

## Original Research Article

# EFFECTIVENESS OF AUGMENTED REALITY-BASED THERAPEUTIC PATIENT EDUCATION ON HEALTH LOCUS OF CONTROL IN TYPE 2 DIABETES MELLITUS PATIENTS

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### Abstract

**Background:** Type 2 Diabetes Mellitus (T2DM) is a chronic disease with a rising global prevalence, significantly affecting patients' quality of life and the health system. Effective management of T2DM requires patients to actively regulate their diet, physical activity, and adherence to treatment. Health Locus of Control (HLC) measures the extent to which individuals believe their health is influenced by their actions (internal), others (powerful others), or chance. Augmented Reality (AR) technology presents an innovative method for therapeutic education, potentially enhancing patient engagement and learning effectiveness.

**Objectives:** To analyze the effect of Augmented Reality-based therapeutic patient education on health locus of control in T2DM patients.

**Methods:** A quasi-experimental design with pre- and post-tests and a control group was used. Non-probability purposive sampling selected 100 respondents, divided into an intervention group (50) and a control group (50). The Multidimensional Health Locus of Control questionnaire served as the research instrument. Univariate analysis described respondents' frequency distribution, mean, median, and standard deviation. Bivariate analysis utilized the Wilcoxon test.

**Results:** Augmented Reality based Therapeutic Education significantly improved HLC scores in T2DM patients: Internal ( $p = 0.01$ ), Powerful Others ( $p = 0.02$ ), and Chance ( $p = 0.00$ ). However, no significant difference was found between the intervention and control groups in terms of overall HLC improvement, indicating the need for further research to confirm these preliminary findings.

**Conclusion:** Augmented Reality-based Therapeutic Education shows promise in enhancing patients' perception of control over their health. This innovative approach could significantly impact clinical practice and patient education.

**Keywords:** *Augmented Reality, Health Locus of Control, Therapeutic Patient Education, Type 2 Diabetes Mellitus*

## INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a metabolic condition characterized by increased blood glucose levels caused by a combination of two main factors, namely impaired insulin secretion by pancreatic cells and the inability of body cells to respond to insulin (Galicia-Garcia et al., 2020). T2DM is a common chronic condition affecting millions of people worldwide and is a significant global health challenge and is associated with acute and chronic complications and can lead to reduced quality of life, morbidity and premature mortality (Fajriyah & Trisnawuri, 2023; Yılmaz et al., 2020). This disease requires strict management and patient compliance with treatment and a consistent healthy lifestyle to prevent long-term complications. However, patient compliance is often less than optimal due to various factors, including lack of awareness, self-confidence, and motivation to undergo the necessary lifestyle changes (Hati et al., 2021). One psychological concept related to patient adherence to chronic disease management is Health Locus of Control (HLoC). HLoC refers to an individual's beliefs about the extent to which they can control their health. Individuals with internal HLoC believe that their health outcomes are largely influenced by their own actions, while those with external HLoC believe that external factors such as fate, luck, or the actions of others play a greater role in determining their health (Haskas et al., 2019).

The International Diabetes Federation reported that in 2022 there were 537 million adults worldwide aged 20-79 years with diabetes. In 2023 this number is projected to increase to 643 million (1 in 9 adults) and 784 million (1 in 8 adults) in 2045. An estimated 240 million people have diabetes, 44% of whom are undiagnosed. Worldwide, 1 in 10 adults have impaired glucose tolerance. This increases the risk of developing T2DM (International Diabetes Federation, 2021). The results of the early detection survey of Diabetes Mellitus in Indonesia based on ASIK data were

14.05% (13,470,556 of 95,900,441 targets). East Java was ranked 12th (with a total of 14.80%) of the 35 provinces in Indonesia that were observed (Kementerian Kesehatan Republik Indonesia, 2023). The number of diabetes sufferers in Surabaya increased from 102,599 in 2017 to 115,460 in 2018 (Hasina et al., 2022).

Complications of T2DM can be classified into microvascular complications, such as retinopathy, neuropathy, and nephropathy, or macrovascular complications, including cardiovascular, cerebrovascular, and peripheral vascular disease (Mansour et al., 2023). DMT2 patients must be trained to carry out the 5 pillars of DMT2, which include effective self-care, adhering to treatment regimens, maintaining a healthy diet, and doing regular physical activity (Fajriyah et al., 2023) and monitoring their blood glucose levels (Fajriyah et al., n.d.). Innovative approaches are needed to improve patient education and self-management as achieving optimal self-care is challenging for individuals. (Adu et al., 2019). Therapeutic Patient Education (TPE) has been proven effective in the treatment of long-term diseases (Correia et al., 2023). Several studies have shown that TPE has been shown to be very effective in increasing medication adherence (Ortega Pacheco, 2024a).

One of the factors that influence medication adherence in patients with Type 2 Diabetes Mellitus (T2DM) is Health Locus of Control (HLoC). Research shows that HLoC is related to various aspects of health, including quality of life and blood glucose control. Patients with internal HLoC tend to be more proactive in following medical recommendations and living a healthy lifestyle, which in turn can improve their quality of life and help control blood glucose. In contrast, patients with external HLoC may feel less responsible for their health and more dependent on external factors, which can hinder effective management of T2DM (Juan et al., 2023). Patient Therapy Education (TPE) benefits patients, but there are still challenges in

maintaining the interest and engagement of patients with chronic diseases, especially when the information provided is complex or requires in-depth understanding (Ortega Pacheco, 2024). Advances in digital technology in recent years have opened up unprecedented opportunities for health education (Amjad et al., 2023). Technology is increasingly being used to improve health literacy. Augmented Reality (AR) offers contextual learning experiences and complements the real world with virtual objects. This is a beneficial learning approach for patients. However, to achieve this, a deeper understanding of the state of AR in health education and patient literacy is needed (Adapa et al., 2020).

Several early studies have explored the use of AR in the context of health education for chronic diseases. For example, a study showed that Virtual Reality and Augmented Reality positively impact patients with heart failure. This technology can reduce pain and anxiety levels, and improve patient experience and participation in rehabilitation programs. Nurses can use this technology at almost all stages of the nursing process, from assessment to implementation of nursing care (Kusumastuti & Herawati, 2024). Previous studies have revealed the positive impact of using digital education (AR) methods on the nutritional knowledge of pediatric patients with type 1 diabetes, especially regarding carbohydrate calculations, so it is important to conduct further research in adult patients. Meanwhile, other research discusses that Group therapeutic education is a useful tool for improving the metabolic control of persons with diabetes, by improving the level of knowledge of the disease that they suffer from and increasing their motivation to engage in self-care. The study underutilized modern technologies such as mobile applications and online platforms that could provide ongoing education and interactive support for patients (Casado-Hoces et al., 2024).

One of the new nursing intervention solutions for T2DM management is the

integration of the 5 pillars of T2DM into AR-based TPE. AR is expected to be more effective than traditional methods (such as booklets or lectures) because AR can increase learning engagement and retention through a more interactive and engaging experience. AR allows patients to see and interact with health information in a more realistic and practical context, which can improve their understanding and en So far, research on Therapeutic Patient Education based on Augmented Reality has not been able to be explained in health management. However, the specific use of AR for T2DM patients has not been explained. Based on these findings, there is great potential to further explore how AR can be used to improve HLOC in T2DM patients.

**Objective(s):** This study aims to analyze the effect of Augmented Reality-based Therapeutic Patient Education on health locus of control in DMT2 patients. It is hoped that the results of this study can provide new insights into the effectiveness of AR in increasing patient awareness and responsibility for their health. By using an innovative intervention approach, this study is expected to make a significant contribution to the health education literature and offer new strategies for more effective management of T2DM.

## METHODS

### *Study Design*

This type of research was Quasi Experiment, with a design of pre and post-test with control group design.

### *Setting*

This research was conducted in 3 private hospitals in Surabaya City, with a research period of 3 months, namely July to September 2024.

### *Research Subject*

Participants were recruited using non-probability sampling type of purposive sampling. The sample calculation using the Lemeshow formula, obtained a sample result of

100 respondents, consisting of 50 including the intervention group, and 50 control groups. Power analysis was conducted to ensure that the sample size was sufficient to detect a significant difference with a significance level of 0.05 and a power of 80%. The results of the power analysis supported that a sample size of 100 participants was sufficient to detect a significant difference between the two groups. The study subjects were the intervention group (Therapeutic Patient Education based on Augmented Reality), and the control group received standard health promotion therapy from the Hospital. The population of this study was all DMT2 patients in three Hospitals in Surabaya. Standard health promotion therapy content for the control group included face-to-face counseling by health workers and distribution of information booklets on the management of Type 2 Diabetes Mellitus. Meanwhile, the AR-based intervention included more interactive and in-depth educational content, with visual and simulation features designed to enhance patient engagement and understanding.

Inclusion criteria include: 1) DMT2 patients aged 18 - 65 years, 2) Cooperative and able to read, write, speak Indonesian well, 3) Compositentis awareness, 4) Patients can operate smartphones, 5) receive oral antidiabetic drug therapy. Exclusion criteria include: 1) patients with letter and color vision deficiencies, 2) hearing impaired patients, 3) pregnant patients, 4) patients with severe physical disorders (stroke, diabetic gangrene). Data collection lasted 3 months, and interventions for 3 times per week, lasting 60 minutes.

The selection of participants based on these criteria aims to ensure that participants have a basic understanding of their disease and are able to use the augmented reality (AR) technology used in the intervention. To reduce selection bias, participants who meet the criteria are taken from the patient list at three hospitals in Surabaya, then randomly selected from the list. This step was taken to reduce the

potential for selection bias and ensure the diversity of participants.

The intervention was given three times a week for three months. The selection of this frequency and duration was based on previous research showing that a three-month intervention can provide significant changes in health behavior and glycemic control in patients with Type 2 Diabetes Mellitus. The duration of three months was considered optimal to ensure that participants could apply and internalize the information provided without causing boredom (Nurlaily et al., 2021).

#### *Instruments*

The first measuring tool used in this research was collecting sociodemographic data using a questionnaire including (Age, gender, education level, profession, marriage status, and long-suffering DM). Researchers assisted respondents in conducting pre-tests and post-tests by filling out the Multidimensional Health Locus of Control (MHLC) questionnaire developed by Wallston in the 1970s and has been adapted into Indonesian, consisting of 3 sub-variables (Internal HLOC, Powerful Others, and Chance HLOC) totaling 18 items consisting of 6 items in each internal and chance dimension and 3 subscale items in the powerful others dimension, namely doctors and other people. There are 2 score categories, Low =  $X \geq \text{Mean}$ , High =  $x < \text{Mean}$ .

Construct validity and content validity were used to assess the questionnaire's validity. Confirmatory factor analysis was used to assess construct validity, making sure that each subscale's questions indeed measure the desired construct. To make sure the questionnaire items were pertinent and indicative of the construct being measured, content validity was assessed using expert opinion. The Cronbach's alpha coefficient for each subscale was used to gauge the questionnaire's reliability. Good reliability is indicated by an alpha value greater than 0.70.

Interpretation of MHLC scores is as follows: 1) Internal HLOC: A high score

indicates that individuals believe that their health outcomes are largely determined by their own actions. 2) Powerful Others: A high score indicates that individuals believe that their health outcomes are influenced by people with authority or power, such as doctors or other health care professionals. 3) Chance HLOC: A high score indicates that individuals believe that their health outcomes are largely influenced by luck or fate.

### *Intervention*

In the initial stage, an explanation of the research procedure was given to the intervention and control groups. Research subjects who were willing to become respondents then signed a consent form to participate as respondents.

Furthermore, the intervention group received augmented reality-based patient education using markers available in the booklet. The TPE-AR DM2 application is integrated with the 5 Pillars of Diabetes Mellitus Management. AR technology consisting of 3 Dimensions (3D) combined with Interactive Media provides interactive and immersive education to patients. In the context of reducing fasting blood glucose levels, this education includes realistic visual simulations of how a healthy lifestyle, including diet, physical activity, and adherence to treatment, can affect blood glucose levels, and is equipped with educational games about diabetes. Graphic design and 3D modeling software is used to generate 3D simulations that allow for realistic visualization. To trigger interactive content, the app can be accessed through a booklet using an AR barcode marker. Each interactive media is designed to target the five pillars of diabetes management: disease education, diet, physical activity, blood glucose monitoring, and medication. The app also includes quizzes to test patient knowledge, and explanations of the elements of diabetes management.

The intervention was given three times a week and the therapy lasted for three months. The control group received a booklet without

Therapeutic Patient Education and received standard therapy from a health institution. Construction and assessment were carried out through online communication with all respondents.

### *Data Analysis*

Data were analyzed for patients who met the inclusion criteria and who participated in the study from the beginning to the end using the Statistical Package for Social Sciences (SPSS v.27). Descriptive statistical analysis included descriptions of the socioeconomic characteristics of the study population, and other behavioral and clinical data using frequencies, percentages of qualitative data and means and standard deviations for quantitative variables. Bivariate analysis uses the Wilcoxon Test, because to determine the difference in the mean pretest and posttest values because the data was not normally distributed, to testing the efficiency of therapeutic patient education in improving Health Locus of Control. Inferential analysis was used to test the hypotheses with statistical significance at  $\alpha \leq 0.05$ .

### *Ethical Consideration*

This study has obtained ethical approval from the Research Ethics Committee (KEP) of the Hospital, Surabaya with No. 153.EC.KEP.RSIAY.08.24 in 2024, and has been guided by 3 research principles, 7 WHO standards 2011 and 25 CIOMS Guidelines 2016.

## **RESULTS**

### **Univariate**

Table 1 shows that there is no difference between the treatment (intervention) group and the control group, and the majority of respondents are aged 18 – 44 years with a total of 34 people (68%). Most of the respondents who participated in this study were female, with a total of 56 people (56%). The majority of respondents in both groups had a marital status of married with a total of 80 people (80%). Most of the respondents who

participated in this study in the intervention group, namely 24 people (48%) had a final education of Senior High School (SMA) and 19 people (38%) had a final education of college. The majority of the work in the treatment (intervention) group and the control group was in the other job category (other than Civil Servants) with a total of 73 people (73%). In the subcategory of duration of diabetes mellitus (since initial diagnosis), the majority of respondents who participated in this study had suffered from diabetes mellitus for  $\geq 5$  years, namely in the intervention group there were 25 people (50%), while in the control group there were 27 people (54%).

**Tabel 1. Characteristics of Respondents**

Variable	Intervention Group		Control Group	
	F	%	F	%
<b>Age</b>				
Middle Age	10	20	9	18
Elderly	18	36	14	28
Young	22	44	12	24
Total	50	100	50	100
<b>Gender</b>				
Man	20	40	22	44
Woman	15	30	13	26
Total	50	100	50	100
<b>Education Level</b>				
Elementary School	5	10	6	12
Junior High School	17	34	13	26
Senior High School	24	48	12	24
Higher Education	4	8	19	38
Total	50	100	50	100
<b>Profession</b>				
Not Working	10	20	12	24
Civil Servants/TNI/POLRI	3	6	2	4
Other	37	74	26	52
Total	50	100	50	100
<b>Marriage Status</b>				
Married	35	70	30	60
Widow/Widower	15	30	20	40
Total	50	100	50	100

<b>Long Suffering DM</b>				
< 5 years	25	50	23	46
$\geq 5$ years	25	50	27	54
Total	50	100	50	100

Based on the following Table 2, namely in the pre-test, the results of Health Locus of Control where the internal sub-variable Health Locus of Control in the intervention group were mostly in the low category, namely 12 people (24%) where respondents who have confidence in their health with external influences are more dominant than themselves. In the Health Locus of Control category Powerful Others, the majority are in the high category, namely 41 people (82%) where patients who have confidence in controlling their health all entrust it to others (health workers and family). Health Locus of Control category chance as many as 45 people (90%) are mostly in the high category, which means that patients believe more in fate, destiny, luck, or opportunities that have a major influence on their health. After receiving Augmented Reality-based Therapeutic Education intervention, most respondents believe that internal factors can control individual health with a total of 44 people (88%).

**Bivariate**

After receiving Augmented Reality-based Educational Therapy treatment using the TPE-AR DM2 application media, the three HLOC subvariables—Internal ( $p=0.01$ ), Powerful Others ( $p=0.02$ ), and Chance ( $p=0.00$ )—in the intervention group showed a P value  $<0.005$ , namely Sig  $<\alpha$ , based on the Wilcoxon Test results in Table 3. This shows that there is an effect of Augmented Reality-based Educational Therapy on Health Locus of Control in the intervention group.

**Table 2 Description of Health Locus of Control Before and After Treatment in the Intervention and Control Groups**

Variable	Sub Variable	Category	Before Treatment		After Treatment	
			f	%	f	%
			Health Locus of Control (Intervention group)	Internal	Low	12
		High	38	76	44	88
		Total	50	100	50	100
	Powerful	Low	9	18	14	28
		High	41	82	36	72
		Total	50	100	50	100
	Others	Low	5	10	15	30
		High	45	90	35	70
		Total	50	100	50	100
Health Locus of Control (Control group)	Internal	Low	14	28	10	20
		High	36	72	40	80
		Total	50	100	50	100
	Powerful	Low	12	24	11	22
		High	38	76	39	78
		Total	50	100	50	100
	Others	Low	17	34	14	28
		High	33	66	36	72
		Total	50	100	50	100

The control group was only standard therapy from a health institution without TPE-AR. The results show that the third HLOC sub-variable in the control group has a P value > 0.005, namely Internal (p = 0.13), Powerful Others (p = 0.14), and Chance (p = 0.90).

**Tabel 3. Wilcoxon Test of Augmented Reality-based Therapeutic Education on Health Locus of Control in the Intervention and Control Group**

Variable	Sub Variable	Category	Mean ± SD	Z	P Value
Health Locus of Control (Intervention group)	Internal	Pre-test	21.46 ± 5.05	3.358	0.01
		Post-test	25.88 ± 3.48		
	Powerful Others	Pre-test	22.78 ± 4.45	3.041	0.02
		Post-test			

Chance	Pre-test	18.42 ± 5.18	5.737	0.00
	Post-test	28.74 ± 5.07		
Internal	Pre-test	21.94 ± 4.96	1.516	0.13
	Post-test	23.16 ± 5.415		
Powerful Others (Control group)	Pre-test	21.94 ± 4.96	1.451	0.14
	Post-test	23.06 ± 5.45		
Chance	Pre-test	21.94 ± 4.96	0.123	0.90
	Post-test	21.94 ± 4.96		

The P value > 0.005, namely Sig < alpha, indicates that there was no significant change in the three HLOC sub-variables in the control group after the study period. Thus, the standard intervention given to the control group did not have a significant impact on their beliefs about control over their health.

**DISCUSSION**

The results showed that the three Health Locus of Control sub-variables, namely Internal, Powerful Others, and Chance in the intervention group after receiving Augmented Reality (AR)-based Therapeutic Education treatment using the TPE-AR DM2 application media showed a P value <0.005. This means that the alternative hypothesis (H1 is accepted, which indicates that there is a significant effectiveness of Augmented Reality-Based Therapeutic Patient Education on HLOC in the

Internal, Powerful Others, and Chance categories. A significant increase in internal locus of control indicates that participants feel more able to control their health conditions after participating in the TPE-AR DM2 program.

It is important to note that the success of AR technology is highly dependent on the extent to which patients can interact with and understand the application provided. Some patients may find it difficult to use this technology, especially if they are not familiar with digital devices. Therefore, to maximize the benefits of AR, it is necessary to ensure that all participants have an adequate level of skill in using the application, as well as adequate access to the necessary devices, so in this study there needs to be assistance from nurses and families. In addition, the duration of the intervention is an important factor in determining its effectiveness. If the duration of the AR-based intervention is too short, patients may not have enough time to fully engage with the educational materials and to feel changes in their beliefs about health control, so this study considered a duration of three months to obtain maximum tested results.

The results of this study are in line with previous studies, only the difference lies in the implementation technique, that group therapy education is a useful tool to improve metabolic control in diabetes sufferers, by increasing the level of knowledge about the disease they suffer from and increasing their motivation to carry out self-care (Casado-Hoces et al., 2024). The results of previous research on the Utilization of Augmented Reality to Improve Nutrition Education in Children and Adolescents with Type 1 Diabetes. This study revealed the positive impact of using digital education methods (AR) on the nutritional knowledge of diabetes patients, especially regarding carbohydrate calculations (Alshebil et al., 2023).

Augmented Reality-Based Therapeutic Patient Education, with an Augmented Reality-based application, may have provided more

interactive and interesting education, helping participants to better understand and master information about diabetes management, which in turn increases their sense of internal control. Although an increase in powerful others locus of control can be considered negative because it indicates dependence on others, in the context of diabetes management, this could mean that participants are becoming more aware of the importance of following advice and instructions from health professionals. Education through AR may have emphasized the importance of collaboration with healthcare professionals in managing their condition, thereby increasing participants' belief that professional help is essential. A significant decrease in chance locus of control indicates that participants became less likely to believe that their health is controlled by chance or fate after the intervention. This is a positive outcome, as the belief that health is controlled by chance can lead to a passive attitude towards health management. AR-based education may have provided clear and concrete information about how behaviors and medical interventions can affect health, reducing the belief that fate plays a major role.

Many lifestyle habits must be carried out by people with type 2 diabetes mellitus (T2DM), such as controlling blood sugar, exercising, taking medication, and maintaining a healthy diet (Chacko & Signore, 2020). This condition can cause unhealthy psychological reactions when they are controlling their health condition. Diabetes management involves strict routines such as monitoring blood sugar levels, regulating diet, and taking medication regularly (Ahmad & Joshi, 2023). The inability to manage the disease properly can cause anxiety and stress. Each individual has a different way of dealing with stress caused by their health condition. Coping mechanisms are strategies used by a person to deal with stress and negative emotions (Nuetzel, 2023).

Health locus of control, which is a person's belief in controlling their current health condition, can come from past



experiences (internal) or from external forces (powerful others or coincidences) that control their health. This is one of the factors that influence coping mechanisms (Kurniawan et al., 2024). HLOC can influence how a person deals with stress and the health challenges of T2DM. Individuals with an internal locus of control tend to use more proactive and positive coping mechanisms. They believe that they have the ability to influence their health through the actions and decisions they make. They may be more disciplined in following treatment regimens, making healthy lifestyle changes, and seeking additional information about managing their disease (Gerçek & Özveren, 2024). Examples of proactive coping include diabetes management planning, regular blood sugar monitoring, and active involvement in health education programs. Individuals with a powerful others locus of control may rely more on support and guidance from health professionals. Their coping mechanisms may involve working closely with doctors, nurses, and health counselors. They are more likely to comply with medical advice and instructions (Siennicka et al., 2022). Examples of collaborative coping include attending regular medical appointments, following recommended therapies, and consulting with a nutritionist or fitness trainer. Individuals with a chance locus of control may feel less in control of their health and are more likely to use more passive or avoidant coping mechanisms. They may feel that their efforts will not significantly change their health outcomes, making them less motivated to follow health recommendations or make necessary lifestyle changes (Haskas et al., 2019). Examples of passive coping include ignoring medical instructions, avoiding routine checkups, and not seeking information about their health condition.

Each person's locus of control is different because each person has different assessments and experiences, which ultimately affect their behavior (Mulyani et al., 2023). In this study, disease control in DMT2 patients includes controlling blood sugar levels, diet,

activity, and emotional control, each of which will have an impact on their health status (Barteit et al., 2021). Increasing HLOC for health in a positive direction. This shows that patients are more likely to take responsibility for their own health and comply with self-management guidelines for their blood sugar stability (Hati et al., 2021). In the powerful and chance locus of control variables before and after treatment, the majority are in the high category where the majority of patients have confidence in controlling their health, all of whom entrust it to other people, be it health workers or family, and have the assumption that in controlling their health, apart from destiny, luck or opportunity can affect their health (Hati et al., 2021). Powerful and challenging variables are part of external HLoC where health control becomes an external responsibility, namely health control in diabetes patients whose responsibility is others (health workers and family) and also fate, destiny, and luck are not the result of one's own responsibility (Zielińska-Więczkowska, 2016). This is in line with previous research that psychoeducational therapy can improve the HLOC status of T2DM patients. Through psychoeducation, patients are taught practical skills to manage T2DM such as diet, physical activity, blood sugar monitoring, and medication use. With these skills, patients feel more able to control their condition (ElGerges, 2020).

Understanding a patient's HLOC can help healthcare professionals create more appropriate and effective interventions that can improve patients' coping mechanisms and, ultimately, improve patient health outcomes. Interventions aimed at improving internal locus of control, such as interactive health education and patient empowerment, can make patients feel more in control of their own health and make patients more motivated to adhere to treatment regimens. The results of this study have important clinical implications. AR-based therapeutic education can be used as an effective tool to improve patients' HLoC and

self-efficacy in their ability to manage their own health conditions, including controlling blood glucose levels by implementing health behaviors in accordance with therapeutic education integrated with the 5 (five) pillars of Type 2 Diabetes Mellitus. Programs such as TPE-AR DM2 can help patients understand the importance of active involvement in their care and strengthen their belief in the effectiveness of medical actions recommended by healthcare professionals. Further research could investigate how personalized content can improve patient outcomes. For example, providing more specific information about diabetes treatment tailored to a patient's characteristics and lifestyle habits could make the material more engaging and useful.

## CONCLUSION

The results showed that the three Health Locus of Control subvariables, namely Internal, Powerful Others, and Chance in the intervention group after receiving Augmented Reality (AR)-based Therapeutic Education treatment using the TPE-AR DM2 application media showed a P value  $<0.005$ . These results indicate that the intervention carried out had a significant effect on the perception of individual health control in the intervention group. Based on the results of the study, providing Augmented Reality-Based Therapeutic Patient Education was very effective in increasing Health Locus of Control in Type 2 Diabetes Mellitus patients. Overall, the intervention using the TPE-AR DM2 application was proven effective in modifying the perception of health control in Type 2 Diabetes Mellitus patients, by increasing their confidence in managing their personal health and utilizing support from health workers, as well as reducing dependence on uncontrollable factors. The results of this study provide strong support for the use of augmented reality technology in therapeutic health education to improve patient engagement and health outcomes.

## SUGGESTIONS

This study has several limitations, Health Locus of Control measurement relies largely on self-report from participants, which can be susceptible to subjective bias and measurement error. Therefore, further research can use more objective assessment methods to improve the reliability of the results.

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## DECLARATION OF CONFLICTING INTEREST

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare no conflicts of interest during the research activities and publication of this article.

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## AUTHOR CONTRIBUTION

**Novita Fajriyah:** Conduct the study, collect the data, translation and submit this manuscript

**Susanti:** Conduct the study, coordinating participants, and data analysis

**Rina Budi Kristiani:** Conduct the study, provided access and coordinated participants.

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