e-pocket book; balanced nutrition; nutrition knowledge; digital education

1. INTRODUCTION

Indonesia is currently grappling with a significant public health challenge known as the triple burden of malnutrition, which includes undernutrition, micronutrient deficiencies, and overnutrition. This complex issue reflects the coexistence of undernutrition (such as stunting and being underweight) and overnutrition (such as overweight and obesity) within the same population, households, or individuals. The 2022 Indonesia Nutrition Status Survey highlights the severity of this problem, reporting that 21.6% of toddlers are stunted, indicating chronic malnutrition and impaired growth. Additionally, 17.1% of toddlers are underweight, reflecting a lack of adequate nutrition, while 3.5% are overweight, pointing to issues related to excess calorie intake.[1]

The nutritional status of adolescents is closely linked to their childhood nutritional experiences, underscoring the long-term impact of early dietary deficits or excesses.[2] According to the 2018 Basic Health Research survey, the prevalence of stunting among Indonesian adolescents is alarmingly high, with 25.7% of those aged 13–15 years and 26.9% of those aged 16–18 years affected. Furthermore, obesity rates among adolescents are also concerning, with 16.0% of those aged 13–15 years and 13.5% of those aged 16–18 years classified as obese.[3] These figures suggest that nutritional problems are not confined to any single age group but are a pervasive issue affecting children and adolescents.

In 2018, Yogyakarta emerged as one of the provinces in Indonesia with a higher prevalence of overweight and obesity compared to the national average, highlighting regional disparities in the nutritional landscape. Specifically, Yogyakarta City stands out as the area with the highest prevalence of obesity among its five districts, with a staggering rate of 40.15%.[4] This indicates a critical need for targeted nutritional interventions in urban areas, where lifestyle factors such as diet, physical activity, and access to healthy food options may contribute significantly to the observed trends. Addressing these challenges requires a comprehensive approach that includes preventive measures, public education, and tailored interventions to tackle the distinct aspects of the triple burden of malnutrition in Indonesia.[5]

In addition to obesity and being underweight, anaemia remains a critical public health issue affecting diverse populations globally. The World Health Organization (WHO) estimates that approximately 37% of pregnant women and 30% of women aged 15-49 years worldwide suffer from anaemia, highlighting the widespread nature of this condition.[6] In Indonesia, the 2018 Basic Health Research survey revealed that 48.9% of pregnant women and 32.35% of adolescents are anaemic. This high prevalence of anaemia is further exacerbated by poor adherence to iron supplementation; the survey found that only 38.1% of pregnant women consumed iron tablets despite 73.2% receiving them, and a mere 1.4% of adolescents took iron tablets from the 76.25% who were provided with them3. Adolescents, particularly girls, often engage in unhealthy dieting practices driven by the desire to maintain a slim body image, which leads them to restrict nutritious food intake, reduce portion sizes, and adopt other harmful eating behaviours that worsen malnutrition and negatively impact their productivity and overall health.[7]

Technological and economic advancements have also influenced changes in lifestyle, including diet, physical activity, and sleep patterns, contributing to the triple burden of malnutrition. Rapid globalization has increased access to fast food that is high in fat, sugar, salt, and low fibre, coupled with the prevalence of ultra-processed foods.[8] The growing popularity of online food ordering applications, offering various affordable options and promotional discounts with quick delivery times, has significantly boosted consumer demand, especially among teenagers.[9] Additionally, sedentary lifestyles are becoming more common as active modes of transportation like walking, cycling, and public transit are increasingly rare, reducing energy expenditure and contributing to rising obesity rates.[10,11] Poor dietary habits and insufficient physical activity are primary drivers of weight gain and other related health issues.

Education is a critical strategy in preventing worsening nutritional problems among adolescents. However, traditional nutrition education in Indonesia has often fallen short of meeting the specific needs of adolescents, particularly in delivering content that is both relevant and engaging.[12] Conventional methods such as lectures and leaflet distribution tend to be less interactive and ineffective in enhancing adolescents' understanding and awareness of balanced nutrition. Innovative educational approaches that align more closely with the digital inclinations of today's youth are necessary, as current methods do not fully capitalize on the potential of digital engagement. In comparison, previous studies

have demonstrated success with digital media, such as the 'Ibu Sehati' app for anaemia prevention among pregnant women,[13] and 'Resepin' app for adolescent nutrition education,[14] and other digital health initiatives for adolescents.[15,16]

The novelty of this study lies in the use of Android-based e-pocket book media designed specifically for adolescents. This media is equipped with interactive features that support independent learning and encourage digital discussions through WhatsApp groups. Unlike previous digital applications that tend to focus on general counseling or require large application capacity, this e-pocket book is lightweight, easily accessible, and has been validated directly through a feasibility test by the target user. Thus, this study contributes to enriching digital-based nutrition education approaches by providing empirical evidence on the effectiveness of adaptive media aligned with adolescents' digital habits.

This research seeks to address the need for more effective educational tools by evaluating the impact of e-pocket books as an interactive digital medium tailored to adolescents. By focusing on this specific age group and their unique engagement with technology, the study aims to fill the existing lack of targeted digital interventions for nutrition education. This approach is expected to provide actionable insights and evidence that can inform the integration of digital tools in school-based nutrition programs, making them more engaging and effective. Moreover, the findings from this study could serve as a foundation for the broader adoption of technology-driven health education initiatives, which could help reduce obesity rates and improve nutritional outcomes in adolescents over the long term.

2. METHODS

2.1 Study Design and Interventions

This study was a quasi-experimental study with pre- and post-tests with a control group design. Both groups were given different nutrition education media to find out which media was more effective. The media prepared were an e-pocket book for the intervention group and an e-leaflet for the control group. The media were given by downloading the media on their respective Android devices. Each group had WhatsApp groups created to facilitate discussions between students as participants and nutritionists every two days for nine days. The pre-test and post-test scores were measured on the same day as the intervention, while post-test two was carried out nine days after the intervention. Data collection and intervention were carried out during school hours for three days, including research explanations, pre-test data collection, intervention for 120 minutes, and post-test 1 and post-test 2 measurement.

2.2 Media of Education

The media was structured in several stages, including collecting learning materials, designing media, validation testing by experts, repair (if needed), testing, re-validation testing (if needed), and the final step was user testing. Grade categories in the material test and media test are: a) > 4.2 Excellent; b) 3.4–4.2 Good; c) 2.6–3.4 Average; d) 1.8–2.6 Poor; e) ≤ 1.8 unsatisfactory.[17] The material test results were in the good category and the media test was in the excellent category. Next, the user test was conducted to find out whether the media were acceptable. User testing was carried out at Senior High School 11 Yogyakarta because the characteristics of the school were similar to the research sample. The test method used was the System Usability Scale (SUS). The SUS method was chosen because it is easy and fast. Testing with SUS focuses on the user's point of view, so the test results will be the same as what the user experiences.[18] User test results show that the two media created are grade B; Good; Acceptable. However, e-pocket books have a higher value than leaflets.

During the research, participants created a WhatsApp group. The e-pocket book and e-leaflet were sent through the WhatsApp group. Researchers invited participants to download the files that had been sent. The researcher gave an example while asking students to do it together. If anyone experienced problems, they could report it and the researchers would help with the download process until it was successful.

2.3 Setting and time

The research was conducted in March–April 2023 at Senior High School 2 Yogyakarta as the treatment group and Senior High School 4 Yogyakarta as the control group. To validate the questionnaire and the readability of our educational media, we involved Senior High School 11. The three schools have the same characteristics: urban schools and accredited A. The setting selection was based on the severe problem of malnutrition in urban areas in Yogyakarta, especially among female adolescents.

2.4 Subject selection procedures

The Lemeshow formula was used to determine the subject.[19] The sample size was calculated according to Equation 1. The minimum sample size for each treatment group was 27 people, with the selection process detailed in Figure 1.

$$n1 = n2 = \frac{2\delta^2\left[\left(Z1-\frac{\propto}{2}+Z1-\beta\right)\right]^2}{(\pi 1-\pi 2)^2} \text{ ------ (1)}$$

Where:

n: sample size

δ: standard deviation (2.28)

Z1-α/2: significance value 95% (1.64)

Z1-β: significance value 95% (1.96)

μ1 - μ2: difference in score knowledge before and after treatment (2.29).[20]

2.5 Data Collection and Instruments

Adolescent knowledge data was gathered through face-to-face interviews in a classroom, using a 20-question survey that demonstrated a validity score of 0.60 and a reliability score of 0.823. Each question was scored 0 for incorrect answers and 1 for correct answers, with a maximum total score of 100. The e-pocket books and e-leaflets used in the educational interventions underwent feasibility testing by two media and material experts each, using the PSSUQ method, yielding positive results. Media evaluation required a score above 80 to be considered eligible.

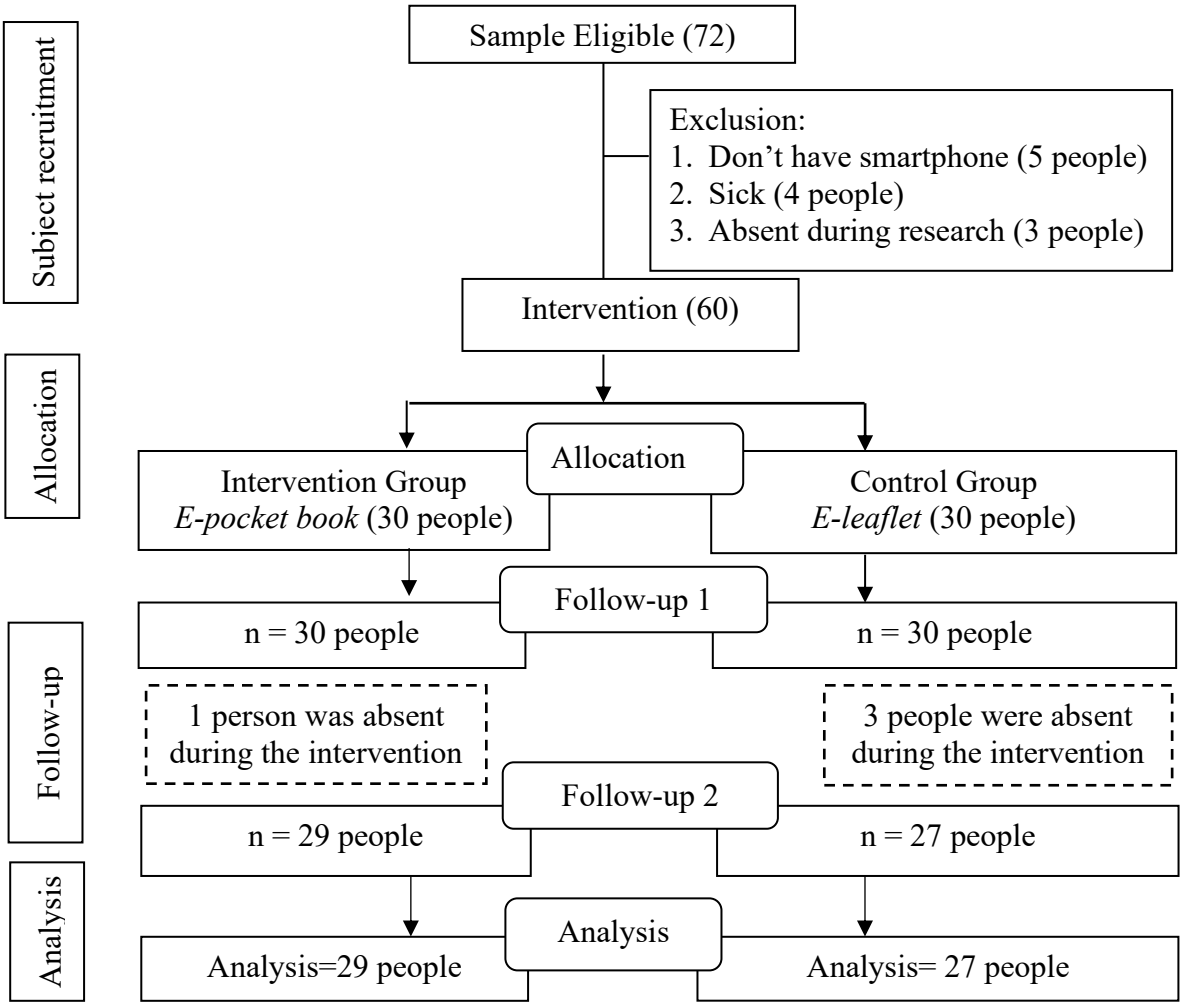

Figure 1. CONSORT Diagram

2.6 Data Analysis

Data were analyzed using the Wilcoxon signed-rank test for within-group comparisons and the Mann-Whitney U test for between-group differences, with $p < 0.05$ set for significance using SPSS-19.

2.7 Ethical Practices

This research was approved by the IRB of Poltekkes Kemenkes Yogyakarta (approval number e-KEPK/POLKESYO/0635/VIII/2022, dated August 24, 2022). Informed consent was obtained through student

assent and parental consent via forms sent home. The researcher provided contact information for any questions. Participant data were kept confidential and anonymized throughout the study.

3. RESULTS

At baseline, there were no significant differences between the intervention and control groups regarding age, gender distribution, or initial nutrition knowledge scores ($p > 0.05$). Both groups were similar, allowing for a fair comparison of the intervention's effects. In detail in the Table 1.

Both the treatment and control groups showed a noticeable increase in adolescent knowledge after the intervention, with the treatment group using the e-pocket book demonstrating a greater improvement in scores compared to the control group using e-leaflets. This suggests that the type of educational media significantly influences adolescents' understanding of balanced nutrition. Figure 2 illustrates the pre-test, post-test 1, and post-test 2 scores, highlighting the e-pocket book's effectiveness in delivering engaging and impactful educational content.

Following the intervention, the median knowledge score in the intervention group increased significantly from 76.3 (IQR: 72.0-80.0) at pre-test to 93.8 (IQR: 90.0-95.0) at post-test 1 ($p < 0.001$). This improvement was sustained at post-test 2, with a median score of 91.3 (IQR: 88.0-94.0), showing a slight, non-significant decrease compared to post-test 1 ($p = 0.068$). In the control group, scores increased modestly from 73.8 (IQR: 70.0-78.0) at pre-test to 82.5 (IQR: 80.0-85.0) at post-test 1 ($p < 0.05$), and slightly decreased at post-test 2 to 81.3 (IQR: 78.0-84.0), with no significant difference from post-test 1 ($p = 0.312$) (Table 2).

Table 1. Characteristics of adolescents

Variable	Group				Total		*p*-value
	Intervention (n=29)		Control (n=27)				
	n	%	n	%	n	%	
Gender							0.485
Male	11	37.9	9	33.3			
Female	18	62.1	18	66.7			
Age (years)							0.070
15	9	31.2	11	40.7	20	35.7	
16	20	68.9	14	51.8	34	60.7	
17	0	0	2	7.5	2	3.6	
Have received balanced nutrition education							0.557
Yes	13	44.8	11	40.7	24	42.9	
No	16	55.2	16	59.3	32	57.1	

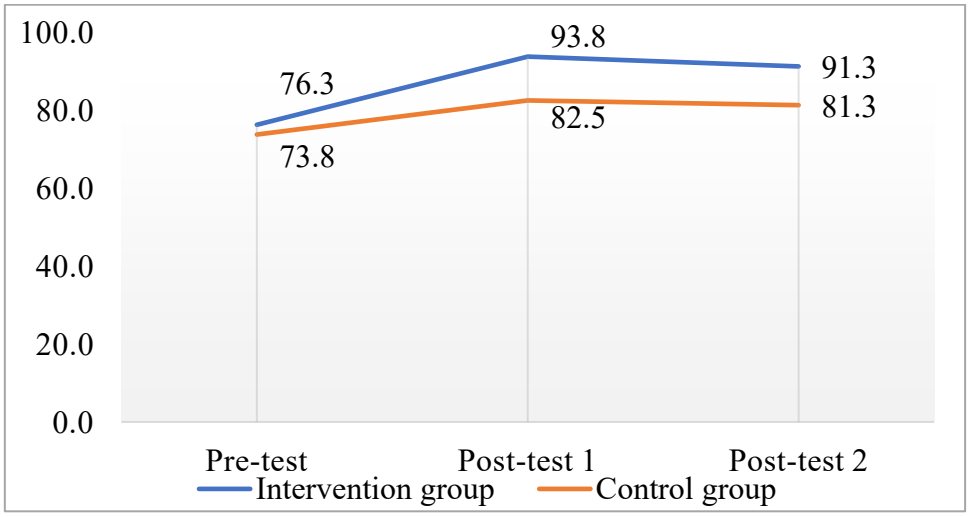

Figure 2. Adolescent knowledge in the intervention and control groups

Table 2. Adolescent knowledge before and after the intervention

Group	$\bar{x}$ ± SD			*p*-scores	
	Pre-test	Post-test 1	Post-test 2	Post-test 1 vs pre-test	Post-test 2 vs pre-test
Intervention	76.±8.30	93.8±5.65	91.3±6.27	< 0.001*	< 0.001*
Control	73.8±15.39	82.5±8.68	81.3±10.68	< 0.001*	< 0.001*
p-scores		< 0.001*	< 0.001*		

Wilcoxon test; **p*-scores < 0.05

When comparing the change in scores between groups, the intervention group showed a significantly greater improvement in knowledge scores compared to the control group from pre-test to post-test 2 ($p < 0.001$), indicating the effectiveness of the e-pocket book intervention over the e-leaflet (Table 3).

4. DISCUSSION

Adolescent health is an essential factor in determining the health and quality of life in the future, so adolescent education is one of the efforts to fulfill the rights of their health and welfare needs.[21] In addition, adolescents are an active group of learners and have high curiosity, so health education interventions in adolescents can provide leverage for success and wide implementation potential in all periods of their lives.[22]

The study's results stated that both treatment groups experienced increased knowledge scores. The increase in knowledge in this study is the result of the interaction between the stimulus provided by the researcher during intervention education and the response of adolescents as participants, such as the Bandura theory. The existence of media supports teenagers' convenience in understanding the educational materials provided. The more senses are involved, the higher the likelihood that science will be absorbed.[23] In this study, the e-pocket book has audio-visual properties while the e-leaflet is visual, so the impact of the intervention with the e-pocket book is higher than the e-leaflet.[24]

Table 3. The effectiveness of media to improve adolescent's knowledge

Group	Mean rank ± SD	
	ΔPost-test 1 – pre-test	ΔPost-test 2 – pre-test
Intervention	35.31±9.17	34.45±9.49
Control	21.19±9.3	22.11±14.04
p-scores	0.001*	0.004*

Mann Whitney test; **p*-scores < 0.05

E-pocket books that are integrated with Android have many benefits, learning materials are concise, informative, and equipped with appropriate images so that they are easy to understand. In this study, the e-pocket book was made by considering the feasibility and needs of adolescents with attractive advantages, ease of installation on Android, small storage memory, helping adolescents to remember, and providing good motivation to learn, as well as interactive between nutritionists and adolescents who use.[25] The results of this study are in line with several previous studies on the use of e-pocket books which are audio-visual as an effective educational tool to increase knowledge about cervical cancer screening,[26] Food sources of protein elements and Fe,[27] and learning about nursing in students.[28]

Unfortunately, the results of the knowledge score in post-test2 in both the treatment and control groups decreased slightly. The intervention in this study was only given once with a short duration, about 120 minutes for 4 materials so that it is possible that adolescents only know or know but do not understand. The tendency of memory decline towards the educational materials provided will continue to increase if adolescents are not motivated to open or learn e-pocket books or e-leaflets that have been given. Naturally, the knowledge gained through educational interventions will decrease over time.[29] Furthermore, adolescents' understanding of balanced nutrition is not comprehensive. Therefore, ongoing assistance and intervention are required to

ensure that teenage nutrition knowledge is retained and used in day-to-day activities.

Adolescent health is a crucial determinant of future health outcomes and quality of life, making adolescent education a key strategy in fulfilling their health and welfare needs. Adolescents, characterized by their active learning habits and high curiosity, are particularly receptive to health education interventions that can significantly impact their behavior and lifestyle choices throughout their lives.[21] Effective education during adolescence addresses immediate knowledge gaps and lays a foundation for long-term health benefits extending into adulthood. The significant increase in knowledge scores observed in both the e-pocket book and e-leaflet groups supports the idea that educational interventions are effective tools for empowering adolescents with essential health information.[30]

The study's results demonstrated that both the treatment (e-pocket book) and control (e-leaflet) groups experienced increased knowledge scores, highlighting the effectiveness of educational interventions in improving adolescent nutrition knowledge. According to Bandura's social cognitive theory, the interaction between the educational stimulus and the participant's response plays a critical role in learning, which was evident in the increased scores across both groups.[31] However, the greater improvement in the e-pocket book group suggests that the multimedia format, which integrates both visual and audio elements, is particularly effective. This finding aligns with the theory that involving multiple senses enhances the absorption and retention of information, making learning more effective.[32] This is evident from the higher post-test scores in the e-pocket book group compared to the e-leaflet group, indicating that multimedia tools may provide a superior learning experience.

The e-pocket book's compatibility with Android platforms provides concise content, relevant images, and easy access, catering to adolescents' preferences for an engaging learning experience. This likely explains the superior outcomes in the treatment group. Additionally, the interactive element between researchers and adolescents may have improved content retention. These findings align with previous studies, indicating that targeted digital media can significantly enhance learning outcomes.[33] The study results showed that the e-pocket book group consistently outperformed the control group, reinforcing the value of interactive and accessible digital education.

The study found a slight decline in knowledge scores at post-test 2 for both groups, indicating that the intervention's effects may not be sustained over time without continued engagement. Conducted just once for 120 minutes and covering four topics, the intervention likely facilitated only surface-level understanding. This decline reflects the natural memory decay when educational material isn't reinforced. Both groups showed reduced scores from post-test 1 to post-test 2, suggesting that sustained learning requires more frequent interactions. The findings emphasize the importance of ongoing support and follow-up to deepen adolescents' understanding of balanced nutrition and encourage practical application of nutritional concepts. Periodic refreshers and reminders are recommended to maintain knowledge retention.[34] Additionally, integrating educational content into routine school curricula or extracurricular activities could help sustain engagement and learning over time.[35]

In summary, the e-pocket book has shown short-term effectiveness as an educational tool, but ongoing interventions can enhance its impact. This study highlights the need for continuous education to maintain adolescents' nutrition knowledge and underscores the role of digital media in this process. The positive results from the e-pocket book group suggest that integrating multimedia elements into health education is beneficial.

Strength and Limitation

The main strength of this study lies in the use of innovative digital educational media which are designed according to the characteristics of adolescents. This media was accessible, saves storage space, have interactive features and has been validated by the target user through a feasibility test. The study also successfully reached participants from high school environments in urban areas with a high prevalence of obesity, making the results relevant and applicable to at-risk populations. In addition, the data collection approach is carried out directly and uses validated and reliable measuring instruments, thereby increasing the credibility of the measurement results. However, this study have some limitations, the intervention was only carried out once with a short duration, so it could not describe the long-term impact on behavior change or knowledge retention of participants. A decrease in scores in the second post-test indicates a possible decline in memory without periodic reinforcement. In addition, the scope of the study was limited to a single city and the number of

samples was relatively small, so generalizing the results to the adolescent population nationally still requires follow-up research with a broader design and longer duration of interventions.

5. CONCLUSION

This study found that e-pocket books effectively enhance nutrition knowledge among adolescents, providing a more engaging alternative to e-leaflets. Their interactive features align with adolescents' learning preferences, improving attention and retention. The findings suggest integrating digital tools into school and community health programs can benefit nutrition education, particularly for underserved populations. Policymakers are encouraged to invest in digital resources and training for educators, while health practitioners are advised to use multimedia tailored to adolescents for lasting behavior change. Future research should investigate the long-term effects of e-pocket books and their application in various settings, potentially alongside other interventions to enhance engagement.

Ethical Approval

This research was approved by the IRB of Poltekkes Kemenkes Yogyakarta (approval number e-KEPK/POLKESYO/0635/VIII/2022, dated August 24, 2022).

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Competing Interests

All the authors declare that there are no conflicts of interest.

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No funds were received for this study.

Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

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