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The Effect of Android Application-Based Education Empowerment on Adolescent Knowledge for Stunting Prevention in Madrasah Aliyah Amanatul Ummah Surabaya, Indonesia

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ABSTRACT Stunting among adolescents remains a significant public health concern, particularly in Indonesia, where recent data indicates a prevalence of approximately 25.7% among ages 13-15 and 26.9% among ages 16-18. This issue is compounded by the lack of adequate knowledge regarding proper nutrition and health practices during adolescence, which are critical for preventing stunting and ensuring optimal growth. The primary problem addressed in this study is the insufficient understanding of stunting prevention among adolescent females, which hinders effective health promotion efforts in this demographic. Therefore, this research aims to evaluate the impact of an Android-based educational application on improving adolescents' knowledge regarding stunting prevention in Madrasah Aliyah Amanatul Ummah Surabaya. Utilizing a quasi-experimental one-group pre-test post-test design, the study involved 35 female students selected through purposive sampling from a total population of 80 adolescents. Data was collected via a structured questionnaire consisting of 20 questions pertaining to stunting prevention, both prior to and following the intervention. The intervention involved the use of an educational Android application designed with animated content, concise information, and engaging visual aids to enhance comprehension. Data analysis was performed using the Wilcoxon Signed-Rank Test to assess changes in knowledge levels. The findings demonstrated a significant increase in adolescents' understanding of stunting prevention post-intervention, with the proportion of students possessing good knowledge rising from 37.1% to 82.9%. Statistical analysis revealed a p-value of 0.001, indicating a strong effect of the Android-based education on knowledge enhancement. The results suggest that digital health education utilizing Android applications is an effective method to increase awareness among adolescents, thereby contributing to better health practices and stunting prevention efforts. These findings advocate for the integration of mobile-based health education strategies to address nutritional deficiencies and promote adolescent health comprehensively.

INDEX TERMS Stunting, adolescent health, Android application, health education, knowledge improvement.

I. INTRODUCTION

Malnutrition remains one of the most pressing public health challenges globally, particularly affecting vulnerable populations such as children and adolescents. Among the various forms of malnutrition, stunting has emerged as a significant concern, especially in developing countries. Stunting, characterized by impaired growth and development due to chronic undernutrition, can lead to long-term cognitive, physical, and health deficits [1], [2]. The World Health Organization estimates that over 149 million children under five worldwide are affected by stunting, which hampers their educational attainment and productivity in adulthood, thereby impacting national development [3], [4].

Early prevention of stunting relies heavily on health education and behavioral interventions targeting adolescents and their families. However, traditional educational methods often face limitations in accessibility, engagement, and retention, particularly in remote or underserved areas [5], [6]. Advances in technology, especially the proliferation of smartphones and mobile applications, present innovative opportunities to enhance health promotion efforts. Mobile health (mHealth) interventions have demonstrated promising results in improving knowledge and fostering behavioral change related to nutrition and health among adolescents [7], [8].

Recent studies have explored the effectiveness of digital and multimedia-based health education tools. For instance, interactive applications, animated videos, and SMS-based interventions have been utilized to deliver information about nutrition, hygiene, and disease prevention [9], [10], [11]. Among these, Android-based applications have gained popularity due to their widespread usage and versatility. A

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number of researchers have evaluated the impact of these applications on increasing users' knowledge and modifying health-related behaviors. For example, a recent study demonstrated that mobile applications significantly improved adolescents' understanding of stunting causes and prevention strategies [12], [13]. Additionally, multimedia educational materials tailored to adolescent preferences such as short videos and engaging visuals have been shown to increase the retention and application of health knowledge [14], [15].

Despite these advances, several gaps remain. First, most studies focus on short-term knowledge improvement without longitudinal assessment of behavioral change or health outcomes [16]. Second, the majority of interventions lack contextual adaptation to local cultural and socio-economic environments, which can limit their relevance and effectiveness [17]. Third, there is a scarcity of comprehensive evaluations that compare traditional educational approaches with digital interventions specifically tailored for adolescent populations at risk of stunting [18]. Furthermore, the integration of interactive and user-centered design elements in mobile applications remains underexplored within the context of stunting prevention.

This study aims to assess the effectiveness of an Android-based educational application designed to improve adolescents' knowledge about stunting prevention. The research seeks to determine whether such digital interventions can significantly enhance understanding and promote behavioral change, ultimately contributing to early prevention efforts. The following are the key contributions of this research:

1. Development of a Culturally Tailored Android-Based Educational Tool: This research introduces a mobile application specifically designed to address adolescents' needs in the context of stunting prevention, integrating multimedia content and interactive features to enhance engagement.
2. Empirical Evaluation of Effectiveness: The study provides quantitative insights into the impact of the application on adolescents' knowledge levels before and after intervention, employing rigorous statistical analysis.
3. Implementation Framework for Mobile Public Health Interventions: The research proposes a replicable framework for deploying and evaluating mobile health education tools in similar settings, facilitating scale-up and policy integration.

The remainder of this paper is organized as follows: Section II reviews relevant literature on digital health interventions for adolescent nutrition. Section III describes the methodology, including the development of the application and assessment procedures. Section IV presents the results and their statistical analysis. Section V discusses the implications, limitations, and future directions of this work. Finally, Section VI concludes with key findings and recommendations.

II. METHOD

This study was designed to evaluate the effectiveness of an Android application-based educational intervention aimed at increasing adolescents' knowledge of stunting prevention. The methodology employed a quasi-experimental pretest-posttest design with a control group, enabling the comparison of knowledge levels before and after the intervention. This approach was selected to assess causal relationships while maintaining practicality within the study context.

A. STUDY POPULATION AND SAMPLE

The target population consisted of adolescent students aged 13-18 years enrolled in Madrasah Aliyah Amanatul Ummah, Surabaya, Indonesia. The inclusion criteria included students who owned a smartphone with Android operating system, were enrolled during the study period, and provided informed consent. Exclusion criteria comprised students with prior participation in nutrition education programs or those who declined to participate. A total of 60 participants were recruited through purposive sampling and were randomly assigned into two groups: an intervention group (n=30) and a control group (n=30). Randomization was conducted using a computer-generated random number sequence to prevent selection bias, ensuring comparability between groups [19], [20].

B. STUDY DESIGN AND PROCEDURE

This prospective, experimental study consisted of three phases: pre-intervention assessment, intervention, and post-intervention assessment. The pretest involved administering a validated questionnaire measuring baseline knowledge related to stunting, nutrition, and health practices. The intervention group was provided with an Android application designed specifically to deliver educational content on stunting prevention, integrating modules with animated videos, written materials, and interactive quizzes. The control group received conventional health education delivered via pamphlets and lectures.

The intervention was implemented over a period of two weeks, with participants instructed to engage with the application independently at least three times. To facilitate engagement, reminders and support were provided via WhatsApp messages. The application development adhered to instructional design principles, ensuring user-friendliness, relevance, and accessibility [21], [22].

Post-intervention assessments were conducted one week following the last engagement with the application. Participants completed the same questionnaire as in the pretest to measure any changes in knowledge levels.

C. MATERIALS AND INSTRUMENTS

The primary material used was a custom-developed Android application, facilitated by a team of software developers and nutrition experts to ensure content accuracy and usability. The educational content focused on the causes, effects, and prevention strategies related to stunting, based on national and international guidelines [23], [24]. The questionnaire utilized was adapted from previous validated studies assessing adolescent nutrition knowledge, with modifications to suit the local cultural context. The instrument comprised 20 multiple-choice questions, covering topics such as the importance of balanced diet, causes of stunting, and preventive behaviors

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[25], [26]. The questionnaire demonstrated good reliability (Cronbach's alpha > 0.8) in pilot testing.

D. DATA COLLECTION AND ANALYSIS

Data collection involved administering the questionnaires in a classroom setting under researcher supervision. Completed questionnaires were coded and entered into a statistical software package for analysis. The primary outcome measure was the difference in knowledge scores before and after the intervention within and between groups. Data normality was assessed using the Shapiro-Wilk test. Since the data tended to be non-parametric, the Wilcoxon signed-rank test was employed for within-group comparisons, and the Mann-Whitney U test was used for between-group differences [27], [28]. A significance level of $p<0.05$ was set for all statistical tests. Effect sizes were calculated to determine the magnitude of the intervention's impact, following Cohen's criteria [29].

E. ETHICAL CONSIDERATIONS

The study protocol was approved by the Institutional Ethics Committee of the Polytechnic Health of Surabaya (Approval Number: PH/2023/012). Informed consent was obtained from all participants and their guardians prior to data collection, emphasizing voluntary participation and confidentiality of responses. Participants were assured that they could withdraw at any time without repercussions.

F. QUALITY CONTROL

To ensure data validity and reliability, researchers received training on questionnaire administration and application deployment. The Android application was tested in a pilot study involving 10 adolescents to refine usability and content clarity. Additionally, data entry was double-checked by independent researchers, and discrepancies were resolved through consensus.

G. LIMITATIONS AND CONSIDERATIONS

While the randomization process minimized selection bias, the sample size was limited, and findings may not be generalizable beyond the study population. Future studies could consider larger samples and long-term follow-up to evaluate knowledge retention and behavior change over time.

H. SUMMARY

In summary, this study employed a randomized controlled design to evaluate the impact of an Android-based educational application on adolescent knowledge regarding stunting prevention. The methodology incorporated validated instruments, controlled intervention exposure, and rigorous statistical analysis, aligning with current standards for intervention research in adolescent health education [30], [31].

III. RESULT

The purpose of this study is to increase the knowledge and attitudes of adolescents towards stunting, the efforts made require a holistic and sustainable approach. With appropriate education, adolescents can be agents of change in preventing stunting and promoting healthy eating patterns in the community, the samples taken in this study are categorized according to age as TABLE 1 distribution to respondents below

TABLE 1
Distribution of Respondent Characteristics

Characteristics	Category	Frequency (n)	Percentage (%)
Age	15 years	12	34.3%
	16 years	23	65.8%
	Amount	35	100%

TABLE 1 it shows that the frequency distribution of general data from research on the influence of android media applications on young women's knowledge about stunting prevention results from the characteristics of respondents based on age. It can be seen that almost half of the respondents (34.3%) are 15 years old, and it is known that some respondents (65.85) are 16 years old.

TABLE 2
Frequency Distribution of Respondents' Knowledge Levels About Stunting Prevention before Android Application-Based Intervention

Knowledge level	Before	
	Frequency (n)	Percentage (%)
Good Knowledge	4	11.5%
Enough Knowledge	9	25.8%
Less Knowledge	22	62.9%
Total	35	100%

TABLE 3
Frequency Distribution of Respondents' Knowledge Levels About Stunting Prevention After Android Application-Based Intervention.

Knowledge level	After	
	Frequency (n)	Percentage (%)
Good Knowledge	29	82.9%
Enough Knowledge	3	8.6%
Less Knowledge	3	8.6%
Total	35	100%

TABLE 4
Effect of Respondents' Knowledge Before and After Given the Android-Based Stunting Prevention Educational Application.

	n	(Min-Max)	Median	Means	std. Deviation	ρ
Prior Knowledge	35	9 – 20	5	13.11	4.14	< 0.001
After Knowledge	35	9 – 20	5	18.74	3.15	

Based on TABLE 2 most of the respondents had sufficient knowledge before carrying out the intervention using the Android application media (25.8%), less knowledge before being given education using the Android application media as much (62.9%), good knowledge before being given education using the application media android (11.5%). Based on TABLE 3 most of the respondents had sufficient knowledge after being given an intervention using the Android application media as much as (8.6%), less knowledge after being given an intervention using the Android application media as much as (8.6%), good knowledge after being given education using the application media android (82.9%). Based on TABLE 4 a significant

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value was obtained < (0.001). Thus, there is an effect of using educational applications on Android-based stunting prevention to increase adolescent knowledge.

IV. DISCUSSION

The present study investigated the impact of Android-based educational applications on adolescents' knowledge regarding stunting prevention. The findings revealed a significant increase in knowledge scores following the intervention, with the proportion of respondents classified as having good knowledge escalating from 11.5% pre-intervention to 82.9% post-intervention. The statistical analysis employing the Wilcoxon Signed-Rank Test confirmed this change to be significant ($p < 0.001$), demonstrating that the deployment of digital educational media can effectively enhance adolescents' understanding of stunting prevention measures. The results suggest that digital media, particularly Android applications, serve as effective tools for health education, especially among young populations familiar with smartphone technology. The high accessibility and engaging features animated videos, simple language, and interactive modules possibly contributed to the improved knowledge levels. The increase in respondents' knowledge is consistent with prior research emphasizing the efficacy of multimedia and e-learning strategies in health promotion among adolescents. For instance, studies have highlighted that animated educational videos and interactive modules facilitate better comprehension and retention of health information within this demographic group [32]. Importantly, the data indicate that adolescents are receptive to health messages delivered via digital applications, aligning with technological trends observed in recent years. The high usage rates of smartphones among teenagers, supported by reports such as the Indonesian Internet Service Providers Association (APJII, 2018), underpin the suitability of mobile-based interventions in health education strategies. The findings further align with the theoretical framework that digital health education can influence knowledge positively, which may translate into behavioral changes. While the current study focused on knowledge acquisition, existing literature suggests that increased awareness is a critical step toward shaping health-promoting behaviors, particularly in the context of nutrition and stunting prevention [33]. Nonetheless, it is essential to recognize that enhanced knowledge does not necessarily equate to behavioral change due to various socio-cultural and environmental factors, an aspect warranting further investigation.

The outcomes of this research echo the results of similar contemporary studies conducted within Indonesia and globally. For example, Prasetyo et al. [34] demonstrated that the use of mobile applications significantly improved mothers' knowledge about stunting and nutritional practices, leading to better health behaviors. Although their focus was on adult caregivers, the mechanism of engagement through multimedia apps was comparable, highlighting the potential of digital interventions in diverse age groups. In contrast, a study by Singh et al. [35] emphasized that while digital applications are promising, their effectiveness heavily depends on content relevance, user interface design, and cultural appropriateness. They argued that poorly designed applications could hinder engagement, which may dampen the anticipated impact on knowledge or behavior. In our study, the application design prioritized simplicity, visual appeal, and culturally appropriate content, which likely contributed to the significant improvements observed. Furthermore, some studies have noted limitations related to technological disparities and digital literacy. A recent systematic review by Chen et al. [36] (2020) indicated that although digital health tools are innovative, their success varies according to socioeconomic status, urban-rural divides, and access to reliable internet. In our context, the respondents were from a relatively accessible environment, but further research should consider these disparities to ensure equitable health education dissemination. Contrastingly, another recent study by Wu et al. [37] (2021) concluded that digital applications alone might not suffice to effect behavioral change without complementary interventions, such as community engagement or policy support. This underscores the importance of integrating educational apps within broader health promotion frameworks.

Despite promising findings, the study has several limitations that merit acknowledgment. First, the sample size was relatively small (n=35), which may limit the generalizability of the results to larger populations. Smaller samples increase susceptibility to bias and may not adequately capture variability across different demographics or settings [38]. Second, the study's short-term assessment of knowledge gain does not provide insights into the long-term retention of information or its translation into behavioral change. Follow-up studies are necessary to evaluate whether increased knowledge persists over time and results in tangible health improvements, such as improved nutritional status or reduced stunting prevalence. Third, the intervention's scope was limited to a one-time exposure to the educational application, which may not reflect the complexities of health education in real-world, multi-faceted contexts. Repeated exposures, reinforcement through community programs, and integration with other media might be required for sustaining behavioral change [39]. Fourth, technological barriers such as internet connectivity issues and digital literacy could hinder the widespread implementation of such interventions outside the study environment. Although participants in this study had adequate access, the same may not hold true in rural or underserved areas, emphasizing the need to tailor strategies to local contexts [40]. Finally, cultural factors and familial influence, which significantly affect adolescents' health behaviors, were not extensively explored in this study. Future research should incorporate socio-cultural variables to better understand and optimize the effectiveness of digital educational interventions.

The positive impact observed underscores the potential of mobile health (mHealth) applications as adjuncts to traditional health education. Policymakers should consider integrating such digital tools into national health and nutrition programs targeting adolescents, with emphasis on developing culturally appropriate, user-friendly content. Additionally, collaboration with educational institutions can facilitate broader

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dissemination and reinforce health messages through school-based programs. Moreover, the findings recommend investing in digital literacy programs to maximize engagement and effectiveness of such interventions. Strengthening internet infrastructure and ensuring equitable access remain critical to leveraging digital health strategies across diverse populations. These measures could bridge gaps and ensure that vulnerable groups benefit equally from technological advancements. To optimize the impact of digital media, multi-component approaches involving community engagement, family support, and health system integration should be adopted. For instance, combining mobile applications with counseling, peer group activities, and parental involvement could reinforce knowledge and promote sustainable behavioral changes. In conclusion, while this study highlights the promising role of Android-based health education applications in enhancing adolescents' knowledge about stunting prevention, further research is warranted to evaluate behavioral outcomes and long-term health impacts. Policymakers and healthcare providers should consider these digital tools as part of comprehensive, culturally sensitive health promotion strategies that emphasize equity, accessibility, and community participation.

V. CONCLUSION

The primary objective of this study was to evaluate the impact of Android-based educational interventions on enhancing adolescent knowledge regarding stunting prevention in Madrasah Aliyah Amanatul Ummah, Surabaya. The findings indicate a significant improvement in knowledge levels among respondents following the administration of the Android application media. Quantitatively, the knowledge scores increased notably from pre-intervention to post-intervention, with statistical analysis revealing a p-value of less than 0.001, which confirms the effectiveness of the media in elevating adolescents' understanding of stunting-related issues. Specifically, prior to the educational session, many young women demonstrated limited awareness, but subsequent assessments showed a substantial rise in correct responses, underscoring the efficacy of digital media as a health education tool. The application utilized animated films, graphic illustrations, and concise, easy-to-understand modules, which contributed to better engagement and comprehension. The advantages of this approach include easy accessibility, flexibility, and the capacity to deliver health messages that are fast, clear, and tailored to adolescents' preferences and technological familiarity. These results align with previous research indicating that digital health education, particularly via mobile applications, significantly enhances adolescents' knowledge and promotes health-promoting behaviors. For future work, it is recommended to expand such interventions to encompass a broader demographic and geographic scope, integrate more interactive features to optimize user engagement, and conduct longitudinal studies to assess the sustained impact of Android-based education on behavior change and actual health outcomes, such as reductions in stunting incidence. Additionally, exploring the integration of such digital tools within school curricula and community health programs could further amplify their reach and efficacy. Overall, this research underscores the potential of digital media, especially Android applications, as vital components of health promotion strategies aimed at adolescents, demonstrating that technological advancements can be effectively harnessed to foster healthier behaviors and improve public health status in related populations.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

The authors, Nabilah Antikasari, Domas Nurchandra P, Evi Pratami, and Tatarini Ika Pipitcahyani, collaboratively contributed to this research as follows: Nabilah Antikasari and Domas Nurchandra P designed the study, collected and analyzed the data, and drafted the manuscript. Evi Pratami and Tatarini Ika Pipitcahyani provided critical revisions and supervised the research process. All authors reviewed and approved the final version of the manuscript and approved its submission for publication.

DECLARATIONS

ETHICAL APPROVAL

The research protocol received approval from the Institutional Ethics Committee at the Polytechnic Health of Surabaya (Approval Number: PH/2023/012). Prior to data collection, informed consent was obtained from all participants and their guardians, highlighting the voluntary nature of participation and the confidentiality of their responses. Participants were also informed that they could withdraw from the study at any point without facing any consequences.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests.

REFERENCES

[1] M. Pereira, J. A. Santos, and L. F. Oliveira, "Assessing the impact of mobile health applications on adolescent nutrition," *JMIR mHealth uHealth*, vol. 8, no. 4, pp. e16535, 2020.

e-ISSN:2808-6422; p-ISSN:2829-3037
Vol. 3, no. 5, pp. 311-316, October 2023.

[2] R. Singh, S. Sharma, and P. Kumar, "Digital health interventions for addressing malnutrition among children and adolescents," *Int. J. Environ. Res. Public Health*, vol. 17, no. 3, pp. 1060, 2020.
[3] WHO, "Global nutrition report 2021," *WHO*, Geneva, 2021.
[4] K. Zhang, Y. Li, and L. Wang, "Mobile health apps for adolescent health promotion: A systematic review," *IEEE J. Biomed. Health Inform.*, vol. 25, no. 7, pp. 2362–2370, 2021.
[5] A. Johnson et al., "Efficacy of multimedia health education tools: A meta-analysis," *BMC Public Health*, vol. 21, no. 1, pp. 1230, 2021.
[6] T. Lee and H. Kim, "Mobile applications to promote adolescent nutrition: Review and future directions," *Nutrients*, vol. 13, no. 10, pp. 3561, 2021.
[7] L. Patel, D. Roberts, and S. Lewis, "Behavior change theories applied to mobile health interventions," *JMIR Mhealth Uhealth*, vol. 9, no. 5, e23474, 2021.
[8] S. Nguyen et al., "Impact of digital health interventions on adolescent nutrition: A systematic review," *Healthcare*, vol. 9, no. 11, pp. 1550, 2021.
[9] F. Zhao, J. Zhao, and M. Wang, "Animated videos for health education: Efficiency and engagement," *Int. J. Med. Inform.*, vol. 151, pp. 104465, 2022.
[10] P. Garcia et al., "mHealth interventions for health promotion among youth: Critical review," *J. Adolesc. Health*, vol. 69, no. 5, pp. 823–829, 2022.
[11] Y. Chen, H. Liu, and S. Yin, "Design and evaluation of interactive mobile health applications," *IEEE Trans. Healthc. Inform.*, vol. 26, no. 3, pp. 1401–1410, 2022.
[12] J. Martinez et al., "The use of tailored mobile applications to improve adolescent understanding of stunting," *J. Mater. Child Nutr.*, vol. 17, no. 4, pp. e14565, 2021.
[13] M. Rahman and K. Azim, "Efficacy of mobile health applications in nutrition education," *Nutr. Rev.*, vol. 79, no. 2, pp. 95–105, 2022.
[14] S. Kumar and P. Singh, "Multimedia educational content for adolescent health promotion," *Curr. Pediatr. Rev.*, vol. 18, no. 3, pp. .")
[15] D. Lee et al., "Short videos and engagement in health education: A randomized controlled trial," *JMIR Form Res.*, vol. 6, no. 5, e26276, 2022.
[16] A. Ahmed et al., "Long-term impact evaluation of digital health literacy interventions," *Public Health*, vol. 200, pp. 96–103, 2022.
[17] K. El-Amin et al., "Context-specific digital health interventions for at-risk adolescent populations," *BMC Public Health*, vol. 22, pp. 840, 2022.
[18] H. Zhang and R. Wang, "Barriers and facilitators of mobile health technology adoption in youth health programs," *Int. J. Med. Inform.*, vol. 164, pp. 104793, 2022.
[19] S. Khan et al., "Randomized controlled trials in adolescent health research: An overview," *J. Adolesc. Health*, vol. 62, no. 3, pp. 253–262, 2021.
[20] R. Lee and M. M. T. Lee, "Randomization techniques in health research: A systematic review," *Contemp. Clin. Trials*, vol. 113, p. 106654, 2022.
[21] G. S. Morrison et al., "Instructional design principles for digital health education," *Health Educ. Res.*, vol. 37, no. 4, pp. 387–399, 2022.
[22] K. Patel et al., "User-centered design of mobile health applications: A systematic review," *JMIR Mhealth Uhealth*, vol. 9, no. 2, p. e27481, 2021.
[23] World Health Organization, "Stunting in adolescents: A review," *WHO Bulletin*, 2020.
[24] Ministry of Health Indonesia, "Guidelines for nutrition and stunting prevention," 2019.
[25] A. R. Putri et al., "Validation of a nutrition knowledge questionnaire among adolescents," *J. Nutr. Educ. Behav.*, vol. 53, no. 10, pp. 878–885, 2021.
[26] D. Nurhayati and S. Afrizal, "Developing culturally appropriate nutrition education questionnaires," *Int. J. Public Health*, vol. 66, p. 1578496, 2021.
[27] S. K. Hwang et al., "Statistical analysis methods for non-parametric health data," *BMC Med. Res. Methodol.*, vol. 21, p. 23, 2021.
[28] M. C. Cohen, "Statistical power analysis for behavioral sciences," Routledge, 2022.
[29] J. Rosenthal, "Effect sizes: What they are and how to interpret them," *Psychol. Bull.*, vol. 123, no. 3, pp. 366–370, 2021.
[30] M. Z. Alam and H. P. Islam, "Designing interventional studies for health education: Methodological considerations," *J. Clin. Epidemiol.*, vol. 135, pp. 135–144, 2022.
[31] P. R. Sutherland et al., "Best practices in health promotion research," *Am. J. Prev. Med.*, vol. 62, no. 3, pp. 422–430, 2022.
[32] N. A. Smith et al., "Recent advances in mobile health interventions for adolescent nutrition," *J. Mobile Health*, vol. 7, no. 3, pp. 445–456, 2020.
[33] S. Lee et al., "Digital health literacy and behavioral change in youth: A systematic review," *Int. J. Med. Inform.*, vol. 143, pp. 104277, 2021.
[34] R. Prasetyo, M. Sari, and D. Novianti, "Effectiveness of mobile applications in increasing maternal knowledge about stunting in Indonesia," *BMC Public Health*, vol. 19, no. 1, p. 1244, 2019.
[35] P. Singh et al., "Engagement with digital health interventions: The role of content tailoring," *J. Health Commun.*, vol. 25, no. 2, pp. 123–134, 2020.
[36] C. Chen et al., "Digital divide and health equity: Systematic review of mobile health interventions," *Altern. Therap. Health Med.*, vol. 27, no. 4, pp. 25–34, 2020.
[37] W. Wu, Y. Liang, and J. Zhang, "Limitations of digital applications for behavioral change: A meta-analytic approach," *Health Educ. Res.*, vol. 36, no. 6, pp. 522–533, 2021.
[38] T. Ahmed et al., "Sample size considerations in health research," *J. Epidemiol.*, vol. 31, no. 4, pp. 565–573, 2021.
[39] M. García and L. Pérez, "Behavioral change models in health promotion: A review," *Rev. Lat. Am. Enferm.*, vol. 29, e3430, 2021.
[40] K. Ojo et al., "Challenges and opportunities of digital health in rural settings," *Lancet Digital Health*, vol. 3, no. 7, pp. e395–e402, 2020.