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Effectiveness of Mobile Apps and Digital Media Interventions on Knowledge and Anemia-Related Behaviors Among Adolescent Girls in Indonesia

Rani Fitri Pranita[1], Ajeng Mustika[2*]
[1,2]Universitas Pembangunan Nasional "Veteran" Jakarta
*Correspondence: ajengmustika@upnvj.ac.id
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Abstract: Anemia among adolescent girls is a significant public health problem in Indonesia. The development of digital technology and the widespread use of smartphones have created opportunities for nutrition education through mobile apps and digital media. This article reviews the evidence gathered over the past ten years (2014-2024) regarding the effectiveness of digital interventions in enhancing knowledge, changing behaviors, and improving hemoglobin (Hb) levels in adolescent girls. This study aims to assess and summarize the effectiveness of the existing literature on anemia education delivered via mobile applications and digital media targeted at adolescent girls in Indonesia. The methodology employed was a narrative review by searching scientific articles through Google Scholar, the Garuda Portal, and PubMed platforms. The narrative review included 14 articles and highlighted the variations in the use of digital media and applications for anemia education. The results revealed that digital interventions consistently improved knowledge and attitude about anemia, and increased adherence to iron tablet consumption in several studies ($p<0.05$). However, evidence concerning changes in Hb levels varied significantly. In conclusion, digital education is an effective means of enhancing knowledge and can improve behavior when combined with iron supplementation and monitoring strategies.

Keywords: Anemia, adolescent girls, knowledge, digital education, mobile applications, Indonesia

1. INTRODUCTION

Iron deficiency anemia is one of the major nutritional problems among adolescent girls in Indonesia. According to the World Health Organization (WHO, 2023), the prevalence of anemia among women aged 15–49 years is around 30.7%, with the rate of anemia among non-pregnant women in this age group at 30.5%, reflecting that it remains a global issue with a high prevalence in developing countries. In Indonesia, data from the 2018 National Health Survey (Riskesdas) confirms that the prevalence of anemia reaches 32% in the 15–24 age group, meaning that nearly one in three adolescent girls in Indonesia suffers from anemia.

The 2023 Indonesian Health Survey (SKI) indicates a positive trend, showing a decrease in the prevalence of anemia among individuals aged 15 to 24, now at 15.5% (Ministry of Health, 2024). Despite this significant decline, anemia in adolescent girls remains a pressing issue. Its short-term effects can weaken immunity, reduce physical productivity, and impair cognitive abilities, which may hinder academic performance and

increase the risk of complications in future reproductive health (Yeboah *et al.,* 2024). Moreover, the long-term consequences of anemia can profoundly impact pregnancy, raising the likelihood of premature births and low birth weights (Litaqia & Mulat, 2025).

As part of a national mitigation effort, the Indonesian government has initiated a program to provide iron tablets, known as Weekly Iron-Folic Acid Supplementation (WIFAS), through schools (Ministry of Health, 2020). This program aligns with the WHO's global recommendations (2011), which highlight the importance of weekly iron supplementation in reducing the prevalence of anemia in areas where incidence rates exceed 20%. However, the effectiveness of this program is hindered by low compliance among adolescents in taking iron supplements. This low compliance is often attributed to factors such as poor nutritional literacy, side effects, and a lack of consistent monitoring in schools, resulting in many distributed tablets not being consumed (Alfiah *et al.,* 2020). This gap between distribution and consumption calls for innovative monitoring methods that are more personalized and follow interactive digital trends.

The rapid growth of digital technology is evident in a report from the Indonesian Internet Service Providers Association (2024), which reveals that over 221 million people, or nearly 80% of Indonesia's total population, are now connected to the internet. This growth is particularly driven by easy access to mobile devices, especially among teenagers. According to Statistics Indonesia (BPS), smartphone ownership among individuals aged five and older reached 67.88% in 2022. The use of digital health technology presents a strategic opportunity to overcome existing barriers in healthcare. Digital platforms offer the flexibility to deliver health messages about anemia tailored to the dynamic characteristics of teenagers who are heavily engaged with digital devices in their daily lives.

Several digital innovations, including smartphone applications, e-health platforms, and web-based media, are being utilized to enhance compliance with iron supplement consumption aimed at preventing anemia in adolescents (Sari *et al.,* 2020; Rohani *et al.,* 2022; Rowi *et al.,* 2025). Studies have shown that these digital media tools are more effective in engaging adolescents compared to traditional lecture methods (Yulianti *et al.,* 2023). These app-based interventions not only focus on transferring information but also aim to foster positive perceptions through interactive and enjoyable user experiences.

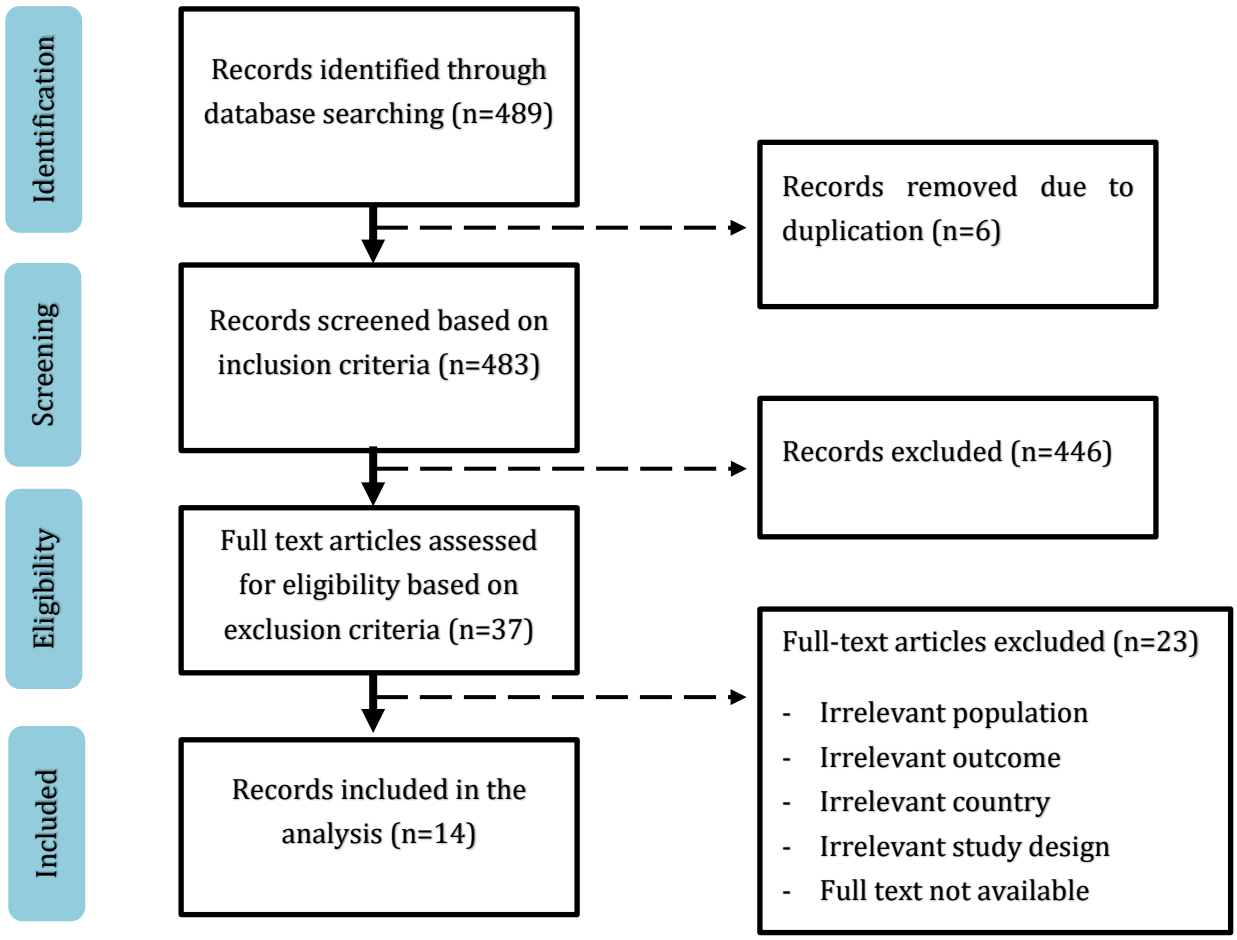
Although the potential for digitalization is significant, scientific evidence regarding its effectiveness in promoting long-term behavioral change and improving biological indicators remains mixed. Some studies have reported notable increases in hemoglobin (Hb) levels, while other literature reviews indicate that digital interventions often succeed in raising awareness but fail to produce consistent changes in dietary habits (Kurniawan *et al.,* 2025). These variations in outcomes are influenced by several factors, including the design of the application interface, the duration of the intervention, and the support provided by the school ecosystem for using this technology (Mahrorani *et al.,* 2025). This review aims to summarize the latest evidence regarding the effectiveness of various applications and digital media interventions implemented for Indonesian adolescent girls. It is expected to offer strategic recommendations for health policymakers.

2. METHODS

This study employs a narrative review approach. This method was strategically chosen to facilitate a thorough exploration and synthesis of various digital technology-based nutrition education interventions. The interventions analyzed include mobile applications, e-books, e-posters, interactive digital modules, social media, and web-based information (WHO, 2019; Marcolino *et al.,* 2018). The review process followed strict inclusion criteria to ensure the relevance and quality of the evidence. The publications screened spanned a decade, from 2014 to 2024, to capture the latest advancements in nutrition intervention technology.

The target population for this study was adolescent girls aged 10 to 18 years, as this group is particularly vulnerable to iron deficiency anemia (Ministry of Health, 2020). The main intervention focus was on nutrition education delivered through mobile applications and digital media (WHO, 2019). The primary outcomes assessed included nutrition knowledge, behavioral changes, and adherence to Iron-Folic Acid Supplement (IFAS) consumption. Literature sources were systematically reviewed using various scientific databases and official portals, including PubMed, Google Scholar, the Garuda Portal, in English or Indonesian full text were included. To maximize relevant search results, a combination of keywords was adjusted, including: "mHealth anemia adolescent," "digital nutrition education," "anemia adolescent girls Indonesia," and "iron supplementation mobile app." The selection process began with an initial screening based on the suitability of the titles and abstracts according to the inclusion criteria. Following this, full-text readings were conducted to verify the compatibility between the type of intervention and the relevant study outcomes.

Figure 1. Flowchart of study selection.



3. RESULTS AND DISCUSSION.

A total of 14 articles were analyzed after screening the database, removing duplicate articles, and assessing articles for full-text screening and eligibility (Figure 1). The included studies primarily evaluated the effectiveness of anemia education using digital applications and media targeted at adolescent girls in Indonesia. Quasi-experimental designs were the most commonly employed in these anemia education initiatives, featuring pretest and posttest assessments with intervention durations that varied from several weeks.

Table 1. Summary of studies reporting the influence of digital media or applications on knowledge and behavior related to anemia in adolescent girls in Indonesia.

Author, year	Study Design	Sample Size (n)	Methods	Digital Media/ Application	Outcome
Rachman *et al.,* 2021	A quasi-experimental study	241 adolescents; 11-17 years	14 weeks of intervention	WhatsApp Group	The nutrition education program improved Hb status and reduced the prevalence of anemia among adolescent girls compared to the baseline and control groups ($p<0.05$).
Rohani *et al.,* 2022	An experimental study	95 adolescents; 15-17 years	14 weeks of intervention; pretest-posttest	"TEENFIT" smartphone apps	Increased compliance with Fe supplement consumption in the intervention group compared to the control group ($p=0.000$) and differences before and after the intervention using the 'TEENFIT' app ($P=0.000$).
Ernawati *et al.,* 2022	An experimental study	47 adolescents; 17-18 years	8 weeks of intervention; pretest-posttest	Web-Based "She Smart"	There is an effect of using the She Smart web-based education model on the use of information about anaemia ($p=0.000$), ($p<0.05$), attitude p-value of 0.016 ($p<0.05$), and action ($p=0.001$).
Sari *et al.,* 2022	A quasi-experimental study	277 adolescents; 15-18 years	12 weeks of intervention; pretest-posttest	"WANTER" m-Health Education apps	Adolescents' knowledge and attitudes improved after the WANTER intervention and booklet on anaemia prevention with $p<0.001$. However, there was no significant difference in the knowledge, attitude, and practice (KAP) of anemia between the control and intervention groups.

Author, year	Study Design	Sample Size (n)	Methods	Digital Media/ Application	Outcome
Adlu & Fayasari, 2023	A quasi-experimental study	68 adolescents; 15-18 years	2 weeks of intervention; pretest-posttest	Audio podcast via smartphone	An increase in knowledge scores (p=0.000) and attitudes (p=0.036) about anemia in the audio podcasts group, except in the flyer group, a significant increase only in knowledge scores (p=0.000). Audio podcasts were more effective in increasing knowledge (p=0.007) than flyers, but not for attitudes (p=0.389).
Yulianti *et al.,* 2023	An experimental study	80 adolescents; 12-14 years	4 weeks of intervention; pretest-posttest	Web-based educational media (E-WoHealth)	There was a significant difference before and after the use of the web-based E-WoHealth media (p=0.000), indicating that the media effectively increased adherence to iron supplement consumption among 7th and 8th grade female students.
Andini & Agestika, 2022	A quasi-experimental study	70 adolescents; ± 14 years old	3 weeks of intervention; pretest-posttest	Whatsapp group & video conference	A difference in the average knowledge score of adolescents regarding anemia prevention (p=0.001) and adherence to iron supplementation (p=0.008) in the intervention group. However, there was no difference between the control and intervention groups in knowledge scores (p=0.127), attitudes (constant variance), and adherence (p=0.306).
Magfirah *et al.,* 2023	A quasi-experimental study	49 adolescents; 16-17 years old	12 weeks of intervention; pretest-posttest	"LADIES" android-based apps & e-posters	The findings indicated that there were differences between groups in knowledge and nutritional intake (protein and iron) (p<0.01) for prevent of anemia.
Wijaya *et al.,* 2024	A quasi-experimental study	49 adolescents; 16-18 years old	12 weeks of intervention; pretest-posttest	E-pocket book	The intervention increased knowledge and perception of anemia, with greater improvement in the intervention group compared to the control group up to follow-up 1. However, statistical significance was only found for the improvement in perception in both groups (p=0.001).

Author, year	Study Design	Sample Size (n)	Methods	Digital Media/ Application	Outcome
Patmawati *et al.,* 2024	A quasi-experimental study	78 adolescents; 10th grade students	9 weeks of intervention; pretest-posttest	"CEMARA" apps	A significant increase in knowledge about anemia prevention in the posttest compared to the pretest ($p<0.001$), while before the intervention there was no significant difference ($p=0.10$).
Rialihanto *et al.,* 2023	A quasi-experimental study	105 adolescents; 15-17 years old	4 weeks of intervention; pretest-posttest	Website-based & WhatsApp	Knowledge and attitudes increased in both the website and WhatsApp groups ($p<0.05$). The WhatsApp group showed a greater increase in attitude than in knowledge. The increase in attitude in the WhatsApp group reached 40.6%, while the increase in knowledge was only 10.7%.
Jumiyati *et al.,* 2024	A quasi-experimental study	60 adolescents; 12-15 years old	4 weeks of intervention; pretest-posttest	Self-designed Android application media in the PlayStore	Significant differences in pre-test and post-test knowledge were observed between the treatment groups ($p=0.002$). In comparison, mean attitudes before treatment did not differ between groups ($p=0.048$); each group showed differences after treatment. The intervention and control groups influenced knowledge and attitudes before and after treatment ($p=0.013$).
Febryanti *et al.,* 2024	An experimental study	66 adolescents; 15-16 years old	4 weeks of intervention; pretest-posttest	Social media "TikTok"	There was an influence of health education with TikTok social media on respondents' knowledge and attitudes about anemia with a ρ-value of 0.000 ($\rho<0.05$).
Sartono *et al.,* 2024	A quasi-experimental study	70 adolescents; 11th grade students	4 weeks of intervention; pretest-posttest	Animated video	A significant difference between animated video media and leaflets with respondents' knowledge about anemia ($p=0.043$). Animated videos exhibited significantly more gains in knowledge compared to leaflets.

The reviewed articles highlight various forms of digital media and applications used to support anemia education. Digital media includes audio podcasts, e-posters, animated videos, electronic books, and web-based educational platforms. In terms of digital applications, some utilize social media platforms like TikTok and WhatsApp, video

conferencing tools, and special Android-based applications, all aimed at providing education on anemia.

The analysis of the fourteen articles demonstrated the effectiveness of using digital media and applications for anemia education among adolescent girls in Indonesia (Table 1). Each article revealed an increase in knowledge, as well as positive changes in attitudes and behaviors related to anemia prevention among these girls ($p<0.05$). Furthermore, the education provided through various digital tools led to greater compliance in consuming iron supplements and an overall increase in iron intake (Rohani et al., 2022; Andini & Agestika, 2022; Yulianti et al., 2023). A notable positive outcome is the improvement in hemoglobin (Hb) levels and the reduction of anemia among adolescent girls who received education through audio podcasts (Rachman *et al.,* 2021). This finding aligns with a study by Ghadam *et al*. (2023) in Iran, which demonstrated that educational interventions using digital games over 12 weeks positively influenced adolescent girls' knowledge, attitudes, and behaviors regarding iron deficiency anemia. The intervention also led to an increased intake of essential nutrients, including iron, and significantly improved the Hb levels of these girls ($p<0.001$). Conversely, a study by Rahman *et al.* (2025) focused on adolescent girls in Bangladesh, which found no statistically significant change in Hb levels following online counseling and education delivered via a mHealth application. However, there were increases in hemoglobin levels within the intervention group, along with significant improvements in knowledge, attitudes, and behaviors compared to the control group ($p<0.05$). The discrepancies in results across these studies may be attributed to an insufficient sample size, which could limit the ability to detect clinically relevant changes in hemoglobin levels (Sharma *et al*., 2020; Rahman *et al.,* 2025). Whereas the articles analyzed in Indonesia related to Hb had a sample size of 241, the study in Iran had 176 samples, and the study in Bangladesh had 138 samples of adolescent girls (Rachman *et al.,* 2021; Ghadam *et al.,* 2023; Rahman *et al.,* 2025).

A study has compared the direct effects of animated video media with traditional leaflets. For instance, Sartono *et al.* (2024) found that animated videos significantly increased knowledge related to anemia before and after treatment compared to leaflets. Another study indicated that providing anemia education through video media via an Android application resulted in a knowledge score that was 10.5 points higher than education delivered through lectures. Animated videos create engaging presentations that convey information through moving images combined with sound (Turnip & Arisman, 2022). Susanti *et al.* (2025) supported these findings, indicating that information is more effectively received when using both visual and auditory elements in animated videos. Media aids can influence attitude changes towards anemia, making it easier for respondents to remember the material presented. By combining images with the messages about anemia, respondents can better understand the content by seeing, hearing, and reading, which facilitates acceptance of knowledge about the condition (Turnip & Arisman, 2022). Additionally, video-based media interventions have also been shown to increase responses to the consumption of iron tablets to prevent anemia (Darsono & Hidayat, 2025).

Similar to video media, the use of e-pocket books has proven to be an effective medium for educating adolescent girls about anemia, significantly increasing their knowledge and awareness (Wijaya *et al.,* 2024). When comparing e-pocket books to

posters, a significance value of p<0.017 was found regarding the difference in the average increase in knowledge about anemia. In the intervention group, 70% of respondents demonstrated good knowledge, while 30% showed sufficient knowledge after receiving education through digital pocket books. Digital pocket books offer an engaging way to access information through text, images, and even videos, all of which can be viewed on digital screens such as tablets or smartphones. This flexibility allows users to learn independently, promoting faster, more interesting, and easily understandable dissemination of information (Ferbriani *et al*., 2024; Endriati *et al*., 2025). Likewise, education through audio podcasts positively impacts teenagers by enhancing their listening skills and helping them learn new vocabulary and topics. They can conveniently learn on their devices while training their minds to visualize what they hear through the podcasts (Andriawan *et al*., 2024). Consequently, integrating audio podcasts into education could improve teenagers' knowledge and attitudes towards anemia prevention (Adlu & Fayasari, 2023).

In web-based educational interventions, three studies have demonstrated positive effects on increasing knowledge and improving behaviors related to anemia and compliance with iron supplement consumption among adolescent girls (Ernawati *et al.,* 2022; Rialihanto *et al*., 2023; Yulianti *et al*., 2023). The web-based approach proves to be an effective educational medium, enhancing understanding of the importance of taking iron tablets to prevent anemia. These findings highlight the significant potential of web-based media to reach a broader audience and improve health literacy, particularly concerning nutrition (Qodri *et al.,* 2025).

This study leveraged social media platforms such as TikTok and WhatsApp, yielding significant results (p<0.05) that indicated an increase in knowledge and positive attitudes regarding anemia and iron supplementation compliance among Indonesian adolescents (Andini & Agestika, 2022; Rialihanto *et al.,* 2023; Febryanti *et al.,* 2024). WhatsApp proved to be an effective tool for reminding adolescents about the importance of knowledge transfer and adherence to iron supplement consumption (Viyanti *et al.,* 2025). Supporting research indicates that Indonesian adolescents who actively use social media demonstrate a better understanding of anemia (Zulfajriani *et al.,* 2023). Overall, social media has fundamentally transformed adolescents' lives, coinciding with advances in communication and information technology. This shift is characterized by changes in interaction patterns and the methods of sharing information, moving from face-to-face communication to digital interactions (Al Hidayah *et al.,* 2025). The use of WhatsApp and other social media platforms enhances collaboration among young people, enabling them to engage in flexible virtual learning without geographical limitations. This development increases social awareness related to education and information, keeping pace with the rapid advancements in digital technology (Ohara, 2023). However, the effectiveness of these platforms largely depends on the level of active participation, management of discussions, and teenagers' digital literacy in utilizing social media effectively (Fathurrohman *et al.*, 2024). It is important to acknowledge that social media can have negative consequences, such as the spread of false or inaccurate information. Therefore, careful usage is essential to avoid misunderstandings and confusion when seeking valid knowledge (Rijal *et al.*, 2024).

The substantial development of various creative applications aimed at addressing anemia has led to innovative strategies for enhancing knowledge about anemia prevention and promoting compliance with iron supplement consumption among adolescents. Notable examples of these applications include the "TEENFIT" smartphone app, the "WANTER" m-Health Education app, the 'LADIES' Android-based app, the "CEMARA" app, and a self-designed Android application available on the PlayStore. These tools have significantly improved knowledge, attitudes, and practices related to anemia prevention among adolescents in Indonesia (Rohani *et al*., 2022; Sari *et al.,* 2022; Magfirah *et al.,* 2023; Patmawati *et al*., 2024; Jumiyati *et al.,* 2024). In comparison to traditional educational media, using digital applications as active educational tools, which present material in a structured, classified, and interactive manner, has greatly improved subjects' understanding. Furthermore, subjects in the application-based intervention group reported higher satisfaction levels with the information received and their comprehension compared to those in the control group (Timmers *et al.,* 2018). The integration of mobile applications that feature behavior reinforcement tools, such as reminders and games, facilitates effective, repetitive, and independent learning. In this context, digital game-based nutrition education not only enhances the cognitive and emotional understanding of anemia among adolescent girls but also positively influences their intake patterns of macro and micronutrients (Fitri *et al*., 2025).

4. CONCLUSION

The narrative analysis confirmed the significant positive effects of various forms of digital education, such as animated videos, audio podcasts, e-pocket books, web-based resources, social media, and smartphone-based application development, in increasing knowledge about anemia prevention and iron supplement consumption compliance among adolescent girls in Indonesia through pre-test and post-test measurements. Meanwhile, in measuring improvements in blood hemoglobin after education about anemia through digital platforms, the results varied. The use of digital media and applications provides an interactive nutritional education experience by combining the use of the senses, both visually and audibly, which strengthens adolescent girls' understanding and memory of knowledge about anemia. The use of digital tools in anemia education is crucial, given how integrated digital media is in the daily lives of adolescents.

This analysis revealed variations in digital media and the development of creative applications for anemia education. However, the applications examined did not provide comprehensive insights into the effectiveness, as primarily measured knowledge, attitudes, and practices through pre- and post-tests without deeper clinical monitoring and evaluations. Additionally, this research is limited in its ability to discuss the progress of hemoglobin status among adolescent girls due to a lack of robust data sources or research methodologies suitable for clinical measurement. Therefore, it is highly recommended that future research focus on the clinical conditions of respondents to examine the relationship between knowledge and attitude changes and their health outcomes. Furthermore, a comparative study is necessary to evaluate the effectiveness of digital applications designed for anemia education after development. The results of this study can provide recommendations for the government on the most effective applications

to promote and widely implement within the community, helping to prevent and control anemia among adolescent girls in Indonesia.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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