



Interactive nutrition education for pregnant women: Strengthening maternal health and environmental sustainability in stunting prevention

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ABSTRACT

Background: Pregnancy is a critical period that determines both maternal and child health while influencing household food choices and environmental sustainability. Limited nutrition literacy during pregnancy not only increases the risk of malnutrition and stunting but also perpetuates unsustainable dietary practices that burden local ecosystems. This study aims to optimise pregnant women's nutrition understanding through interactive education programmes that strengthen maternal health and promote environmentally sustainable practices. By emphasising balanced nutrition, positive attitudes, and the use of local food resources, the programme seeks to prevent stunting while reducing ecological impact. **Method:** A quasi-experimental pre-test and post-test design was employed with 50 pregnant women selected through purposive sampling. The intervention consisted of animated educational videos, interactive simulations on sustainable food choices, quiz-based learning, and guided group discussions with health workers. **Findings:** Findings demonstrated a significant improvement in nutrition knowledge among the intervention group compared to the control group ($\Delta = 2.96$ vs 0.4 ; $p < 0.001$). Beyond knowledge, participants reported greater awareness of the benefits of local, environmentally friendly food consumption patterns as part of stunting prevention efforts. **Conclusion:** Interactive education effectively enhances maternal nutritional literacy while integrating environmental sustainability into dietary behaviour. This dual benefit highlights the potential of participatory, eco-conscious educational models to improve maternal and child health outcomes while fostering sustainable food systems at the community level. Future researchers can compare various other education methods, such as digital-based education or a combination of conventional and interactive education, to determine the most effective approach in increasing mothers' knowledge and behavioural change in stunting prevention. **Novelty/Originality of this article:** This study uniquely integrates maternal nutrition education with environmental sustainability, using interactive, eco-conscious methods to simultaneously prevent stunting and promote sustainable dietary practices.

KEYWORDS: interactive education; pregnant women; nutrition understanding; stunting.

1. Introduction

Pregnancy is a critical period that significantly influences both maternal and child health. During this time, a mother's nutritional intake is crucial for the development of the fetus, and insufficient nutrition can result in complications such as low birth weight, anemia, and stunting (Desi & Izah, 2024). Beyond these immediate health concerns, limited nutrition literacy during pregnancy can also perpetuate unsustainable dietary practices, exacerbating risks for malnutrition and stunting. Therefore, interventions that enhance nutritional knowledge and promote sustainable dietary behaviors among pregnant women are vital for

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breaking the intergenerational cycle of malnutrition and fostering long-term well-being (Siregar et al., 2023). To this end, initiatives focused on educating pregnant women about optimal nutrition and reproductive health have demonstrated significant positive impacts on stunting prevention (Permatasari et al., 2020). Stunting, in particular, is a serious condition resulting from chronic malnutrition, leading to long-term consequences for children's physical and cognitive development. It is a major public health concern, especially in low- and middle-income countries, where access to proper nutrition and healthcare may be limited (Sukmawati et al., 2021). Education and nutritional interventions targeting pregnant women are therefore essential, as these efforts not only safeguard maternal and fetal health but also establish a strong foundation for preventing stunting in offspring (Siregar et al., 2023). Studies have consistently shown that comprehensive nutrition and reproductive health education delivered through interactive methods can substantially improve pregnant women's knowledge, attitudes, and practices, ultimately contributing to better maternal and infant health outcomes and reduced childhood stunting (Permatasari et al., 2020; Siregar et al., 2023).

Despite the importance of nutrition during pregnancy, many pregnant women lack adequate knowledge about their nutritional needs. This limited nutrition literacy contributes to poor dietary practices, which not only elevates the risk of maternal malnutrition and stunting in offspring but also hinders the adoption of sustainable dietary habits (Siregar et al., 2023; Desi & Izah, 2024). Addressing this gap necessitates innovative educational interventions that can effectively convey crucial nutritional information and foster behavioral changes among expectant mothers. His knowledge gap often arises from factors such as limited access to health information, cultural beliefs, and inadequate communication with healthcare providers. To counteract these challenges, interactive education techniques, incorporating multimedia presentations, group discussions, and digital tools, have shown significant promise in enhancing pregnant women's knowledge, attitudes, and practices regarding essential nutrients like iodine (Mohamed et al., 2024). As a result, pregnant women may make suboptimal dietary choices that compromise their health and the health of their children. Therefore, implementing comprehensive nutrition education programs specifically designed for pregnant women, particularly in underserved regions, is crucial to improve maternal and child health outcomes and break the intergenerational cycle of malnutrition (Aminin et al., 2022; Siregar et al., 2023). Such programs, which often include micronutrient supplementation and dietary counseling, have been demonstrated to significantly reduce the incidence of low birth weight and stunting (Siregar et al., 2023; Liu et al., 2024). In many regions, poor nutrition education during pregnancy is a contributing factor to high rates of stunting and other related complications. For instance, studies have shown that intensive nutrition education and counseling programs can significantly reduce undernutrition and improve the overall nutritional status of pregnant women (Burkhart et al., 2024).

One effective way to address this issue is through interactive nutrition education programs that leverage various modalities to enhance understanding and retention (Permatasari et al., 2020; Siregar et al., 2023). These interventions, ranging from multimedia presentations to practical cooking demonstrations, can effectively address knowledge gaps and behavioral barriers, thereby promoting better dietary choices and ultimately improving maternal and fetal health outcomes (Sukmawati et al., 2021; Beressa et al., 2024). Unlike traditional one-way education methods, interactive education engages participants in active learning, making the material more accessible and memorable. This approach not only facilitates comprehension of complex nutritional information but also cultivates positive attitude shifts towards preventive health behaviors, which are particularly critical during pregnancy when health risks are elevated (Mohamed et al., 2024). This approach uses visual aids, group discussions, simulations, and quizzes to enhance learning. Furthermore, integrating such interactive educational strategies into prenatal care can significantly improve the adherence to recommended nutritional guidelines and the adoption of healthier lifestyles among expectant mothers (Mohamed et al., 2024). By actively involving pregnant women in the education process, such programs

have the potential to improve their understanding of nutrition and stunting prevention, leading to better dietary choices and healthier pregnancies. These improved practices, influenced by pregnant mother assistance, contribute to a positive shift in attitudes towards stunting prevention and align with findings that nutrition education enhances knowledge and practices concerning appropriate complementary foods (Siregar et al., 2023).

In addition to improving maternal health, there is growing recognition of the need to incorporate environmental sustainability into nutrition education programs. This integration aims to promote dietary choices that are not only beneficial for maternal and child health but also environmentally responsible, thereby contributing to broader public health and ecological goals (Permatasari et al., 2021). Sustainable food choices, such as consuming locally sourced and seasonal foods, not only support maternal health but also help reduce the ecological footprint of food production. Moreover, by emphasizing sustainable food systems, these educational interventions can contribute to long-term food security and resilience, particularly in vulnerable communities (Mukodri et al., 2023). By integrating eco-conscious practices into nutrition education, pregnant women can learn how to make healthier, environmentally friendly food choices, contributing to both personal health and the health of the planet. The efficacy of such interactive methods in enhancing knowledge, attitudes, and practices among pregnant women has been well-documented, with interventions showing significant improvements in these metrics compared to control groups (Permatasari et al., 2020). Specifically, studies have shown that interactive educational approaches lead to a significant increase in knowledge retention and positive shifts in attitudes towards healthy dietary practices among pregnant women (Mohamed et al., 2024).

This paper explores the effectiveness of interactive nutrition education programs in improving maternal health and preventing stunting, while also promoting environmentally sustainable dietary practices. This includes evaluating various interactive techniques, such as multimedia presentations and group discussions, and their impact on knowledge, attitudes, and behaviors related to nutrition and stunting prevention among pregnant women (Mohamed et al., 2024). It further investigates how these programs can integrate principles of environmental sustainability to encourage dietary choices that benefit both maternal-child health and ecological well-being (Chehade et al., 2023). The study also examines the challenges and opportunities in implementing these programs within diverse cultural and socioeconomic contexts, emphasizing the need for tailored approaches to maximize their effectiveness. The study aims to demonstrate how such education can empower pregnant women with the knowledge needed to make informed decisions about nutrition, ultimately strengthening maternal health and contributing to long-term stunting prevention efforts. Ultimately, this comprehensive approach seeks to enhance maternal well-being, foster healthy fetal development, and contribute to the broader goal of reducing maternal malnutrition and child stunting rates globally (Muhamad et al., 2023; Shenoy et al., 2023).

2. Methods

2.1 Study design, population and sample

This study utilized a quasi-experimental design with pre-test and post-test measurements to evaluate the effectiveness of interactive nutrition education on pregnant women's knowledge and behavior. The intervention focused on providing educational content through an application to improve knowledge, attitudes, and practices concerning stunting prevention among brides-to-be, a critical demographic for early intervention (Hartini et al., 2024).

Total of 50 pregnant women were recruited from local health centers using purposive sampling, with inclusion criteria including being in the first or second trimester of pregnancy and having no cognitive impairments. Participants were randomly assigned to either the intervention group, which received the nutrition education program, or the

control group, which did not receive any education. The intervention consisted of a series of interactive modules, including animated videos on nutrition, sustainable food choices, and stunting prevention, supplemented by group discussions, quizzes, and hands-on activities focused on local food resources. The control group received standard prenatal care without any additional educational intervention.

2.2 Data collection and statistical analysis

Data collection was carried out at two points: before the intervention (pre-test) and after the intervention (post-test). The pre-test measured baseline knowledge, attitudes, and behaviors related to nutrition and stunting prevention, while the post-test assessed changes in these parameters following the intervention period, typically spanning several weeks to allow for adequate exposure to the educational content (Permatasari et al., 2020). A structured questionnaire was developed to assess participants' knowledge of nutrition, stunting prevention, and attitudes toward sustainable food practices.

The intervention group received a total of six interactive education sessions, each lasting 45 minutes, over the course of three weeks. These sessions incorporated multimedia presentations and practical demonstrations to enhance engagement and facilitate comprehension, focusing on concepts such as balanced diets, the importance of micronutrients, and environmentally friendly food sourcing (Permatasari et al., 2021; Sukmawati et al., 2021). The sessions focused on balanced nutrition, the importance of micronutrients such as iron and folic acid, and sustainable food practices, emphasizing the consumption of local, seasonal foods to reduce ecological impact. Statistical analysis, including paired t-tests and Wilcoxon tests, was performed to compare pre-test and post-test results within and between the control and intervention groups, with significance set at $p < 0.05$.

3. Results and Discussion

3.1 Description of pregnant women's knowledge (pre-test) before interactive education

Prior to analysis of outcome changes, this study compared baseline knowledge categories between groups to ensure comparability. As shown in Table 1, the intervention group had a notably higher proportion of pregnant women classified in the "Insufficient" knowledge category (60%, 15/25) compared to the control group (56%, 14/25). Conversely, the control group exhibited a higher concentration in the "Fair" and "Good" categories (32% and 8%, respectively), while the intervention group had 36% and 8% in these categories, respectively. These disparities indicate that at the start of the study, the two groups had uneven baseline knowledge levels. Specifically, the intervention group had a stronger knowledge foundation, which should be considered when interpreting the post-intervention effects. This baseline imbalance might influence the degree of improvement observed after the intervention, and it underscores the importance of interpreting post-test results with this context in mind (see Table 1).

Table 1. Distribution of average knowledge of pregnant women in the control and intervention groups

Category	Control		Intervention	
	Frequency	%	Frequency	%
Good	2	8	2	8
Fair	8	32	9	36
Insufficient	15	60	14	56
Total	25	100	25	100

Before the intervention, 60% of the pregnant women in the control group had insufficient knowledge about nutrition and pregnancy health, 32% had fair knowledge, and

only 8% demonstrated good knowledge. In comparison, the intervention group showed a slightly better baseline, with 56% having insufficient knowledge, 36% possessing fair knowledge, and 8% being in the good knowledge category. These results clearly highlight the need for educational interventions aimed at enhancing pregnant women's understanding of nutrition and maternal health. Given that the intervention group began with a stronger knowledge base, it is important to assess the post-test changes relative to these initial conditions. This baseline difference suggests that although the intervention group had more knowledge at the outset, there remains a substantial need for improvement, which the intervention aimed to address effectively.

The results of this study align with findings from other research indicating that interactive and participatory educational programs can significantly improve maternal health knowledge. Interactive education, including group discussions and hands-on activities, increased pregnant women's knowledge of nutrition and health during pregnancy, leading to improved dietary practices (Mohamed et al., 2024). This sustained engagement not only enhances immediate knowledge acquisition but also fosters long-term retention and application of healthy behaviors, which is crucial for stunting prevention and overall maternal-child well-being (Permatasari et al., 2021). For instance, interventions incorporating lectures, discussions, and practical demonstrations have been shown to significantly enhance mothers' knowledge and attitudes regarding prenatal nutrition and exclusive breastfeeding (Syafitasari et al., 2024). Similarly, a study demonstrated that interactive approaches, particularly those using multimedia such as videos and quizzes, were effective in enhancing nutrition understanding among pregnant women in rural areas, where access to health education is often limited. These findings corroborate earlier research highlighting that innovative interactive education techniques significantly improve dietary practices related to iodine-rich foods, and that comprehensive programs encompassing educational activities and dietary guidance lead to increased information retention (Sudirman et al., 2023; Mohamed et al., 2024). These studies, along with our findings, support the notion that engaging and participatory methods are more effective in delivering complex health information compared to traditional lecture-style education. Moreover, evidence suggests that contextualized nutrition education materials, particularly during public health emergencies, can significantly improve the nutritional status of pregnant women and enhance their knowledge retention (Sebastian et al., 2022).

Moreover, the initial knowledge disparities observed in this study are consistent with previous research that has shown significant variability in baseline nutritional knowledge among pregnant women, particularly in low-resource settings. Such disparities underscore the critical need for targeted and culturally sensitive educational interventions to address specific knowledge gaps and promote equitable health outcomes (Sukmawati et al., 2021; Prasetyo et al., 2023). Studies highlight the lack of adequate nutrition knowledge in rural areas, where many women rely on traditional or limited sources of information (Sudirman et al., 2023). This educational gap often necessitates the implementation of diverse instructional methods, including role-playing, exercises, and games, to ensure effective information dissemination and retention, especially in communities with lower literacy rates (Permatasari et al., 2021). Furthermore, educational programs that utilize interactive approaches, such as lectures, discussions, questions and answers, and practical demonstrations, have been shown to significantly improve knowledge and attitudes among pregnant women. These results collectively indicate that well-designed, interactive nutrition education programs can effectively bridge existing knowledge gaps and empower pregnant women to adopt healthier dietary practices, thereby contributing to improved maternal and child health outcomes (Fallah et al., 2013; Mohamed et al., 2024).

3.2 Description of s of pregnant women's knowledge (post-test) after interactive education

Prior to analysis of outcome changes, this study compared baseline knowledge categories between groups to ensure comparability. As summarized in Table 2, the intervention group shows a markedly higher proportion of pregnant women in the Good

category (60%, 15/25) than the control group (20%, 5/25), while the control group clusters more in the fair and insufficient categories (40% and 40%, respectively) compared with the intervention group (28% and 12%). These distributions indicate that, at measurement, knowledge levels were uneven across groups, with the intervention group starting from a stronger position—a pattern that should be considered when interpreting post-intervention effects (see Table 2).

Table 2. Distribution of average knowledge of pregnant women in the control and intervention group

Categories	Control		Intervention	
	Frequency	%	Frequency	%
Good	5	20	15	60
Fair	10	40	7	28
Insufficient	10	40	3	12
Total	25	100	25	100

The baseline knowledge disparities observed in this study highlight a common challenge in maternal health education: the variation in starting knowledge levels across different populations. In our study, the intervention group began with a stronger knowledge base, with 60% classified as "Good" compared to just 20% in the control group. This initial difference underscores the need for tailored educational approaches, where content and delivery methods are adapted to address the specific needs and existing knowledge gaps of diverse maternal populations. This disparity further emphasizes the necessity of pre-intervention assessments to accurately gauge educational needs and customize interventions for maximal effectiveness. Indeed, personalized education strategies, particularly those leveraging technology, have shown promise in addressing these variations by offering adaptive content delivery based on individual learning paces and prior knowledge. For instance, mobile phone applications can provide tailored information on maternal health, adapting to the user's educational background and ensuring greater access to relevant resources, especially for those with higher education levels (Obonyo et al., 2024). This aligns with research indicating that individuals with higher educational attainment often process and retain information more effectively, thereby benefiting more from sophisticated educational tools and resources (Sudirman et al., 2023). Furthermore, the utilization of e-booklets and virtual educational platforms has been demonstrated to significantly enhance comprehension and long-term knowledge retention, particularly among younger, nulliparous individuals who often exhibit a higher propensity for engaging with novel learning experiences (Romaní et al., 2022; Najmi et al., 2025).

3.3 Distribution of differences in respondents' knowledge before and after interactive education on stunting prevention in the intervention group and control group

The table above shows that there is a significant difference between the control group and the intervention group before and after the intervention was carried out. In the control group, the average pre-test score was 4.70 ± 0.931 , and increased slightly to 5.10 ± 0.953 in the post-test, with a mean difference of 0.4. Although this increase was statistically significant ($p = 0.000$), the magnitude of the change was relatively small. Meanwhile, in the intervention group, the average pre-test score was 4.96 ± 0.781 and increased significantly to 7.92 ± 1.122 in the post-test, with a mean difference of 2.96 and a p-value of 0.000.

Table 3. The effect of interactive education on improving the knowledge of pregnant women

Group	N	Mean \pm SD (Pre-test)	Mean \pm SD (Post-test)	Mean Difference	p-value
Control	25	4.70 ± 0.931	5.10 ± 0.953	0.4	0.000*
Intervention	25	4.96 ± 0.781	7.92 ± 1.122	2.96	0.000*
p-value		0.081**	0.000**	0.000**	

Wilcoxon *

Mann-Whitney **

The table above shows that there is a significant difference between the control group and the intervention group before and after the intervention was carried out. In the control group, the average pre-test score was 4.70 ± 0.931 , and increased slightly to 5.10 ± 0.953 in the post-test, with a mean difference of 0.4. Although this increase was statistically significant ($p = 0.000$), the magnitude of the change was relatively small. Meanwhile, in the intervention group, the average pre-test score was 4.96 ± 0.781 , and increased significantly to 7.92 ± 1.122 in the post-test, with a mean difference of 2.96 and a p-value of 0.000. Furthermore, a comparison between the two groups showed that before the intervention there was no significant difference ($p = 0.081$), indicating that the two groups had relatively similar initial conditions. However, after the intervention, there was a very significant difference between the control group and the intervention group ($p = 0.000$), indicating that the intervention had a strong effect in improving the measured outcomes. The difference in mean between the two groups was also significant ($p = 0.000$), indicating that the improvement in the intervention group was much greater than that in the control group.

3.4 Pre-test and post-test scores of control and intervention groups on stunting prevention knowledge and sustainable food practices

The findings demonstrated a significant improvement in maternal nutrition knowledge and awareness of stunting prevention among participants who received interactive education compared to the control group. The intervention group's post-test scores increased substantially ($\Delta = 2.96$, $p < 0.001$), while the control group showed only minor gains ($\Delta = 0.4$, $p < 0.05$). Beyond knowledge, participants in the intervention group reported stronger confidence in applying healthy dietary behaviours, including regular consumption of iron and folic acid supplements, and adherence to balanced meal practices that support maternal and child health (see table 4). In addition to health outcomes, the programme successfully raised participants' awareness of the environmental dimension of nutrition. Many respondents demonstrated improved attitudes towards choosing local and seasonal food sources, reducing reliance on processed foods, and recognising the ecological benefits of sustainable diets. Group discussions revealed that participants valued the integration of maternal health messages with environmental sustainability, which encouraged them to view nutrition not only as a personal health concern but also as a contribution to protecting local ecosystems and food security.

Table 4. Comparison of knowledge and environmental awareness before and after intervention

Variable	Group	Pre-test (Mean \pm SD)	Post-test (Mean \pm SD)	Mean Difference	p-value
Nutrition knowledge (Stunting prevention)	Control (n=25)	4.70 \pm 0.93	5.10 \pm 0.95	+0.40	0.000*
	Intervention (n=25)	4.96 \pm 0.78	7.92 \pm 1.12	+2.96	0.000*
Awareness of sustainable food choices	Control (n=25)	3.85 \pm 0.80	4.10 \pm 0.85	+0.25	0.072
	Intervention (n=25)	3.90 \pm 0.75	6.85 \pm 1.05	+2.95	0.000*

Note: * $p < 0.05$; $p \geq 0.05$ considered not significant (ns)

In terms of nutrition knowledge related to stunting prevention, the intervention group experienced a substantial increase, with mean scores rising from 4.96 ± 0.78 at pre-test to 7.92 ± 1.12 at post-test (mean difference +2.96; $p < 0.001$). In contrast, the control group only showed a minor improvement (+0.40; $p < 0.05$), suggesting that conventional approaches were less effective in enhancing maternal understanding. For environmental awareness regarding sustainable food choices, the intervention group also demonstrated a notable improvement, from 3.90 ± 0.75 to 6.85 ± 1.05 (mean difference +2.95; $p < 0.001$). This finding highlights that the integration of eco-conscious content—such as promoting

local, seasonal, and low-impact food sources—successfully raised participants' recognition of nutrition as both a health and environmental issue. Meanwhile, the control group's change was statistically insignificant (+0.25; $p = 0.072$), reflecting limited progress in environmental literacy without interactive and participatory methods.

3.5 Discussion

3.5.1 Knowledge pregnant women (pre-test) before interactive education

The results of the analysis show that the knowledge of pregnant women about nutrition and health during pregnancy is a key factor in determining the quality of pregnancy and foetal health. This underscores the importance of nutritional knowledge as a modifiable determinant of maternal and child morbidity rates, emphasizing that women's health status significantly influences the quality of future generations (Sandy et al., 2024). Recognizing this, healthcare providers and policymakers must prioritize comprehensive and accessible nutrition education programs as a cornerstone of antenatal care to improve both maternal and infant health outcomes (Triyawati & Yuliani, 2023). Good knowledge about nutrition and health during pregnancy can influence diet, lifestyle, and important decisions made during pregnancy, which ultimately contribute to the health of the mother and baby. This aligns with studies showing that increased nutritional knowledge among pregnant women leads to improved dietary choices and healthier behaviors (Lestari et al., 2021), irrespective of age and educational attainment (Dunneram & Jeewon, 2015). Prior to interactive education, the level of knowledge among pregnant women in Jeneponto Regency varied, influenced by various factors such as education level, access to health information, previous pregnancy experiences, and support from health workers (Arindra et al., 2024). The varied educational backgrounds of the participants, ranging from elementary school to college, also significantly impacted their receptiveness to and retention of health information.

In Jeneponto District, where access to health services is uneven, pregnant women often depend on information from family, personal experiences, and local health workers (Arindra et al., 2024). Therefore, incorporating counseling media and educational modules can significantly enhance the delivery and reception of crucial health information, especially in areas with limited resources and varied educational backgrounds (Halisah et al., 2022). However, many still lack sufficient knowledge about nutrition, pregnancy complications, and the importance of regular antenatal check-ups (Riani, 2016). This deficiency often leads to suboptimal health-seeking behaviors and poorer maternal and neonatal outcomes, particularly in underserved populations (Permatasari et al., 2020). Despite the availability of information, a lack of clear understanding can impact their decisions regarding health during pregnancy, which can affect both maternal and fetal well-being. This gap in knowledge emphasizes the need for better education on essential nutrients like iron, folic acid, and protein, which are vital for fetal development. Moreover, addressing misinformation and culturally ingrained dietary restrictions through targeted educational interventions is crucial for improving adherence to evidence-based nutritional guidelines.

Interactive education is expected to help close this knowledge gap by offering a more engaging and accessible learning experience. Such approaches, which often incorporate visual aids and participatory activities, have been shown to significantly improve knowledge retention and lead to more positive health behaviors among diverse groups of pregnant women, even those with lower educational attainment (Briawan et al., 2024). Interactive methods, which promote active participation through discussions and hands-on activities, have been shown to significantly enhance understanding of nutrition and pregnancy health. This approach is particularly beneficial for individuals with lower educational backgrounds who might struggle with passively presented information, as it allows for personalized engagement and clarification of complex concepts (Lengkong et al., 2023; Meiyenti et al., 2023). By involving participants actively in the learning process, it is more likely that the knowledge gained will be applied in daily life, thereby fostering self-efficacy and empowering informed decisions about maternal health and infant well-being.

(Olloqui-Mundet et al., 2024). These interactive educational strategies are crucial for addressing the alarmingly poor knowledge and practices regarding gestational weight management among pregnant women, particularly in low- and middle-income countries (Wang et al., 2023).

However, while interactive education can greatly improve knowledge, there are external factors that can limit its effectiveness. Challenges such as family support, economic constraints, and access to nutritious food can affect a pregnant woman's ability to apply the education she receives. Therefore, sustainable improvements require not only robust educational interventions but also broader socioeconomic support systems that address these underlying determinants of health (Fallah et al., 2013). For example, the positive effects of educational programs on attitudes toward exercise during pregnancy, observed in studies from Zambia and Sri Lanka, highlight that comprehensive knowledge, complemented by supportive environments, translates into better adherence to recommended health practices (Kushwah, 2024). To maximize the impact of interactive education, it is important to provide continuous support through accessible health services, digital platforms for ongoing education, and community involvement. By addressing these factors, interactive education can help reduce pregnancy complications and improve the overall health of mothers and children, especially in areas with limited healthcare access. This comprehensive approach ensures that educational interventions are not isolated but rather integrated into a larger ecosystem of support, fostering sustainable behavioral changes and ultimately leading to improved maternal and neonatal outcomes (Moshki, 2023; Song et al., 2025). The integration of structured educational tools, such as Self-Instructional Modules, into routine antenatal care has demonstrated significant improvements in maternal knowledge and attitudes, advocating for similar strategies within prenatal education programs to optimize health outcomes (Kushwah, 2024).

3.5.2 Knowledge of pregnant women (post-test) after interactive education provision

After the interactive education sessions in Jeneponto District, there was a significant increase in pregnant women's knowledge about health and nutrition. This improvement was particularly notable in areas concerning balanced diets, the importance of micronutrients, and recognizing warning signs of pregnancy complications, thereby underscoring the efficacy of tailored educational interventions in resource-limited settings (Karmila et al., 2025). The education method used, which included group discussions, visualization, and hands-on practice, proved more effective than conventional methods like one-way counseling or distributing leaflets. This enhanced effectiveness can be attributed to the active engagement and personalized nature of interactive learning, which fosters deeper understanding and better retention of critical health information (Supartiningsih et al., 2025). This approach not only enhanced their understanding of topics such as healthy eating and necessary nutritional intake but also provided clearer, more practical information that could be directly applied in their daily lives. The post-test results showed that most pregnant women had a better understanding of the importance of consuming a balanced diet, the need for iron and folic acid, and recognizing danger signs during pregnancy. This aligns with findings that intensive nutrition education and counseling can improve nutritional status and reduce undernutrition among pregnant women, emphasizing the need for such interventions as part of routine antenatal care (Wakwoya et al., 2023).

In addition to improving knowledge, interactive education also led to noticeable behavioral changes. Pregnant women in the intervention group became more aware of the need to consume iron supplements and attend regular pregnancy check-ups, both of which are crucial for preventing complications (Ansong et al., 2023). These changes highlight the transformative potential of targeted health education in promoting adherence to recommended antenatal practices, thereby contributing to better maternal and neonatal health outcomes (Jibril et al., 2017). Furthermore, digital interventions and applications have also proven effective in promoting healthy behaviors and knowledge among

prospective parents, indicating a promising avenue for scalable educational delivery (Hartini et al., 2024). This suggests that effective education not only increases knowledge but also encourages pregnant women to take positive actions to safeguard their health and the health of their baby. By actively involving participants in discussions, the education helped them connect new information to their own experiences, making it easier for them to remember and apply the material. This participatory approach, incorporating interactive games and minimizing one-way lectures, has been shown to significantly improve knowledge, attitudes, and preventive behaviors, particularly concerning anemia among pregnant women (Janah et al., 2025). This interactive learning environment, coupled with comprehensive and systematic discussions, equips pregnant women with practical knowledge and skills that are essential for promoting maternal and child health (Triyawati & Yuliani, 2023).

However, the sustainability of these behavioral changes depends on several external factors, including the pregnant women's educational level, family support, and access to resources like nutritious food and healthcare services (Nadzirah et al., 2020). Although the education resulted in significant knowledge gains, external challenges such as economic limitations or limited access to healthcare may hinder the implementation of the acquired knowledge. Despite these challenges, the notable improvements in knowledge and attitudes observed post-intervention underscore the effectiveness of structured educational tools in antenatal care, aligning with findings from studies demonstrating that targeted educational interventions can bridge significant information gaps (Kushwah, 2024). To further solidify these gains, future initiatives should integrate continuous support mechanisms, such as mHealth applications or community health worker programs, to reinforce educational messages and facilitate adherence to healthy practices (Mohamed et al., 2025). To ensure that behavioral changes are sustained, it is crucial to provide ongoing support through digital platforms, face-to-face sessions, and community involvement. This multi-faceted support can help pregnant women continue to make informed, healthy choices despite external obstacles. This sustained engagement is critical for long-term health outcomes, as knowledge acquisition alone may not translate into consistent behavioral adoption without continuous reinforcement and accessible resources (Klankhajhon et al., 2023; Wardhana et al., 2025).

Finally, while digital-based education holds great promise, its effectiveness can still be limited by factors such as access to technology and the pregnant women's level of education. To reach a wider audience, including women in remote areas or with limited financial resources, digital education must be paired with more traditional methods, such as community-based workshops and one-on-one counseling, ensuring comprehensive coverage and adaptability to diverse socio-economic contexts (Rasheed & Al-Sowielem, 2003; Mohammed et al., 2025). This blended approach ensures equitable access to critical health information and support, thereby maximizing the potential for improved maternal and child health outcomes across varied populations (Herval et al., 2019). Ensuring that all pregnant women have access to accurate, understandable information will be key to improving maternal health outcomes and preventing complications like anemia and low birth weight. Such comprehensive strategies are vital, especially considering that digital health interventions alone, despite their promise, have shown mixed effects on antenatal health behaviors when lacking participatory elements and tailoring to individual contexts (Saville et al., 2024). Additionally, addressing systemic barriers, such as access to affordable iron supplements and fortified foods, remains crucial for enhancing maternal health outcomes (Wardhana et al., 2025). Therefore, future interventions must incorporate a holistic approach, combining digital tools with community-based strategies to overcome existing disparities and provide sustainable support for maternal and child health (Yap et al., 2022; Shao et al., 2024).

3.5.3 Differences in respondents' knowledge before and after interactive education on stunting prevention in the intervention group and control group

The results of this study show a significant difference in the increase in knowledge about stunting prevention between the intervention group and the control group after interactive education was provided. At the pre-test stage, the initial knowledge levels of the two groups were almost the same, with an average score of 4.70 ± 0.931 in the control group and 4.96 ± 0.781 in the intervention group. Statistical tests showed a p-value of 0.081, which means that there was no significant difference between the two groups before the intervention. This indicates that before the education was provided, the respondents' knowledge was still low, which was most likely due to a lack of access to accurate health information and limited formal education on nutrition and stunting prevention. The results of this study reveal a significant increase in knowledge about stunting prevention in both the intervention and control groups following the interactive education. Before the intervention, the knowledge levels of the two groups were nearly identical, with no significant differences observed, indicating that both groups had limited understanding of stunting prevention. This suggests that prior to the intervention, access to accurate information on nutrition and stunting prevention was inadequate, which is often the case in communities with limited educational resources. However, the post-intervention data demonstrated a substantial improvement in knowledge within both groups, with the intervention group exhibiting a more pronounced and statistically significant increase, thereby underscoring the efficacy of interactive educational methodologies in enhancing maternal health literacy (Abujilban et al., 2018; Choudhury et al., 2023). This aligns with previous research highlighting that well-structured health promotion interventions, particularly those employing models like PRECEDE-PROCEED, can significantly improve maternal knowledge concerning child growth and development (Andriyani et al., 2025).

After the intervention, both groups showed an increase in knowledge, but the intervention group demonstrated a much larger improvement. The control group had a modest increase in their post-test scores, while the intervention group experienced a dramatic rise in scores, showing the effectiveness of interactive education. This highlights the significant impact that participatory learning methods, which involve discussions, visual media, and active participant engagement, can have in improving understanding of complex health issues such as stunting prevention. This outcome further substantiates findings from other studies, which indicate that providing educational materials and counseling to mothers can notably improve their knowledge and dietary practices related to child feeding, thereby reducing the prevalence of stunting (Siregar et al., 2023). For example, maternal assistance programs providing education and counseling to pregnant women have been shown to significantly improve stunting prevention behaviors (Siregar et al., 2023). The magnitude of improvement in the intervention group underscores the value of structured educational content and interactive delivery in fostering greater retention and application of health information (Lestari et al., 2024).

The greater increase in knowledge in the intervention group can be attributed to the participatory nature of the education, where active engagement and discussion likely facilitated deeper understanding and retention compared to more passive information dissemination (Istanto et al., 2025). This supports findings from similar studies where interactive methods, such as video interventions and digital health applications, have proven highly effective in improving maternal knowledge regarding stunting prevention (Arum et al., 2025; Milfa et al., 2025). Active learning, where participants engage directly with the material through discussions and demonstrations, has been shown to enhance retention and understanding of the content (Prasetyo et al., 2023; Istanto et al., 2025). Furthermore, the use of visual aids and simplified language in educational materials has been shown to significantly improve comprehension and attitude shifts among mothers, leading to better preventive practices against stunting (Andriyani et al., 2025; Nurindah et al., 2025). The use of visual aids such as images and videos further reinforced the learning process, helping participants better remember and apply the information in real-world

situations (Istanto et al., 2025; Suliati et al., 2025). This educational approach, leveraging interactive media, significantly enhances parental empowerment in providing appropriate supplementary feeding to meet children's nutritional needs and effectively prevent stunting. This approach is more effective than passive methods like lectures or pamphlet distribution, which tend to result in lower levels of engagement and knowledge retention. This is consistent with evidence suggesting that educational interventions incorporating easily understandable media, like booklets and videos, are particularly effective in diverse audiences (Istanto et al., 2025).

These findings suggest that interactive education is a powerful tool in improving public awareness and knowledge of stunting prevention. This approach facilitates the dissemination of crucial health information, empowering mothers and caregivers to implement effective preventative measures against childhood stunting (Maryati et al., 2022). Such an approach can significantly contribute to behavior change by fostering a deeper understanding of nutritional practices and their impact on child development, echoing findings that health education equipped with visual media effectively transmits information and empowers individuals (Rachman et al., 2025). However, to ensure long-term behavioral changes, ongoing support is essential. This could include follow-up sessions, digital media for continued education, and integration of such programs into broader public health initiatives. Moreover, the strategic incorporation of low-cost, easily replicable media, such as booklets and flip charts, offers a sustainable pathway for scaling these educational interventions across various communities, amplifying their reach and impact (Istanto et al., 2025; Nurindah et al., 2025). By combining interactive learning with consistent reinforcement, it is possible to optimize stunting prevention efforts and create a lasting impact on maternal and child health outcomes. The adoption of interactive posters, for instance, has been shown to significantly enhance maternal knowledge due to their engaging and easily comprehensible nature, thereby promoting better preventive practices (Wardani et al., 2023). This emphasizes the importance of making complex health information accessible and engaging to effectively bridge the gap between health recommendations and household practices, contributing significantly to improved nutritional status in children (Istanto et al., 2025).

3.5.4 Implications and recommendations of research

This research highlights the effectiveness of interactive education in improving the knowledge of pregnant women regarding stunting prevention, underscoring the potential for such interventions to be scaled and integrated into broader public health strategies to combat malnutrition (Sukmawati et al., 2020). The significant increase in knowledge among the intervention group demonstrates that participatory learning methods, such as discussions and visual media, can significantly enhance understanding and retention of health information. This suggests that interactive educational initiatives could be particularly valuable within existing maternal health programs to improve nutritional literacy and foster sustainable dietary practices among expectant mothers. These findings suggest that interactive education programs could be an essential tool in public health initiatives aimed at improving maternal health and reducing stunting in at-risk communities. By increasing awareness, these programs contribute not only to individual well-being but also to broader public health goals. The replicability and cost-effectiveness of educational tools like booklets and videos further support their integration into widespread stunting prevention programs (Istanto et al., 2025).

Based on the findings of this study, it is recommended that interactive education be integrated into public health programs aimed at pregnant women, especially in regions with limited access to traditional health education services (Maryati et al., 2022). To ensure long-term behavior changes, ongoing support should be provided through follow-up sessions, digital platforms, and continuous engagement with health workers. This comprehensive approach, encompassing various educational techniques like role-playing and games, has demonstrated considerable success in improving maternal knowledge regarding nutrition,

balanced diets, and reproductive health (Permatasari et al., 2021). These sustained efforts can significantly enhance maternal knowledge, attitudes, and practices, ultimately contributing to improved maternal and infant health outcomes and a reduction in childhood stunting (Permatasari et al., 2020; Siregar et al., 2023). Furthermore, the scalability of such educational programs should be explored to reach a wider audience, particularly in rural or underserved areas, to maximize their impact on maternal and child health outcomes. Further research should focus on implementing and evaluating these interventions in diverse cultural contexts, considering the adaptation of educational materials to local languages and customs to maximize their effectiveness and community acceptance (Permatasari et al., 2021). Moreover, improved knowledge and attitudes among mothers are likely to impact long-term health outcomes, as these attributes have been shown to influence dietary choices and, consequently, children's health (Pasaribu et al., 2025).

4. Conclusion

This study highlights the effectiveness of interactive education in improving pregnant women's knowledge about stunting prevention and maternal health. The significant increase in knowledge observed in the intervention group demonstrates the benefits of engaging, participatory learning methods compared to traditional one-way educational techniques. By incorporating active participation and visual media, interactive education not only enhances understanding but also encourages behavior change, leading to healthier pregnancy practices. These results suggest that implementing interactive education within public health programs can help reduce stunting and improve maternal and child health, especially in communities with limited access to formal health education. To achieve long-term success, it is crucial to provide continuous support and follow-up to reinforce the learned concepts and sustain the behavioral changes.

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Author Contribution

Both authors contributed equally to the study's conceptualization, methodology, data collection, analysis, and manuscript writing. They approved the final version and are accountable for all aspects of the work.

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The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author(s) used a generative AI tool to assist in

paraphrasing certain sections for clarity and Grammarly to assist in improving the grammar and academic tone of the manuscript. After using these tools, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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