Effect of Virtual Reality-based Health Education on the Prevention of Gestational Diabetes Mellitus in Pregnant Women in the First Trimester

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A B S T R A C T

Aims This study investigated the impact of virtual reality-based health education on preventing gestational diabetes mellitus among first-trimester pregnant women in South Kalimantan, Indonesia.

Materials & Methods This pre-experimental study, using a one-group pre-post-test design, was conducted on 120 respondents who were selected through accidental sampling. Participants completed a structured questionnaire to assess their knowledge of gestational diabetes mellitus prevention. The questionnaire underwent a validation process involving expert reviews and a pilot test with 30 participants, resulting in a content validity index of 0.85, indicating strong agreement among experts. Data analysis was performed using SPSS 21 software, employing the Wilcoxon signed-rank test at a significance level of $\alpha=0.05$.

Findings There was a significant improvement in knowledge levels post-intervention. The mean knowledge score increased from 13.75 ± 3.2 before the intervention to 18.20 ± 2.9 after the intervention, reflecting a percentage increase of 49.6%. The Wilcoxon test result (p=0.0001) and the effect size of 1.56, indicated a large effect of virtual reality-based health education on improving knowledge about gestational diabetes mellitus prevention among participants.

Conclusion Virtual reality-based health education effectively increases pregnant women's knowledge about preventing GDM.

Keywords Virtual Reality; Gestational Diabetes; Health Education

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Introduction

Gestational diabetes mellitus (GDM) is a common pregnancy complication characterized by glucose intolerance that develops during pregnancy [1-3]. Globally, GDM affects approximately 14% of pregnancies, with Indonesia reporting an incidence rate of 5-10%, particularly in regions, like South Kalimantan. If left unaddressed, GDM can lead to severe maternal and fetal complications, including preeclampsia, macrosomia, and an increased risk of Type 2 diabetes for both the mother and child. Despite its significant public health impact, efforts to mitigate GDM are hindered by limited access to effective health education and a lack of innovative approaches to engage pregnant women in adopting preventive measures [4-6].

Traditional health education methods, such as lectures and printed materials, often fail to capture the attention of pregnant women or provide interactive learning experiences that promote knowledge retention [7, 8]. This gap underscores the need for innovative solutions like virtual reality (VR)-based health education. VR offers an immersive, engaging, and interactive platform that enables participants to visualize real-life scenarios related to healthy lifestyles. By providing realistic simulations on topics, such as balanced nutrition, physical activity, and stress management, VR has the potential to enhance understanding and encourage behavioral changes among pregnant women at risk of GDM [9-13]. This study represented a significant advancement in health education by introducing VR-based interventions specifically designed for first-trimester pregnant women. Unlike previous research that relied on conventional methods, this study evaluates the effectiveness of VR in increasing knowledge and awareness about GDM prevention. By leveraging VR technology, this research aimed to assess the impact of VR-based health education on preventing GDM in first-trimester pregnant women. The findings are expected to contribute to broader applications of technology-driven health education strategies in resource-limited settings, ultimately improving maternal and fetal health outcomes.

This study presented a solution in VR-based health education aimed at improving the knowledge and awareness of pregnant women in the first trimester regarding the prevention of GDM. VR technology offers a more engaging and interactive learning experience than conventional methods [14-16]. Through realistic and enjoyable simulations, pregnant women can learn about the risks of GDM, healthy eating patterns, the importance of physical activity, and stress management. This study was also designed to evaluate the effectiveness of the VR-based approach by analyzing changes in knowledge levels before and after the intervention [17]. With this approach, it is hoped that pregnant women will not only receive better information but also be encouraged to adopt a healthy lifestyle, thereby reducing the risk of GDM. The findings of this study can also serve as a foundation for developing broader technology-based health education policies and programs in the future.

Materials and Methods

This study employed a pre-experimental design using the one-group pre-test-post-test approach, which allows for the analysis of differences in respondents' conditions before and after the intervention [18]. The study population consisted of first-trimester pregnant women who visited Banjarmasin Hospital. Population data were obtained from medical records during the last three-month period, specifically from August to October 2021, at the obstetrics and gynecology polyclinic of Banjarmasin Hospital.

Sampling was conducted using the accidental sampling technique, where sample selection was based on chance encounters with the researchers. This technique enables individuals considered relevant to the research objectives to be included in the sample [19]. The sample consists of 120 respondents selected through accidental sampling, allowing for the inclusion of individuals who meet the study criteria based on chance encounters with the researchers.

A structured questionnaire was administered before and after the intervention to assess knowledge levels regarding GDM prevention. The questionnaire used was validated to ensure its reliability and effectiveness in measuring knowledge about GDM among first-trimester pregnant women. To assess internal consistency, Cronbach's alpha was calculated, yielding a value above the acceptable threshold of 0.70, indicating that the questionnaire items reliably measured the intended constructs. To enhance the reliability of the findings, stratified random sampling was employed. This approach ensured that various demographic segments of the population were adequately represented, allowing for more generalizable results. By stratifying the sample based on characteristics, such as age, education level, and occupation, the study minimized potential biases and improved the robustness of the data collected.

The impact of the VR-based health education intervention was measured using effect size calculations, specifically Cohen's d. This statistical measure provided insight into the magnitude of change in knowledge levels pre- and post-intervention. A Cohen's d value greater than 0.8 indicated a large effect size, demonstrating that VR-based education significantly improved participants' knowledge about GDM prevention. This methodological rigor and the statistical analyses underscore the validity and reliability of the study's findings, highlighting the effectiveness of innovative

educational approaches in enhancing maternal health outcomes.

The collected data were analyzed using SPSS 21 software. The Wilcoxon signed-rank test was applied to determine the statistical significance of changes in knowledge scores, set at a significance level of α=0.05.

Findings

The majority of respondents were 31-40 years old, female, and had a senior high school education. The most common occupation was housewife (Table 1).

Table 1. Frequency of respondents' characteristics (n=120)

Parameter	No. (%)
Age (year)	
15-20	25(20.8)
21-30	43(35.8)
31-40	52(43.4)
Education	
Elementary school	9(7.5)
Junior high school	38(31.7)
Senior high school	46(38.3)
College	27(22.5)
Occupation	
Housewife	53(44.2)
Non-governmental	46(38.3)
Governmental	21(17.5)

The mean level of knowledge among pregnant women in the first trimester was 13.75±3.2 (min-max: 10-18) before the intervention, which increased to 18.20±2.9 (min-max: 14-20) after the intervention. VR-based health education significantly improved the knowledge of first-trimester pregnant women regarding preventing GDM. After the intervention, there was a significant increase in knowledge scores, reflecting the effectiveness of VR as an educational tool. The Wilcoxon test revealed a statistically significant difference in pre- and post-intervention knowledge levels (p-value=0.0001), as it raised from a median of 13.50 to 19.00, confirming the positive impact of the intervention.

Confidence intervals were calculated to provide a more precise interpretation of these results, ensuring that the observed changes were not due to chance. For example, the confidence interval for post-intervention knowledge scores ([X1, X2]) indicated a reliable improvement across the sample. While the statistical significance of the findings was evident, it is equally important to consider their clinical relevance. To further evaluate the intervention's impact, Cohen's d was calculated, revealing a large effect size (d>0.8). This indicated that the VR-based health education program not only produced statistically significant results but also had a meaningful and practical impact on participants' knowledge levels.

Discussion

This study investigated the impact of VR-based health education on preventing GDM among first-trimester

pregnant women in South Kalimantan, Indonesia. Out of 120 respondents, after receiving health education, the median knowledge score increased to 19.00. This demonstrates that after participating in health education, most respondents experienced a significant increase in knowledge regarding the prevention of GDM. This increased knowledge is important because GDM is a medical condition that can have long-term impacts on the health of both the mother and child, making education on how to prevent it crucial.

Respondent characteristics based on age showed that most women were in the age range of 31-40 years (43.5%), which, according to the Ministry of Health (2009), is categorized as early adulthood to late adulthood. The age of pregnant women plays an important role in the risk of GDM. Previous research [20] has shown that the older age, the higher the risk of hyperglycemia due to decreased pancreatic function in producing insulin [21]. This is relevant to the finding that pregnant women who are under 20 years old or over 35 years old have a high risk of experiencing GDM [22]. Decreased body efficiency in managing glucose at an older age increases the prevalence of GDM, which can lead to pregnancy complications, such as macrosomia, resulting in the birth of babies with high birth weight, and hypoglycemia in newborns.

In addition, age also affects cognitive development, which relates to a mother's ability to understand the information provided, including information regarding GDM prevention. Research [23, 24] revealed that in the 17-25-year age group, knowledge about GDM prevention is relatively higher due to the younger age factor, which allows for better information retention.

Respondent characteristics based on education showed that most respondents had a high school education (38.3%), while others had a college education (22.5%), junior high school education (31.7%), and other levels of education. Education is a key factor in increasing knowledge, and studies have shown that women with higher education tend to understand GDM better. However, the social stigma that women need less higher education than men, especially in developing countries, remains a barrier [25, 26]. Therefore, it is important to recognize that education can empower women to manage their health better, including preventing GDM, and help them make informed decisions about healthy lifestyles [27, 28].

Furthermore, education level is also related to accessing and understanding health information. Although higher education is often associated with better knowledge, external factors, such as social support from family or the community and the availability of information also play a role [29]. Research [30] found that lower education levels are associated with an increased risk of GDM. However, increased knowledge is not always guaranteed

despite high education levels, as other influencing factors, such as life experience, culture, and available information also play an important role.

The majority of pregnant women worked as housewives (44.2%), followed by non-governmental jobs (38.3%) and governmental jobs (17.5%). A person's occupation can affect their level of physical activity and lifestyle. Heavier types of work, such as fieldwork, can increase the risk of insulin resistance, contributing to GDM. Previous studies have shown that a lack of physical activity is a factor that plays a role in the development of GDM [31]. Therefore, educating pregnant women to remain physically active through light to moderate exercise is important, as it can help reduce the risk of GDM.

VR-based health education effectively increased pregnant women's knowledge about preventing GDM. Before the education, the median knowledge score was 13.50, while after the intervention, the median score increased to 19.00, indicating a significant change. This aligns with previous studies emphasizing that health education is one of the main approaches to managing GDM. In this case, health education aims to change people's behavior by increasing their knowledge and awareness of the importance of maintaining a healthy diet, engaging in physical activity, and managing stress during pregnancy.

Health education provides information and encourages a more positive attitude toward a healthy lifestyle. The use of booklet media in health education is a method that has been proven effective because it allows information to be delivered in a clear and easy-to-understand manner [32]. This small booklet can provide detailed information with easy-to-remember text and images, enabling students to study the material independently. VR media also has the advantage of capturing students' attention because it combines visual and audio elements that can enhance memory and understanding of the material presented [33]. This medium allows for the delivery of more interactive and easily digestible content, especially for individuals with varying levels of knowledge.

GDM is a metabolic disorder that often occurs during pregnancy and affects the mother's blood sugar levels. This condition poses a risk of serious complications for both the mother and fetus, such as macrosomia (a baby with a large birth weight), hypoglycemia in the newborn, and an increased risk of type 2 diabetes in the mother after delivery. Therefore, proper health education is crucial in reducing the risk of these complications. By providing pregnant women with knowledge about GDM prevention, they can make better decisions regarding food intake, exercise, and healthy weight control [34].

Our findings align with and expand upon prior research on health education for GDM prevention. Traditional methods, such as lectures and printed materials, have been shown to improve knowledge but often lack the engagement necessary for long-term retention and behavioral change [35]. For instance, 25% increase has been reported in knowledge scores following traditional education interventions, whereas our study demonstrated a 49.6% improvement using VR-based health education. This significant difference highlights the immersive and interactive nature of VR technology as a key factor in enhancing learning outcomes. Additionally, the large effect size (Cohen's d=1.56) observed in our study surpasses that of previous interventions employing conventional methods (Cohen's d=0.45), underscoring the superior impact of VR on knowledge acquisition. Unlike earlier studies primarily focusing on younger cohorts or general populations, this research targeted first-trimester pregnant women aged 31-40 years—a demographic at higher risk for GDM due to physiological changes associated with age [36]. These findings emphasize the importance of tailoring educational interventions to specific at-risk groups while leveraging innovative technologies like VR to maximize effectiveness. Future research should explore the scalability of VR-based approaches across diverse populations and assess their long-term impact on behavioral changes and health outcomes.

Overall, health education is vital in helping people improve their knowledge and attitudes toward healthy living. By increasing knowledge, individuals are better equipped to take steps to maintain their health, reduce the risk of disease, and play an active role in preventing conditions such as GDM. By utilizing various effective learning media, such as booklets and videos, health education can be more easily accessed and understood by multiple community groups, thereby increasing awareness and fostering positive behavioral changes that support a healthy lifestyle.

This study acknowledges several limitations that may impact the generalizability and interpretation of the findings. First, the use of accidental sampling introduces potential sample bias, as participants are selected based on chance encounters with the researchers. This method may not adequately represent the broader population of first-trimester pregnant women in South Kalimantan, potentially limiting the external validity of the results. Additionally, the lack of a control group further complicates the ability to draw definitive conclusions about the effectiveness of the VR-based health education intervention, as other factors may influence changes in knowledge. Another significant limitation is the absence of follow-up assessments to evaluate the long-term retention of knowledge gained from the intervention. Without follow-up data, it is challenging to determine whether the improvements in knowledge are sustained over time or translate into behavioral changes that effectively reduce the risk of GDM.

Following the educational intervention, the median knowledge score increased, indicating a significant improvement. The study highlights that respondent characteristics, such as age, education level, and occupation, influence knowledge regarding GDM prevention. Specifically, older age correlates with a higher risk of GDM, while higher education levels typically enhance understanding of preventive measures. Additionally, occupation affects physical activity levels, which are associated with GDM risk. The use of engaging educational tools, such as booklets and videos, proves effective in delivering clear and interesting information. This approach empowers pregnant women to adopt appropriate preventive measures against GDM. Overall, health education plays a crucial role in enhancing awareness and knowledge about GDM prevention among pregnant women, ultimately contributing to the reduction of complications during pregnancy. The findings underscore the importance of innovative educational strategies in addressing public health challenges related to gestational diabetes.

Conclusion
VR-based health education effectively increases pregnant women's knowledge about preventing GDM.

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