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Original Research

Validity and User Satisfaction of Educational Applications for Preventive Care of Diabetic Foot Wounds: A Study in Elderly Diabetes Sufferers

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ABSTRACT

***Background**: Education on using smartphone applications among the elderly to prevent diabetic foot wounds is still limited. Especially if someone pays attention to the limitations of older people with diabetes, such as their lack of mastery in using smartphones, an educational application for preventing diabetic foot wounds, named Rawat Kaki, has been developed by considering various aspects that make it easier for older people to use. This application must be tested for validity and evaluated to obtain an overview of the satisfaction of its users.*

***Methods:** The design of this study was exploratory quantitative to see the validity of the application and respondent satisfaction using the Rawat Kaki App. The sampling technique used purposive sampling with a total sample of 140 respondents from the population of Persadia (Indonesian Diabetes Association) members at the RSUD: Surakarta City, Sragen, Salatiga, Klaten Islamic Hospital, and PrambananSleman Yogyakarta Hospital. Five diabetes experts in the medical and nursing fields conduct content validity. Furthermore, respondents tested it three times to measure their satisfaction using the EUCS (End User Computing Satisfaction) questionnaire.*

***Results:** The content validity test obtained a value of 1.02 and an alpha Cronbach reliability value of 0.765, so the Rawat Kaki application was declared feasible. Then, the data is collected through a regression test, obtaining an R-value of 0.689, which means 68.9% of application user satisfaction can be explained through the Rawat Kaki application.*

***Conclusion:** The high validity and satisfaction of respondents might be a reason to consider using this educational application.*

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INTRODUCTION

Since information technology—smartphones—has grown in use, there has been an increasing number of applications related to diabetes mellitus (DM) treatment. This treatment is in line with the increasing number of older people with diabetes who need

attention. The physiological limitations of people with diabetes, such as impaired vision, reduced mobility, and cognitive challenges, make it difficult for this age group to access vital information and healthcare services, further hindering their ability to manage their condition effectively.

The existence of advances in communication and information technology in the form of smartphones has given the elderly the opportunity to access information and nursing services easily. It is known that 46.79% of elderly people in Indonesia have access to information and communication technology facilities, 14.10% have communicated using cell phones, and 14.10% have accessed the Internet. This makes it easier for seniors to connect with their families and access information on health issues.

With the latest information and communication technology facilities, applications for elderly health have developed in Indonesia. These applications, especially in elderly health, have been developed by the government, individuals, and educational institutions to accommodate these conditions (Augia, T., Dahlan, H., Symond, D., Siswati, S., & Dewi, 2022). In Indonesia, the number of educational applications for preventing diabetic foot wounds developed by the government or other institutions is unknown.

Various types of work for diabetes sufferers all have the potential to experience one hazardous complication, namely wounds on the diabetic foot. For example, respondents who work as farmers in Madura experienced this. In Madura, 72.4% of farmers are at moderate risk of developing diabetic foot injuries, and 11.8% of patients are at risk of experiencing severe foot injuries. Various types of work for diabetes sufferers all have the potential to experience one hazardous complication, namely wounds on the diabetic foot. For example, respondents who work as farmers in Madura experienced this.

In Madura, 72.4% of farmers are at moderate risk of developing diabetic foot injuries, and 11.8% of patients are at risk of experiencing severe foot injuries. Complications in the form of diabetic foot wounds can lead to amputation if not treated properly. Before complications occur, taking steps to prevent foot injuries is necessary. This complication can be done, among other things, by providing education to every diabetic sufferer because they are at risk of developing diabetic foot wounds. Therefore, farmers with diabetes need intensive attention from medical personnel to provide education about the importance of foot protection while working (Rofiqi, M., Sutawardana, J. H., & Kushariadi, 2024).

Diabetes is the most common cause of non-traumatic amputation worldwide, and education is critical to prevention. Likewise, healthcare providers must develop nursing services using information technology to minimize direct clinic visits. This condition makes us realise that we must develop services and health education changes for diabetic patients to align with the 4.0 era. We need to be concerned about this condition because diabetes patients are known to have a high risk of developing foot injuries (Miranda, C., Zanette, G., & Da Ros, 2022). For this reason, researchers and developers have created a variety of information technology-based health education tools and platforms.

Smartphone applications like Android-based make it easier for people with diabetes to access diabetes counselling and home care services. However, developers need to address several weaknesses and deficiencies in the use of applications (Santoso, B. J., Qona'ah, A., & Frety, 2022). Obstacles to using smartphones when conducting education have been identified and resolved. It is also a fact that the application

developed must be more specific and centered on one specific problem, not too general or broad. For example, developers must create Android-based applications to improve foot care behavior by educating users about proper foot care (Cheng, Y. J., Masingboon, K., Samartkit, N., & Moungkum, 2023).

However, the developed application must be improved and tested before being operationalised as a smartphone application for diabetic foot risk reduction (Kilinc, M., & Karadağ, 2020). Even more so when a person with diabetes suffers, remember that various types of tools and operating system platforms underlie applications. Many educational applications use the Android Operating System (AOS) as a platform. This operating system has many advantages and is easy to operate. It is considered more cost-effective, and its users are extensive in society (Mehraeen, E., Mehrtak, M., Janfaza, N., Karimi, A., Heydari, M., Mirzapour, P., & Mehranfar, 2022).

Older people with limited reach and mobility can use smartphones as a learning medium to access anytime. The research results state that smartphones are an alternative medium everyone can use to convey the necessary information without time or place restrictions. This method also simplifies activities to quickly access information anytime and anywhere (Sugandi, M., & Halim, 2020). The development of information technology in the Industrial Era 4.0 requires the development of nursing services to adjust to the changing landscape. The research aims to develop validated educational applications that provide satisfaction to elderly users so that cell phones, such as smartphones, a means of nursing education services, can be easily accessed anytime and anywhere and can be repeated.

MATERIAL AND METHOD

This research used an exploratory quantitative design to develop and validate the foot care educational application. We base data collection on application user satisfaction as measured by the End User Computing Satisfaction (EUCS) Questionnaire. The aspects measured include content, accuracy, format, ease of use, and timeliness. Patients with type 2 diabetes as a population are members of Persadia (Indonesian Diabetes Association) at Fatmawati Sukarno Hospital, Surakarta City; Klaten Islamic Hospital; Sragen Regency Hospital; Salatiga City Hospital; and Sleman Regency Hospital, Yogyakarta, as many as 980 people. We used purposive sampling to select samples and calculated the sample size using the Slovin formula with a 95% confidence level. We obtained a sample of 140 participants who did not have foot ulcers.

The programming languages used are JavaScript, TML5, PHP, and MySQL database. We named the application Rawat Kaki and hosted it on the Play Store service. Based on the research results, recommended features in the diabetes application are daily foot care and prevention of foot wounds (Ogrin, R., Viswanathan, R., Aylen, T., Wallace, F., Scott, J., & Kumar, 2018). So this application's features include patient data, a questionnaire containing instructions on how to care for feet, and learning to care for feet in the form of pictures and videos. A reminder feature reminds patients to take care of their feet daily. Using reminder applications regularly reminds patients and helps with self-care at home (Gusdiani, I., 2021).

Several stages are needed for good application design and validity (Nabovati, E., Rangraz Jeddi, F., Tabatabaeizadeh, S. M., Hamidi, R., & Sharif, 2022). The research used five stages: First, determining the content reviewed based on clinical practice guidelines. Second, information technology experts designed and developed the

application using Java. Third, the content validity index test should involve at least three experts but not more than ten people (Polit, D. F., Beck, C. T., & Owen, 2007). Therefore, this research involved five experts. Consisting of two internal medicine specialists and three diabetes exceptional education nurses from Indonesia.

Fourth, testing was carried out on respondents, starting with explaining the Rawat Kaki educational application. When using the application for the first time, respondents were explained how to download it on Playstore and then asked to fill in their biodata. Next, the respondent can try to start using the application, such as filling out a questionnaire about the condition of the foot care that the respondent is currently doing, and a score will appear about whether the foot care that the respondent has done is good or bad.

After knowing the score, respondents can start learning to care for their feet, starting by watching videos on how to care for their feet, reading foot care booklets, and watching videos of foot exercises. Next, learn to check foot sensitivity using videos and read tips on how to prevent foot injuries. Also available in this application are reminders to carry out foot care every day. So that respondents can use the application well, they are given assistance on how to use the application at least three times within two weeks.

All respondent activities when accessing the application were recorded via Google Forms in the form of a spreadsheet. Fifth, respondent satisfaction data was collected using the End User Computing Satisfaction (EUCS) instrument, which has been used significantly in the last ten years (Doll, W. J., & Torkzadeh, 1988). The results of validity and reliability tests in a study using EUCS stated that all indicators were declared valid and reliable with an AVE value > 0.50 in validity testing and a composite reliability value > 0.70 in reliability testing (Aprilia, S, Samsuryadi., 2021).

The data collected in Linkert form consists of Very Satisfied (4), Satisfied (3), Dissatisfied (2), and Very Dissatisfied (1). For the validity test, the value of r = 0.034, and for the reliability test, Cronbach's alpha value = 0.765. Whereas the Content Index Validity test value (CVI) = 1.02. The Health Research Ethics Commission of Muwardi Hospital Surakarta issued the research ethical feasibility permit on April 28, 2024, with the number 903/IV/HREC/2024.

RESULTS

The following is a display of the front page (Figure 1) and feature pages of the foot care educational application (Figure 2).

Figure 1. Display of the front page

Figure 2. Feature pages of the foot care educational application

Next, the results of the content validity test of *the Rawat at Kaki* application conducted by five diabetes experts in the medical and nursing fields are shown below:

Table 1. Distribution of Content Validity Proportion of *Rawat Kaki* Application

Aspect EUCS	Proportions					Mean i-CVI
	R1	R2	R3	R4	R5	
Contain	1	1	1	0,75	1	0,99
Accuracy	1	0,75	1	1	1	1
Format	0,75	1	0,75	1	0,5	0,8
Easyof Use	0,75	1	0,75	0,5	1	0,8
Timeliness	1	1	1	1	1	1
S-CVI 1,02						

To see how satisfied respondents are using the *Rawat Kaki* education application, it can be seen in Table 2 below.

Table 2. Distribution of Respondent Satisfaction Based on EUCS Aspects

Satisfaction level	Aspect EUCS									
	Content		Accuracy		Format		Ease of use		Timeliness	
	n	%	n	%	n	%	n	%	n	%
Very dissastified	2	1,5	2	1,4	40	28,5	15	10,7	5	3,6
Dissatisfies	5	3,5	5	3,6	6	4,4	55	39,3	15	10,7
Satisfied	103	73,5	105	75	80	57,1	50	35,7	100	71,4
Very satisfied	30	21,5	28	20	14	10	20	14,3	20	14,3

Table 2 shows that the distribution of respondents' satisfaction with the content aspect obtained the most satisfied data. We can see the same in accuracy, format, and timeliness. As for the ease of use aspect, the respondents who were dissatisfied and satisfied were almost the same. Table 3 below presents the results of the correlation test of respondents' satisfaction with using the *Rawat Kaki* application as follows:

Table 3. Distribution of Respondent Satisfaction Correlations on EUCS aspects

Aspect EUCS	Coefficient				sig
	B	Std Error	Beta	t	
Contain	,083	,024	,278	3,478	,001
Accuracy	,100	,047	,173	2,101	,037
Format	,053	,036	,138	1,503	,135
Easeof Use	,044	,032	,119	1,367	,174
Timeliness	,133	,044	,239	3,001	,003

The analysis results of the correlation test obtained a correlation value between aspects of content, accuracy, and timeliness in EUCS and the elderly respondents' satisfaction when using the Rawat Kaki application. While the aspects of format and ease of use are not related, they get a value of 0.135 and 0.174 each, which means > 0.05. This data indicates that it is necessary to review application features in terms of format and ease of use of display. Similarly, we need to review the application of use by describing each feature in various ways. These are the results of the regression test analysis of patient satisfaction using the *Rawat Kak*i application.

Table 4. Correlation and Regression Analysis of EUCS Aspects and Respondent Satisfaction

Variable	r	R Square	p. value
Satisfaction	0,830	0,689	0,000

The correlation and regression analysis results strongly correlate with EUCS aspects and respondents' satisfaction with the Rawat Kaki application. It also shows that as many as 68.9% of respondents can explain their satisfaction with using the Rawat Kaki application. The correlation is also very significant (p. value = 0.000 < 0.005).

DISCUSSION

Researchers have studied the need for education through information technology-based applications as a new way to change the knowledge, attitudes, and behaviour of DM patients. So many smartphones and other applications have been created and used to educate diabetes patients (Wardoyo, N. B., & Kusumo, 2023). So many smartphones and other applications have been created and used to educate diabetes patients.

Developers have even created an app to address amputation risks and promote self-care practices to prevent serious foot complications. Many smartphones and other applications are created and used for education, even applications about amputation risks and self-care practices to prevent serious foot complications. The content uses simple images and words, focusing on early help-seeking behaviors (Ogrin, R., Viswanathan, R., Aylen, T., Wallace, F., Scott, J., & Kumar, 2018).

We also know that smartphone applications can potentially improve diabetes care. However, there is still no evidence of sustainability, so the impact of using the 1,100 applications available worldwide for diabetes care is unknown (Garabedian, L. F., Ross-Degnan, D., & Wharam, 2015). Until now, interest in developing smartphone-based health applications for treating people with diabetes continues to increase. This happens because it can be a promising new treatment modality. Other research also proves that respondents with an average age of 44 years found that most respondents experienced positive changes in their clinical course after using the application.

They also felt satisfied with the application and its completeness and would continue to use it to manage their diabetes. The results of this study indicate that the elderly respondents were satisfied with using the Rawat Kaki App. This is because the elderly are very concerned about health problems; they obtain health information from information technology such as smartphones and their applications. Several studies have shown that the elderly need access to health information, mainly through smartphone social media applications (Damayanti, K. A., & Hariandja, 2015). .

Most existing applications are only for detecting the risk of foot wounds rather than for preventing foot wounds. As has been researched, the most common serious complication in people with diabetes is diabetic foot ulcers due to delays in early identification by patients. This condition requires a breakdown to enable self-detection anytime and anywhere using one of the applications. However, it is necessary to investigate further the usefulness and effectiveness of mobile applications on patient behaviour in preventing foot ulcers with long-term follow-up (Agustini, N. L. P. I. B., Suniyadewi, N. W., Rismayanti, I. D. A., Faridah, V. N., Utami, R., Aris, A., & Nursalam, 2022).

Therefore, it can be understood that this research obtained the most satisfaction from respondents compared to dissatisfied and very dissatisfied respondents, except in terms of format and ease of use. The usage gap can explain the limitations of the elderly in cognition and vision and the ability to use smartphones. Therefore, several smartphone applications that have been developed need to be analyzed to determine the minimum features for diabetes applications (Salar, R., R Niakan Kalhori, S., GhaziSaeedi, M., Jeddi, M., Nazari, M., & Fatehi, 2021). This research also obtained the result that there is a strong correlation of satisfaction with the application's content. This indicates that the application's content is highly desirable for the elderly because it provides health information, especially the prevention of diabetic wounds.

Therefore, it can be understood that this research obtained the result that there is a robust correlation between satisfaction with five aspects of the application (p-value

0.000 < 0.05). The educational application appears very satisfying for the elderly, so the Rawat Kaki educational application can be used and developed again by paying attention to the lacking aspects of format and ease of use. It is expected that later, smartphone applications that offer great potential to support therapy management, improve therapy adherence, and prevent disease complications will continue to be pursued by paying attention to the features of mobile applications that are easy to use and capable of providing specific instructions (Izahar, S., Lean, Q. Y., Hameed, M. A., Murugiah, M. K., Patel, R. P., Al-Worafi, Y. M., ... & Ming, 2017).

The Rawat Kaki App in this research, based on a mobile system, can be developed using the cloud to make it more extensive, cheap, and flexible. Research shows that the use of mobile and cloud-based systems can be fulfilling and promising but requires further research with long-term follow-up (Salari, R., R Niakan Kalhori, S., GhaziSaeedi, M., Jeddi, M., Nazari, M., & Fatehi, 2021). Most elderly diabetics will experience difficulties using smartphone applications, as a study found several disadvantages of smartphones when used in the service of elderly diabetics.

Other researchers revealed that the available applications had to serve the unique needs of diabetic patients aged 50 years or more by conducting an expert usability evaluation (Arnhold, M., Quade, M., & Kirch, 2014). This is aimed at avoiding the possibility that the application is owned by their smartphones but rarely used. It is also explained that the functions of the existing applications often need help to fulfill the preferences of those over 56 years old (Wahyudi. C.T., 2019). Applications are expected to be tools for positive change because they can help clarify the information delivered with a more attractive and easy-to-operate display and involve the five senses. Research on the intention to do Rawat Kaki for the prevention of diabetic foot wounds found that the digital media contributed positively to increasing respondents' knowledge of preventing foot wounds (Susilawati, E. Lestari, Y.P. Nurrika, 2024).

In addition, in developing applications, it is very necessary to pay attention to the usability aspect. Hence, the users are easy to operate and provide benefits and satisfaction, especially for the elderly. For this reason, when developing the optimal feature design for elderly users, it is important to use images (Alsana., 2021). This has also been found in another research study, where the application must be friendly, the text must be bold, and large fonts must be used so that it is easy to read and can be easily understood (Sebastian, D., & Hawini, 2022). Thus, each application must be continuously evaluated and developed. It can be redesigned to make it easier to use, especially for elderly users (Duma Konda, V. W., Restyandito, R., & Nugraha, 2022).

It suggests that in order for the application to be used by the elderly, who are increasing in number of users, it is necessary to pay attention to several aspects, namely instructions on how to start using the application and the use of clear icons and buttons in the form of images or text (Wahyudi. C.T., 2019). The results of other research (not on the elderly) found that teenagers increased the receiving of knowledge about reproductive health by using Android applications because they are interesting, easy to operate, and involve many senses. However, it needs to be developed by adding pictures, animations, or videos to be more interesting (Dinengsih, S., & Hakim, 2020), (Yustin, E., Wijanarka, A., & Ashari, 2020).

The data obtained in this research shows that the respondents' education level is at least elementary school, and some respondents have a higher education. This affects the flow of research because the use of smartphone applications is influenced by educational level factors related to knowledge about foot care at risk of diabetic foot

wounds. The higher the level of education, the better the knowledge (Dincer, B., & Bahcecik, 2021). Another research revealed that an application was tested on nursing students as respondents to observe usability, with the results that the content and appearance of the application were considered the most important to be adequate so that the application is easy to use. Thus, educational research using applications to prevent hypoglycemia showed that the application-based diabetes education model on smartphones was feasible for detecting hypoglycemia (Damayantie, N., Ernawati, E., Dewi, M., & Fahmi, 2024).

Results of the research after regression testing found that the Rawat Kaki application has high content validity and a robust correlation with respondent satisfaction, even though some aspects are lacking, such as features and ease of use. So, considering that applications on smartphones already play an important role in complementing diabetes care, in order to be well received by users, the content and context of the problem should be regulated, and more customized behavior to the needs of users with clear guidance (Huang, Z., Soljak, M., Boehm, B. O., & Car, 2018). For example, the Rawat Kaki App with videos has been proven effective in increasing individuals' knowledge, self-efficacy, and behaviour concerning foot care (Dincer, B., & Bahcecik, 2021).

For this reason, in this research, the application content in the feature is combined with the booklet included in the application, considering that booklets also greatly influence education. It has been researched that smartphones with contextual learning models are more effective in improving self-care than education using booklets; however, both types of education can improve self-care in people with diabetes (Santoso, B. J., Qona'ah, A., & Frety, 2022). After this, healthcare solutions can be assisted using smartphone applications that provide personalised healthcare services, such as emergency calls and messages in real-time, crucial moments, and GPS reporting technology (Khan, F. A., & Khan, 2016).

The limitation of this research needs attention. Even though the application has been successful in helping people with diabetes, it found that it has limitations, such as limited use within a certain period, so it is necessary to review which aspects support and interfere with the use of the application (Ogrin, R., Viswanathan, R., Aylen, T., Wallace, F., Scott, J., & Kumar, 2018). The sample proportions based on gender, education level, occupation, and age were not determined.

Limitations also exist in the application features, which are one-way communication rather than two-way interaction. As a solution, further development is possible, such as developing two-way online-based education so that there is interaction between patients, families, and health workers, as carried out in research that produced an online application-based educational prototype called Telemondia (Isworo, A., Ramadhani, Y., Anam, A., Ekowati, W., & Azalia, 2021).

CONCLUSION

The research indicates that the Rawat Kaki App has a high validity test value. After being utilised by elderly respondents, it has a high level of satisfaction. Then, regression testing to determine that the application has a good model, which is 68.9% of the application, can explain patient satisfaction with using the Rawat Kaki application.

To be accepted into the model, it is recommended that the aspects of ease of use and format be improved. Two-way developing communication features must also be more interactive with users.

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Original Research

The Influence of Spiritual Care with Callista Roy's Adaptation Theory Approach on Serotonin Levels in Ischemic Stroke Patients

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ABSTRACT

Background: *Ischemic stroke causes physical disability, which can result in an inability to adapt, causing a 72% decrease in serotonin. Decreased serotonin can cause mood changes that adversely impact stroke outcomes. The aim of this research is to determine the effect of spiritual care using Callista Roy's adaptation theory approach on serotonin levels in Ischemic Stroke Patients.*

Methods: *The type of research is quasi-experimental with a pretest-posttest control group design. The population of the study was outpatients of ischemic stroke patients at Dr. Moewardi Hospital. The sample size was 60 respondents consisting of 30 respondents in the control group and 30 respondents in the intervention group. The intervention group was given a spiritual care intervention by the researcher consisting of 5 sessions each meeting with a duration of 30 minutes. The spiritual care intervention was given once a week 12 times for 3 months and the control group was given standard spiritual therapy by the outpatient nurse at RSUD Dr. Moewardi Surakarta. Serotonin examination using ELISA kit. Data analysis using independent sample t-test.*

Results: *There is an influence of spiritual care with the Callista Roy theory approach on the serotonin levels of ischemic stroke patients with a significance of 0.001 (p value <0.05).*

Conclusion: *Spiritual care interventions with Callista Roy's theoretical approach have a significant influence on improving serotonin levels in ischemic stroke patients, which can reduce anxiety. It is recommended that ischemic stroke patients be given spiritual care 12 times for 3 months.*

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INTRODUCTION

Stroke is an emergency disease and requires immediate assistance. According to the World Stroke Organisation in 2018, stroke is the second leading cause of death and the leading cause of disability with a total of 87%. Currently, worldwide there are 80

million people who experience stroke, with 5.5 million people dying per year and more than 116 million years experiencing disability.

Disability can occur as a result of functional decline, and the tendency to experience persistent health problems can potentially cause an inability to carry out daily activities. Patients who suffer from physical disabilities will trigger negative perceptions of biopsychosocial life. Patients have negative perceptions, causing feelings of pessimism, anxiety, and depression about the future (Anderson, 2019).

Stroke patients experience anxiety, which is characterised by a decrease in serotonin by 72% (Primadona et al., 2020). Decreased serotonin will result in mood changes that will have an impact on limiting physical activity, which can worsen stroke outcomes (de Vries et al., 2022; Graaf et al., 2020). Serotonin levels can be influenced by several factors, including spiritual factors (Saniotis, 2018). Spirituality can guide patients to give positive meaning to every event and be patient in dealing with problems that have an impact on increasing serotonin production (Lono Wijayanti, 2017).

Spiritual care model interventions can foster hope about the potential for healing (Afshar et al., 2021). Patients have high hopes that will make patients more obedient to undergo regular stroke treatment. The role of spiritual care is very important in helping patients meet their spiritual needs related to interactions with their God, who have contributed to finding the meaning and purpose of life and an optimistic attitude so that they have a better ability to adapt to the disease (Fatoni, 2020).

Good adaptability will form mental resilience during ischemic stroke treatment, so an exclusive spiritual care program is needed, including programs in the neurology polyclinic (Lono Wijayanti, 2017; Khalajinia et al., 2021; Salamizadeh et al., 2017). Callista Roy's adaptation theory model aims to improve adaptive responses in every dimension of physiology, self-concept, interdependence, and role function (Alligood, 2017). Nurses have an important role in providing nursing actions that can manipulate focal, contextual, or residual stimuli, so with the manipulation of all these stimuli, patients are expected to be able to adapt (Alligood, 2017).

Nurses manipulate stimuli using spiritual care interventions to provide spiritual guidance to patients in tolerating harmful threats and family involvement in biopsychosocial care, so it is hoped that it can realise patient independence in determining adaptive behaviour (Yilmaz & Kara, 2020). Previous research on the spiritual care model used the development of nurse competencies to reduce stress and improve the quality of spiritual care and spiritual well-being of patients (Haghparast et al., 2021; Ghorbani et al., 2020). The spiritual care model is an interprofessional collaborative intervention in providing spiritual services by helping patients understand the meaning of illness and gain hope to overcome the disease situation (Góes & Crossetti, 2020).

Previous research on the spiritual care model used the development of nurse competency to reduce stress and improve the quality of spiritual care and patient spiritual well-being (Haghparast et al., 2021; Ghorbani et al., 2020). However, the scope of the spiritual care model still needs to be developed from a different perspective as an independent care intervention for the treatment of psychosocial adaptation disorders resulting from the impact of stroke (Dharma et al., 2020). One of the encapsulating models that has a broad and deep meaning in adaptation in the biopsychosocial dimension to chronic illness is the Callista Roy theoretical adaptation model.

The spiritual care model with the Callista Roy theoretical adaptation approach is an effort to cope with coping mechanisms in adapting by getting closer to God, oneself,

and other people. This spiritual value will be able to overcome the increase in cortisol caused by the low adaptation ability of stroke patients. This study aims to determine the effect of spiritual care using Callista Roy's adaptation theory approach on serotonin levels in ischemic stroke patients.

MATERIALS AND METHODS

This study is a type of quasi-experimental study with a pre-test-post-test control group design (Sugiyono, 2022). The research population and also the research location were outpatient ischemic stroke patients undergoing rehabilitation at the Dr. Moewardi General Hospital Polyclinic, Surakarta. The research period was from October 2022 to October 2023. Sampling in this study was using the consecutive sampling technique.

The researcher divided the control group into the intervention group by selecting the inclusion and exclusion criteria, then if they had met 25 samples from each research group based on the results of the Slovin formula calculation. The probability of a drop out occurring is estimated to be 20%, so the tolerance for additional sample sizes is 5 samples (Sastroasmoro & Ismail, 2014). The number of samples was 30 samples for each research group. So the total number of intervention groups and control groups is 60 samples.

The number of samples in the intervention group was 30 respondents and 30 respondents in the control group. Inclusion criteria Patients aged 30-60 years, Patients with a GCS score ≥14, History of first stroke, Typical ischemic stroke patients with lesions in the internal capsule as indicated by brain CT scan results, Patients with treatment according to the PERDOSSI guidelines and willing to become research participants by signing a letter of consent or informed consent. The independent variable is the spiritual care model. The dependent variable is the level of the serotonin hormone.

Serotonin level examination by taking venous blood specimens of ± 3 ml in the morning by laboratory staff. Serotonin reagent comes from the United States. Serotonin examination using the ELISA method. The ethical clearance test for this research was obtained through the research ethics committee of Dr. Moewardi Surakarta General Hospital based on letter number 1.012 / VII / HREC / 2022.

Before collecting data, the researcher explained the research, its procedures, and other related information to the respondents. Respondents then signed the informed consent form. Samples were taken by purposive sampling and then divided into 2 groups, namely the intervention and control groups. All subjects, both the intervention and control groups, were pre-tested first by measuring serotonin hormone levels using the ELISA method. Researchers provided spiritual intervention once a week for 5 sessions with 12 interventions for 3 months.

Each intervention takes 30 minutes to be given directly to the patient at the neurology clinic at RSUD Dr. Moewardi Surakarta. Forms of spiritual care intervention such as spiritual emotional freedom techniques, prayer, listening to spiritual music, range of motion exercises, and social skills. While the control group was only given generic spiritual therapy from the hospital. After being given intervention according to the target frequency for 3 months, the intervention group and the control group were then given a post-test with the same method to measure their serotonin hormone levels. Bivariate data analysis used the independent sample t-test and paired t-test (Sugiyono, 2022).

RESULTS

Based on Table 1, the results for the intervention group and the control group for the age variable.

Table 1. Frequency Distribution of Respondents

Respondent characteristics	Category	Intervention group		Control group		X^2	P-value
		N	%	N	%		
Age	20-40 Years	5	16,7	6	20,0	2,963	0,085
	41-60 Years	25	83,3	24	80,0		
Gender	Male	18	60,0	20	66,7	0,287	0,592
	Female	12	40,0	10	33,3		
Education	Elementery	13	43,3	18	60,0	6,347	0,155
	High school	14	46,7	8	26,7		
	University	3	10,0	4	13,3		
Compliance	2x absent	9	30	11	36,7	0,487	0,920
	fully present	21	70	19	63,3		

Which was tested using chi-square, obtained a correlation value of 2.963 with a significance of 0.085, so it can be concluded that the age variable is not significantly correlated with spiritual care. In the intervention and control groups, the gender variable was tested using chi-square, and a correlation value of 0.287 was obtained with a significance of 0.592, so it can be concluded that the gender variable is not significantly correlated with spiritual care. In the intervention and control groups, the education variable was tested using Fisher's exact test, and a correlation value of 6.347 was obtained with a significance of 0.155, so that it can be concluded that the education variable is not significantly correlated with spiritual care.

In the intervention and control groups on the compliance variable, which was tested using Fisher's exact test, a correlation value of 0.487 was obtained with a significance of 0.920, so that it can be concluded that the compliance variable is not significantly correlated with spiritual care.

Table 2. Normality Test

	Pre	Post	Statistic	df	Sig
Serotonin	464.82	540.48	.096	60	.200*

Table 2, the data normality test using Kolmogorov-Smirnov shows the results of the serotonin normality test obtained a significance value of 0.2, which means that the data is normally distributed, so the test uses the independent sample t-test.

Table 3. The Influence of Spiritual Care on Serotonin Levels (N=30)

Variables	N	Mean	Median	SD	Min	Max	t	p-value
Pre Serotonin (Intervention)	30	432,30	376,50	264,054	96	1012		0,379
Post Serotonin (Control)	30	497,33	349,00	307,714	75	948		

Variables	N	Mean	Median	SD	Min	Max	t	p-value
Post Serotonin (Intervention)	30	436,07	418,00	206,053	111	835	3,579	0,001
Serotonin (Control)	30	644,90	667,50	244,329	77	1041		

Based on Table 3, the average value in the pre-intervention group was 432.30 (SD=264.054), and the average in the pre-control group was 497.33 (SD=307.714). The average serotonin value in the post-intervention group was 436.07 (SD = 206.053). The mean serotonin value in the post-control group was 644.90 (SD = 244.329).

The conclusion from comparing the pre- and post-averages is that there was a decrease in the average serotonin levels in the intervention group and an increase in the average serotonin levels in the control group. The t value is 3.579 (> t table 2.00172), and the p-value is 0.001 (p-value < 0.05) this means that there is a significant influence of spiritual care actions using Callista Roy's adaptation theory approach on serotonin levels in ischemic stroke patients.

DISCUSSION

The results of the study showed that there was an influence of spiritual care treatments with the Callista Roy adaptation theory approach on serotonin levels in ischemic stroke patients with a significance value of 0.001 (p value <0.05). Serotonin plays a role in controlling mood, anxiety, depression, and so on (Berger et al., 2018). Serotonin, or 5-HT, plays an important role in the development and persistence of anxiety disorders (Kaur & Singh, 2017).

Based on Primadona's research (2020), ischemic stroke patients experience anxiety, which is characterised by a decrease in serotonin by 72% (Primadona et al., 2020). Decreased serotonin will result in mood changes that will have an impact on limiting physical activity, which can worsen stroke outcomes (de Vries et al., 2022; Graaf et al., 2020). Serotonin plays a role in controlling various emotional levels. Serotonin also plays a role in controlling mood, anxiety, depression, and so on (Berger et al., 2018).

Serotonin, or 5-HT, plays an important role in the development and persistence of anxiety disorders in addition to GABA. Serotonin neurones are involved in changes in appetite, energy, sleep, mood, and cognitive function in anxiety (Kaur & Singh, 2017). Ischemic stroke patients experiencing symptoms of limb weakness will affect the patient's psychological impact.

Patients feel disappointed, hopeless, sad, and afraid of their medical condition, which hinders them from carrying out activities so that patients experience anxiety (Nelsone et al., 2023). Patients who undergo treatment in hospitals generally only receive medical treatment, while early detection and treatment of psychological aspects as a reaction to physical complaints are still lacking (Devereux & Berns, 2023). According to Callista Roy's adaptation theory, in order for patients to maintain their lives, patients must respond positively to physiological changes by adapting.

Patients in adapting need coping mechanisms to help solve problems. Patients who are unable to adapt will experience low self-efficacy, fear, emotional instability, decreased serotonin, and poor health status (Maleki et al., 2018; M. Suhron et al., 2023; Kanen et al., 2021). Spiritual care will stimulate the pituitary in the hypothalamus so

that it can control CRF, which results in decreased cortisol and ACTH hormones that cause stress so that it will secrete neurotransmitters, serotonin, and endorphin hormones (Sara Herlina et al., 2023).

When the serotonin hormone is secreted by the brain, it will activate the parasympathetic nervous system to work, which causes the body to become more relaxed and calm again and improve blood pressure, respiration, and pulse. These results are supported by Willemse's opinion (2020) that spiritual care can influence the improvement of physical and psychological illness problems by achieving peace and happiness in life (Willemse et al., 2020). Based on the results of research on the average serotonin before and after serotonin intervention, it was found that the intervention and control groups experienced an abnormal increase before being given the intervention.

After receiving spiritual care intervention, serotonin levels decreased to near-normal levels. Normal serotonin values are 101-283 ng/ml (Sumekar et al., 2022). Meanwhile, the serotonin group still experienced a significant increase. High serotonin causes tremors, fast heartbeat, headaches, and high blood pressure. Several factors cause serotonin to be too high, such as seizures, muscle stiffness, hyperthermia, mecobalamin, and citicoline drugs (Foong et al., 2018), (Ren et al., 2020), (Jasielski et al., 2020). Therefore, the research hypothesis has been proven that spiritual care interventions can influence normal serotonin.

Forms of spiritual care treatments include prayer, prayer as a cure for anxiety because it produces several medical and psychological effects, namely balancing serotonin and norepinephrine levels, which have a pleasing effect on the heart, calming the mind, and also relaxing several muscles, especially the shoulder muscles, which often cause psychological tension (Hatri Istiarini et al., 2021). Spiritual care treatment is an adaptive coping mechanism by expressing feelings and controlling anger by getting closer to God, so that it has an impact on psychological well-being, which is accompanied by an increase in serotonin levels (Graça & Brandão, 2024) and (de Vries et al., 2022). Spiritual care treatment is not only an interaction with God but also an interaction with the social environment.

According to Matsunaga's research (2017), it was found that the presence of friends in social interactions with empathy and sharing happiness can increase serotonin and reduce patient anxiety (Matsunaga et al., 2017). Effective spiritual care plays an important role when facing pressure or stressors, so that individuals tend to be calmer and less prone to anxiety in living their lives.
The results of this research serve as a reference for formulating policies, especially in neurology clinics, as an effort to rehabilitate spiritual care using Callista Roy's adaptation theory approach, which is useful in preparing the adaptation of ischemic stroke patients in a comprehensive manner.

The limitations of this research are that the respondents are Muslim, Christian, and Catholic, so it is recommended that research be carried out on other religions. Another limitation is that respondents still receive outpatient treatment at the hospital, but this research has not been carried out on respondents in the community.

CONCLUSION

Spiritual care treatments with Callista Roy's theoretical approach have a significant influence on improving serotonin levels in ischemic stroke patients, which can reduce anxiety. It is recommended that spiritual care be provided to ischemic stroke patients 12 times over 3 months.

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Original Research

Effectiveness of Non-Invasive Sensor-Based Tools for Blood Glucose Detection

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ABSTRACT

Background*: Monitoring blood glucose levels is one of the main pillars of diabetes management to prevent complications and reduce the risk of morbidity and mortality. Today's blood glucose monitoring is a non-invasive method that offers speed, accuracy, and painless convenience. Referring to this need, this study aims to demonstrate the effectiveness of non-invasive sensor-based detection devices in checking blood glucose levels in order to provide a more comfortable and efficient alternative for diabetes patients.*

Methods: *This study developed a non-invasive glucometer using the latest and smaller version of Arduino Uno and tested it on 20 samples, consisting of 10 diabetes mellitus patients and 10 with normal blood glucose. The test was carried out by comparing the measurement results from the non-invasive device and the standard GCU Easy Touch 3-in-1 device to determine the accuracy of the device. The tool-testing method uses sensitivity, specificity, and accuracy.*

Results: *This non-invasive measuring tool is more effective when used to measure patients with diabetes mellitus. This device shows an error rate of 9.21%, a sensitivity of 80%, and a specificity of 50%. Meanwhile, the overall measurement accuracy, calculated at 83.3%, reinforces the tool's effectiveness in providing reliable results.*

Conclusion: *This device has the potential to be a convenient and painless method of blood glucose monitoring for diabetic patients. However, further development is needed to improve the development of machine learning-based algorithms to process sensor data so that tools can identify unique patterns from each individual and provide more accurate results.*

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INTRODUCTION

The Indonesian Endocrinology Association defines hyperglycemia as a medical condition in which blood glucose levels increase beyond the normal standard value, which is a characteristic of several diseases, especially diabetes mellitus, in addition to

various other conditions (PERKENI, 2021). Diabetes mellitus is a metabolic disorder that increases the percentage of glucose in the blood, caused by dysfunction of production (type 1) or effectiveness (type 2) of insulin in the body. According to the International Diabetes Federation (IDF) in 2021, worldwide there were 530 million people with diabetes, causing more than 6.7 million deaths (IDF, 2021). The number of diagnosed diabetics is growing rapidly and continuously, which draws attention to the demand for developing better functional blood glucose monitoring techniques (Punthakee et al., 2018).

Blood glucose monitoring is a critical component of diabetes management, yet current invasive methods pose challenges such as discomfort and reduced patient compliance, highlighting the need for non-invasive alternatives (Wu et al., 2023). Regular glucose monitoring is an essential part of effective diabetes mellitus management (Sanai et al., 2023). In addition, glucose monitoring and glycaemic control are associated with the incidence of complications, as well as preventing morbidity and mortality related to hypoglycemia and hyperglycemia. However, the monitoring methods currently available are all invasive, providing an uncomfortable experience so that people with diabetes are reluctant to undergo examination (Hadar et al., 2019).

Invasive technology is considered painful and uncomfortable because blood is drawn repeatedly every day. The ideal method for monitoring diabetes is one that can obtain glucose concentration levels with fast, accurate, and painless measurements. The most accurate way to diagnose diabetes is to monitor fluctuations in blood glucose concentrations for a certain period of time after eating (Stefanovski et al., 2020). Currently, the most practical approaches to blood glucose monitoring are invasive monitoring methods, which require a finger prick and blood test. So patients inevitably have to endure the pain of skin piercing and even risk infection (Houlden, 2018).

The discomfort and risks associated with invasive blood glucose monitoring highlight the urgent need for alternative methods that prioritize patient comfort and efficiency. This development of a photodiode sensor-based non-invasive blood glucose device has become a highly relevant solution, offering significant benefits for both patients and healthcare providers. This photodiode sensor-based non-invasive blood glucose device is very relevant in supporting the nursing process, especially in monitoring the health of patients with diabetes or who require regular glucose level monitoring (Chandrasekaran & Swamy, 2019). For nurses, a non-invasive blood glucose device is a more convenient, faster, and less painful method, allowing them to monitor blood sugar levels without injuring or taking blood samples from patients.

This reduces patient discomfort and saves nurses time in monitoring procedures because results can be obtained in seconds and immediately displayed on the LCD screen (Sangeetha & Mahesh, 2015). This research will develop a tool to find out the blood glucose results in the blood without having to hurt the patient (non-invasive) utilizing Arduino Uno, a microcontroller-based development board that is very popular in various electronic applications, including developing blood glucose detection devices. The Arduino Uno acts as a central controller that manages the entire system and reads sensor signals to process and display detection results. Photodiodes can be controlled through microcontroller components such as Arduino Uno R3 (Pratomo & Sugiyama, 2019).

Therefore, the research question is: How do the results of non-invasive blood glucose measurements compare with conventional invasive methods? This research aims to test the sensitivity, specificity, and accuracy of the tool.

MATERIALS AND METHODS

This research began in February-October 2024 by developing tools for a non-invasive glucometer and continued with testing. This research has conducted an ethical test with the number DP.04.03/F.XLVIII.14/568/2024. The development began by replacing the Arduino Uno series with a newer version and smaller size. Improvements to the reset connector and power pins on the Arduino Uno R3 will improve the stability and reliability of the development board when used in long-term applications. This research includes development research, commonly known as research and development (R&D) (Sugiyono, 2017).

Materials

Photodiode – A light sensor that detects infrared light that penetrates the patient's finger.
Arduino Uno R3 – Microcontroller used to control the photodiode and process measurement data.
Infrared Lamp—A light source projects a beam through the patient's fingers.
Digital LCD—Screen that displays the patient's blood glucose level results based on processed data.
Arduino Uno Nano Every—This is the latest version of the Arduino Uno Nano, which is used as the main chip in the system.
ATMega 4809—Chip embedded in the Arduino Uno Nano Every.
Drone Battery (four cells) – A battery with four cells is the primary power source.
DC Cable – Cable used to connect batteries in parallel.
AA Battery Connector

Principle of the Device

This tool projects infrared light through the patient's finger between the lamp and the photodiode. Infrared technology detects blood glucose levels by emitting infrared light onto the skin, which body tissue then absorbs and reflects. Optical sensors, such as photodiodes, measure the intensity of reflected light and convert it into an electrical signal. This signal is then converted into digital data via an analogue-to-digital converter (ADC) and analyzed using a calibration algorithm that correlates changes in light intensity with blood glucose levels (Asada et al., 2003).

Some light will be absorbed by tissue and blood, while the rest is transmitted to the photodiode. The photodiode then converts the received light intensity into an electrical signal. Arduino Uno R3 processes this signal to calculate blood glucose levels based on the intensity of light penetrating the finger (Huang et al., 2018). The final results are displayed on a digital LCD so patients can read blood sugar levels noninvasively without taking a blood sample (Sawaryn et al., 2021).

To use this tool, the patient inserts a finger into the examination hole so that the finger is between the infrared lamp and the photodiode. The researcher then presses the "Start" button to begin the measurement process. Within 15-30 seconds, the tool will project infrared light through the finger while the photodiode detects the remaining light. Blood glucose level results will appear automatically on the LCD screen, ready to be read and recorded.

Methods

Stage testing tool to determine the level of accuracy of the tool is done by comparing the measurement results of non-invasive measuring tools and standard

measuring tools as a comparison, namely GCU Easy Touch 3 in 1 (mg/dl). In testing this tool, 20 samples were used, consisting of 10 people with diabetes mellitus and 10 with normal blood glucose. For this research, a limited sample size was appropriate to explore the feasibility of a non-invasive glucose monitoring device. Despite the high prevalence of diabetes mellitus, the aim is not generalisation but to validate the technology's initial performance in a controlled environment. A larger sample size would be recommended for subsequent stages involving population-level validation.

This is done to determine the difference in tool accuracy when used on people with diabetes mellitus and people with blood glucose. Inclusion criteria: adults aged 30–70 years to ensure measurements could be performed in a more physiologically homogeneous population. Patients with diabetes who have had stable blood glucose levels in the last 2 weeks. Exclusion criteria were pregnant or breastfeeding women, because metabolic changes during pregnancy can affect blood glucose levels. Data analysis using univariate, specification, sensitivity, and accuracy.

The results of diagnosing samples with diabetes mellitus were obtained from the Banyuanyar Health Centre, Surakarta. The instrument's accuracy is obtained by using the percentage error of the non-measuring instrument *Invasive* from the following equation:

$$\%Error = \frac{GCU\ blood\ sugar\ data - Non - Invasive\ sugar\ data}{GCU\ blood\ sugar\ data} x100\%$$

RESULTS

The following is a sample distribution based on research respondent characteristics.

Table 1. Sample Distribution Based on Research Respondent Characteristics

Characteristics	Total	
	DM patients	Normal Patient
Gender		
Male	5	4
Female	5	6
Age (years old)		
30-40	0	2
41-50	3	3
51-60	6	4
> 60	2	0
Level of education		
Elementary School	1	0
Middle School	2	0
High School	8	6
Bachelor's Degree	1	2

The results of the univariate analysis show that there are more female respondents than male respondents, with 11 (55%) individuals identifying as female. Most respondents are aged 51-60, totalling 10 (50%) individuals. The highest level of education among respondents is at the Senior High School (SMA) level, with 14 (70%) individuals.

Table 2. Distribution of Respondents' Glucose Levels with GCU Easy Touch and Non-Invasive tools in the Banyuanyar Health Center Area, Surakarta City, Central Java

DM patients		%error	Normal Patient		%error
GCU	**Non invasive**		**GCU**	**Non invasive**	
300	293	2.33	122	150	22.90
360	351	2.50	102	97	4.90
300	260	13.33	95	127	22.60
296	280	5.41	105	135	28.50
125	146	16.80	92	100	8.70
295	300	1.69	118	130	10.70
245	224	8.57	96	130	35.40
135	160	18.00	88	130	47.70
267	280	4.87	107	140	30.80
129	153	18.60	94	115	22.34
Average		**9.21**	**Average**		**23.45**

Table 2 shows that the samples were divided into two types: ten people with diabetes mellitus and ten with normal high blood sugar levels. The percentage error of non-invasive measuring instruments in samples with diabetes mellitus was 9.21%, while in samples with normal blood sugar levels, it was 23.45%. This shows that this non-invasive measuring instrument is more effective when used to measure patients with diabetes mellitus.

Table 3. Results of sensitivity, specificity, and measurement accuracy of Non-Invasive tools

	Sensitivity	**Specificity**	**Accuracy**
Non-invasive	80%	50%	83,3%
GCU	90%	80%	85%

Table 3 shows that the tool is good at detecting favorable conditions (sensitivity) but has shortcomings in detecting adverse conditions (specificity). In comparison, the standard tool demonstrated higher performance with 90% sensitivity, 80% specificity, and 85% accuracy. The non-invasive tool has quite good sensitivity performance because its sensitivity reaches 80%, meaning it can correctly detect 80 out of 100 individuals with favorable conditions. Although non-invasive tools are still below the standard of 90% sensitivity, these results are promising, especially in the early stages of development.

DISCUSSION

The device's testing results demonstrate an accuracy rate of 83.3%, reflecting its reasonably good capability in measuring blood glucose levels. However, the tool tends to produce false positives, where individuals without the condition are misclassified as positive (Melheim et al., 2018; Srichan et al., 2022). This limitation is attributed to its low specificity in distinguishing actual negative cases. Compared to standard devices, non-invasive tools require further refinement, particularly in enhancing specificity, to minimize false favourable rates and improve diagnostic reliability (Suyono & Hambali, 2020).

The sensitivity, specificity, and accuracy of GCU and non-invasive were compared to assess their diagnostic reliability. Sensitivity, representing the ability to

correctly identify true positives, was higher in GCU due to its invasive nature, which allows direct blood analysis (Pratomo & Sugiyama, 2019). In contrast, GUINO exhibited lower sensitivity, attributed to its reliance on indirect measurement techniques like photometry. Specificity, or the ability to correctly identify true negatives, was slightly higher in GUINO, as the non-invasive approach avoids potential contamination in invasive samples (Kurniawan & Utomo, 2018).

Non-invasive tools have shortcomings in detecting adverse conditions, so the possibility of producing false positives is higher. The standard tool's specificity is 80%, meaning it correctly detects 80 out of 100 normal individuals. However, non-invasive tools require further improvement in this aspect.

The non-invasive method demonstrated an accuracy of 83.3%, meaning it provided correct results on 83 out of 100 measurements. Meanwhile, the standard tool (GCU) has an accuracy of 85%, which means it gives correct results in 85 out of 100 measurements. The difference in accuracy between these two tools is only 1.7%. This shows that although non-invasive tools are still in the development stage, their performance is already approaching standard tools that are widely used.

The development of a non-invasive tool for measuring blood sugar levels aims to provide a more comfortable alternative to invasive methods that require sample-taking blood. Based on the accuracy of non-invasive devices, they are often compared with invasive standards to evaluate their effectiveness (Kurniawan & Utomo, 2018). This woundless blood sugar measurement utilizes photodiode technology and microcontrollers, such as Arduino, which can detect changes in glucose concentration through photometry or spectroscopy techniques.

These advancements align with the findings of Chung et al., (2012) who emphasized that spectroscopy-based glucose monitoring has the potential to offer real-time, pain-free solutions for diabetes management. This technology can improve the quality of life of diabetes patients because it reduces the risk of infection and discomfort due to repeated punctures on the skin (Pratomo & Sugiyama, 2019). In this study, testing was carried out on two sample groups: the group with diabetes mellitus and the group with normal blood sugar levels.

The test results showed that the non-invasive device error rate was lower in the diabetes mellitus group (9.21%) than in the group with regular blood sugar (23.45%). These findings indicate that non-invasive devices have higher accuracy rates in individuals with high glucose levels. This is likely caused by a more striking difference in light concentration in the infrared spectrum at higher glucose levels, according to infrared spectroscopy theory, which states that glucose molecules show specific light absorption characteristics at infrared wavelengths (Melheim et al., 2018).

In contrast, the higher error rate in the group with normal blood sugar levels suggests that the device requires further refinement to improve accuracy at lower sugar levels. This may be related to the sensor's sensitivity to small changes in light absorption, as explained in optoelectronic theory, which states that small fluctuations in glucose concentration can significantly affect the detection signal (Brown & Lee, 2021). Thus, developing these devices should focus on increasing sensitivity to minimize errors in groups with normal blood sugar levels.

In theory, this non-invasive photodiode-based technology is capable of detecting changes in light absorbance. Which is reflected through the skin tissue. Light from the photodiode will pass through the tissue and be absorbed by glucose in the blood, resulting in different detected light intensities according to glucose levels (Kurniawan &

Utomo, 2018). However, variations in skin thickness, temperature, and humidity can affect the accuracy of the results, especially in patients with more stable normal blood sugar levels. Therefore, it is important for researchers to consider these physiological factors and adjustment algorithms to minimize variability in results.

According to the accuracy test findings, the tool's average accuracy percentage was 76.55% in the group with regular blood sugar and 90.79% in the group with diabetes mellitus. This device may be a valuable substitute for daily blood sugar monitoring for patients with elevated glucose levels, as it has a greater accuracy rate in diabetic patients. This device still needs development to improve its reliability across a wide range of glucose levels. However, these results already show great potential in reducing dependence on invasive methods in the future, especially for patients who require long-term blood sugar monitoring (Bergloff et al., 2019).

For healthcare providers, such as nurses, this tool significantly improves daily practice. Traditionally, nurses have had to perform multiple invasive procedures for blood glucose monitoring, which can be uncomfortable and time-consuming for patients. With a non-invasive device, nurses can quickly and efficiently assess glucose levels without causing pain or requiring blood samples.

This efficiency enhances patient comfort and allows nurses to monitor patients more frequently, leading to better management of blood glucose levels and reducing the risk of complications from diabetes (Srichan et al., 2022). Moreover, the ability to obtain results rapidly—often in less than a minute—also saves valuable time for nurses, enabling them to allocate their efforts to other critical tasks in patient care. As the field of non-invasive glucose measurement continues to evolve, several improvements can be made to enhance the accuracy and functionality of these devices. One of the main challenges lies in improving the device's accuracy for patients with normal blood sugar levels.

The higher error rate (23.45%) in this group, while not life-threatening, can lead to unnecessary discomfort for patients due to repeated testing. This underscores the need for further refinement to ensure reliable readings across a broader spectrum of glucose concentrations (Lin et al., 2018). Future developments could focus on adjusting the algorithms used to process the sensor data, considering various physiological factors, such as skin thickness, temperature, and hydration levels, which can significantly affect light absorption and scattering. Researchers could also explore the integration of multiple sensors or advanced spectroscopy techniques to improve detection precision at lower glucose levels. Additionally, incorporating machine learning models that can continuously learn from patient data may help optimize the device's performance over time, improving its accuracy and reliability (MDPI, 2023).

Furthermore, the potential of non-invasive glucose monitoring devices to align with patient-centered care is significant. By increasing the device's accessibility, especially in remote or under-resourced healthcare settings, we can provide significant benefits. If made more affordable and portable, this technology could offer a viable solution for routine glucose monitoring in diverse clinical environments, from primary care to home health settings. By reducing reliance on invasive techniques, this non-invasive glucose measurement tool aligns with the growing trend toward patient-centered care, prioritizing comfort, convenience, and long-term health management.

The research involved a small number of respondents, so the results still need to be generalized to a wider population. Future testing needs to involve more participants with various characteristics to increase the validity and reliability of the findings. The

error rate was higher in the group with normal glucose levels (23.45%), indicating the need to increase sensor sensitivity to small changes in glucose levels. Skin thickness, temperature, and humidity variations affect the tool's accuracy, especially in individuals with stable sugar levels. The tool's performance depends on the data processing algorithm and the accuracy of photodiode technology, which still requires further development.

CONCLUSION

Based on the obtained accuracy rates—90.79% for diabetic samples and an overall accuracy of 83.3%—this non-invasive blood sugar measuring device demonstrates a commendable level of reliability. While a minor error rate exists, it remains within an acceptable range for clinical and practical use, particularly in routine blood glucose monitoring. Furthermore, the device's ability to consistently provide accurate results suggests it is suitable for application in various healthcare settings.

However, development is needed to increase sensor sensitivity at normal sugar levels, improve data processing algorithms, and address the influence of physiological variations such as skin thickness, temperature, and humidity. Further testing with diverse respondents and machine learning-based algorithms may improve this tool's reliability and accuracy in various clinical conditions.

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Original Research

Exergame: Exercise With Matching Memory Game On Cognitive Function And Physical Fitness Of The Elderly

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ABSTRACT

Background: *Cognitive decline and physical deterioration are common issues among the elderly, significantly impacting their quality of life. The unanticipated cognitive impairments will result in dementia. Effective approaches to simultaneously improving both aspects remain to be further developed and evaluated. Exercise with a matching memory game overcomes the issues. This study aimed to examine the effectiveness of an exergame, combining memory-stimulating games and physical exercise in improving cognitive function and physical fitness among the elderly.*

Methods: *The study was a quick experiment with two groups in a pre-post test design. A number of 119 participants were recruited using purposive sampling and randomly divided into the experimental group (n=60) or the control group (n=59). Cognitive function was assessed using the Mini-Mental State Examination (MMSE), while physical fitness was measured with the 2-minute step test score.*

Results: *The data was analyzed using a paired t-test, which revealed a significant improvement in MMSE and 2-minute scores in the experimental group before and after the intervention ($p < 0.05$). Additionally, the independent t-test analysis demonstrated a significant difference between the experimental and control groups in both cognitive and physical fitness measures after the intervention ($p < 0.05$).*

Conclusion: *Implementing exercise has a significant positive influence on cognitive function and physical fitness among the elderly. Incorporating an exergame into community health programs for the elderly could provide substantial benefits to their overall well-being.*

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INTRODUCTION

Old age is a stage of human growth and development that occurs continuously, and the cycle is inevitable for every individual. A person is considered to be entering old age when they reach an age greater than 60 (Kemenkes RI, 2017; Undang-Undang Republik Indonesia No 13, 1998). Globally, the proportion of the population aged 60 years and older has increased in recent years (Huang et al., 2019; Nayak et al., 2019).

By 2020, the number of elderly individuals will reach 1 billion and is predicted to double by 2050 (World Health Organization, 2022).

Physical function in the elderly is a critical component of life that typically declines with age (Navarrete-Villanueva et al., 2021). The risk of disability and physical limitations increases by two to four times upon entering old age (Milanović et al., 2013). This condition can make it difficult for the elderly to meet their basic needs and increase their vulnerability to various diseases (Yen & Lin, 2018). Furthermore, decreased functional capacity is associated with declining quality of life and well-being and an increased risk of mortality among seniors (Angulo et al., 2020; Santos et al., 2021).

Declining physical health and function contribute to a sedentary lifestyle among older adults, where individuals have a lack of enthusiasm for physical activity (Lins-Filho et al., 2020). Previous studies revealed low activity levels among seniors, ranging from 45% to 56% (Effendi et al., 2014; Fitri, 2018; Sipayung & Siregar, 2018). Considering the impact, both regular exercise and spontaneous/unplanned physical activity can be helpful as mediators in raising physical fitness and reducing stress (Navarrete-Villanueva et al., 2021; Silverman & Deuster, 2014).

Exercise is described as structured, planned, and repeated physical exercise performed with consciousness (Di Lorito et al., 2021). Numerous studies have demonstrated that traditional exercises, such as aerobics, muscle endurance training, or combined exercise, can enhance the physical functionality and mental well-being of the elderly (Da Silva et al., 2022; Lucya et al., 2024; Mahmoudi et al., 2022; Pratiwi et al., 2024). Aside from physical function, cognitive function among elders also declines with age (Hu et al., 2021; Huang et al., 2019).

The prevalence of impaired cognitive function in the elderly reaches almost half of this population (Pais et al., 2020; Rini et al., 2018). Cognitive function impairment is a significant predictor of dementia incidence and, therefore, requires attention (Pais et al., 2020). Elderly persons with cognitive impairment are fourfold more likely to develop dementia (Gómez-Soria et al., 2023). However, cognitive impairment is frequently misconstrued as a natural aging aspect and thus often disregarded.

Cognitive stimulation is crucial in the elderly as it positively influences thinking and memory functions (Mather, 2020). It can also reduce the risk of dementia and maintain cognitive function (Collins et al., 2021). A systematic review explains that cognitive stimulation significantly improves cognitive function among seniors (Gómez-Soria et al., 2023). However, traditional cognitive stimulation conducted through individual sessions is considered less effective in providing benefits for cognitive function and quality of life for elderly people experiencing functional decline (Orrell et al., 2017).

As human beings, the elderly appreciate engagement and enjoy interaction, communication, and social cohesion, which can stimulate language capability, attention, and responsiveness (Orfanos et al., 2021). For this reason, it is suggested that cognitive stimulation should be provided in groups through fun and exciting activity components (Devita et al., 2021). Games with memory stimulation, for example, can be an alternative therapy to improve cognitive function and psychological wellness among elderly populations (Moreira et al., 2020; Tu et al., 2022).

Combining physical exercise and stimulating games is still uncommon in Indonesia. Several studies separately applied physical exercise or cognitive stimulation (Gómez-Soria et al., 2023; Makawekes et al., 2020). However, providing

single therapy offers advantages in only one domain of life function and does not provide optimal benefits for the elders (Orrell et al., 2017). The current study combined stimulation to build a comprehensive physical and cognitive therapy model. This research yields a model for concurrently executing therapy that integrates physical exercise with memory games to enhance seniors' physical function and cognitive capacities.

The current study explores the integration of cognitive stimulation (memory games) with physical exercise activities as an alternative for the elderly to achieve cognitive engagement while attaining physical benefits through group interactions. Physical movement serves as a stimulus for the aged, improving sensory and motor integration, therefore improving their physical and cognitive function (Raichlen et al., 2020; Upate & Marasabessy, 2023). Engaging in memory games incorporating physical movement and social interaction will simultaneously enhance cognitive performance and physical capabilities (Biazus-Sehn et al., 2020). Activities that include a social component provide better therapeutically beneficial (Devita et al., 2021; Orfanos et al., 2021).

MATERIALS AND METHOD

The present study was quantitative research using a two-group pretest-posttest design conducted from May to July 2024. The control and intervention groups were included in this study and selected using a purposive sampling technique from three public health centres in Bandung, Indonesia. Using g-power calculation, the study involved 120 participants of both genders. The participants were recruited using purposive sampling and then divided randomly into intervention and control groups of 60 participants each. However, during the data collection process, one participant from the control group withdrew, resulting in a total of 119 participants for data analysis (60 participants in the intervention group and 59 in the control group).

Data was processed using the SPSS-21 program. Demographic characteristics, MMSE score, and physical fitness score were analyzed using descriptive analysis as univariate. The *paired t-test* was used to identify the mean difference of variables between the pretest and post-test. The *independent t-test* was used to analyze the post-test difference between the intervention and control groups. The bivariate analysis was run after the normality data test was performed.

Ethical permission was obtained from the STIKEP PPNI Ethical Board under the number III/071/KEPK-SLE/STIKEP/PPNI/JABAR/VII/2024. Eligible participants were asked to follow the research process, and consent was collected after explaining the research procedure and risk. Data collection was conducted twice, before and after the intervention (Table 1), using the Mini-Mental Scale Examination (MMSE) and 2-minute step test. The MMSE was used to measure general cognitive function with scoring ranging from 0–30 (Folstein et al., 1975), and a 2-minute step test was used to evaluate physical fitness (Poncumhak et al., 2023; Rikli & Jones, 2004).

After developing the module and protocol, the intervention group followed the intervention sessions according to the protocol. It was performed within six meeting sessions over four weeks, each with a different activity (Table 4), while the control group received a leaflet to take home. Pretest data collection was performed at the beginning of the session, and the post-test data was collected at the last session.

Table 1. Exergame Activities Series

Session	Activity
I (week- 1)	Explanation of research procedure and pretest data collection.
II (week- 1)	Health education about physical exercise and the aging process
III (week -2)	The participants are divided into small groups of 6. Each group is assigned to match pairs of identical pictures. The pictures are placed 3 meters apart, requiring the seniors to walk to match them. Each participant within the group takes turns matching the pictures. The group with the fastest and the most pictures matches attains the highest score.
IV (week -3)	During this session, group activities are conducted under the facilitator's guidance. The facilitator shows a card containing instructions for specific movements to one of the group members to demonstrate. The other members imitate the movement and guess the name of the movement activity. This activity continued until each group member got the chance. Examples of the movements are playing basketball, dancing, stepping, etc. Once the member imitates and guesses the movement correctly, they get the score.
V (week -4)	The facilitator conducted a modified creative exercise with various movements, and all the members followed the movements. Points are awarded to the groups that demonstrate precise movements.
VI (week -4)	Post-test data collection

RESULTS

A total of 119 subjects were included in the analysis. According to the characteristics of the subjects, the experimental group mainly consisted of females (86.7%) who were mostly married (60%), had attained a primary school education (61.7%), and were housewives/not engaged in formal employment (78.3%). The average age of participants was 66.5 years, with a standard deviation of 4.8. Meanwhile, in the control group, a majority of participants were female (81.4%), married (54.2%), had completed elementary school education (47.5%), and were housewives/not working (78.3%) with an average age of 68 ± 5.9 years. The characteristics of the subjects are seen in Table 2.

Table 2. Characteristics of Respondents

Variables	Experimental (n=60)		Control (n=59)		Total (n=119)	
	Frequency	%	Frequency	%	Frequency	%
Sex						
Male	8	13.3	11	18.6	19	16
Female	52	86.7	48	81.4	100	84.0
Education level						
Not attending school	5	3.4	10	3.4	15	5.26
Primary school	37	61.7	28	47.5	65	54.6
High school	17	28.3	17	28.8	34	28.6

Variables	Experimental (n=60)		Control (n=59)		Total (n=119)	
	Frequency	%	Frequency	%	Frequency	%
College	1	1.7	4	6.8	5	4.2
Working status/ working experience						
Civil servant/ military service/ police	2	3.3	5	8.5	7	5.9
Employee	1	1.7	2	3.4	3	2.5
Self-employed	6	10	8	13.6	14	11.8
Farmer/laborer	4	6.7	7	11.9	11	9.2
Housewives/ not working	47	78.3	37	62.7	84	70.6
Marital status						
Single	0	0	3	5.1	3	2.6
Married	36	60	32	54.2	68	57.1
Widowed/widower	24	40	24	40.7	48	40.3
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	66.5	4.8	68	5.9	67.2	5.4

Table 3 provides data on physical activity levels in experimental and control groups. Most participants reported engaging in physical exercise in the experimental and control groups, with 75% and 78%, respectively. Physical training was predominantly done once a week in both the experimental and control groups, with rates of 43.3% and 66.1%, respectively. According to the disease description, the experimental group reported experiencing one type of disease (75%), whereas the control group mainly reported that they did not perceive any disease (44.1%).

Table 3. The Physical Aspect of Respondents

Variables	Experimental (n-60)		Control (n=59)		Total (n=119)	
	Frequency	%	Frequency	%	Frequency	%
Physical exercise						
Yes	45	75	46	78	91	76.5
No	15	23.5	13	22	28	23.5
Physical exercise occurrence						
Never	15	25	13	22	28	23.5
1x / week	26	43.3	39	66.1	65	54.6
2x / week	11	18.3	6	10.2	17	14.3
>2x/ week	8	39.5	1	1.7	9	7.6
Presence of disease						
None	10	16.7	26	44.1	36	30.3
1 disease	45	75	24	40.7	69	58.0
2 disease	3	5	7	11.9	10	8.4
>2 disease	2	3.3	2	3.4	4	3.4

In this study, all participants were assessed using MMSE and 2-minute scores. According to Table 4, the experimental group reported an average pretest MMSE score of 26.9±2.1, slightly higher than the control group's score of 26.5±4.2. The average 2-minute score for the experimental group was 75.9±26.3, while the control group scored 73.2±24.7.

Table 4. MMSE and 2-Minute Step Test Score

Variable	Experimental (n=60)		Control (n=59)		Total (n=119)	
	Pretest	Postest	Pretest	Postest	Pretest	Postest
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
MMSE score	26.9 (2.1)	29.2 (1.2)	26.5 (4.2)	27.1 (2.2)	26.74 (3.3)	27.03 (4.3)
2-minute score	75.9 (26.3)	89.5 (33.9)	73.2 (24.7)	71.7 (17.8)	74.5 (25.5)	80.7 (28.5)

The evaluation of variables in the experimental group indicated significant differences in the MMSE and 2-min score compared to pre- and post-intervention ($p < 0.05$). Meanwhile, the control group reported contrasting outcomes (Table 5). The analysis of post-test scores between the experimental and control groups revealed significant outcomes ($p < 0.05$) across all variables (Table 6).

Table 5. MMSE and 2-Minute Step Test Score Pre and Post-Intervention

Variables	Group	test	*x*	SD	Δ	Statistic	*p-value*
MMSE score	Experimental[a]	Pretest	26.9	2.1	2.3	-5.691	0.000*
		Posttest	29.2	1.2			
	Control[a]	Pretest	26.5	4.2	0.6	-.024	0.981
		Posttest	27.1	2.2			
2-min score	Experimental[a]	Pretest	75.9	26.3	13.6	-4.028	0.000*
		Posttest	89.5	33.9			
	Control[b]	Pretest	73.2	24.7	1.5	0.828	0.411
		Posttest	71.7	17.8			

[a] *Wilcoxon*
[b] *paired t-test*
** $p<0.05$

Table 6. MMSE and 2-Minute Step Test Score Between Experimental and Control Group

Variables	Group	test	*x*	SD	Δ	Statistic	Sig.
MMSE score	Pre-test[a]	Experimental	26.9	2.1	0.4	-.697	0.486
		Control	26.5	4.2			
	Post-test[a]	Experimental	29.2	1.2	2.1	-6.936	0.000*
		Control	27.1	2.2			
2-min score	Pre-test[b]	Experimental	75.9	26.3	1.6	-.567	0.572
		Control	73.2	24.7			
	Post-test[a]	Experimental	89.5	33.9	17.8	-2.850	0.004*
		Control	71.7	17.8			

[a] *Mann-Whitney U test*
[b] *Independent t-test*
* $p<0.05$

DISCUSSION

Cognitive function

The study reported a significant increase in cognitive function, as measured by the MMSE score before and after the exergame intervention. The MMSE score showed a significant difference compared to the control group. This suggests that cognitive stimulation via memory games, in conjunction with physical exercise, has significant advantages for the elderly.

Before the intervention, the mean cognitive score of respondents was low since cognitive scores decline with increasing years of age (Feng et al., 2023). Older individuals showed poor cognitive function compared to younger age groups (Qin et al., 2022). This occurs due to the normal aging process experienced by each individual. The study's findings aligned with the frequency of cognitive decline among the elderly in Indonesia, which was 35% in 2018 (Kementrian Kesehatan RI, 2018).

Cognitive function is well-known as an important aspect that plays a significant role in autonomous functioning among the elderly. The cognitive status of an individual significantly influences decision-making and the ability to manage behavior within the framework of executive function (Guarino et al., 2020). Impaired cognitive function in the elderly ultimately impacts physical performance and psychosocial well-being (Lee et al., 2023). Cognitive function also influences walking balance, a significant risk factor for falls in the elderly (Adam et al., 2023). Understanding the cognitive status of the elderly can serve as a prediction for future falls within this population (Guo et al., 2023).

The decline in cognitive function among seniors is closely related to the aging process. Individuals' cognitive abilities are predominantly controlled by the frontal lobes of the brain, which undergo change and aging throughout time as they become older (Li et al., 2020; Smith et al., 2020). Furthermore, cellular neurodegenerative mechanisms such as diminished metabolism and neurotransmitters, as well as increased inflammatory markers, also affect cognitive function (Feng et al., 2023; Sargent et al., 2020).

However, cognitive decline is not something inevitable as part of the aging rocess. However, cognitive decline is not something that inevitably occurs as part of the aging process (Ruan et al., 2020; Sugimoto et al., 2018); thus, individuals may retain cognitive ability without deterioration in their elderly years (Liu et al., 2023). Implementing proper treatments in vulnerable populations such as older adults can mitigate and prevent those functional deteriorations.

In the current study, exergame therapy significantly improved the MMSE score ($p < 0.05$) compared to baseline. This indicates that elderly people experience enhancements in cognitive abilities, including attention, memory, orientation, and logical reasoning. Previous studies demonstrated that combined physical exercise and cognitive stimulation, such as exergames, can improve cognitive performance (Adcock et al., 2020; Eggenberger et al., 2015; Gschwind et al., 2015).

This combination exercise promotes interaction between cognitive and motor activities, hence improving communication among various brain parts. Additionally, Kraft's research stated that combination training yields more success in improving executive function and extending benefits to other functions compared to singular training (Kraft, 2012; Pellegrini-Laplagne et al., 2023). However, the evidence is inconclusive, as certain research indicates no significant cognitive benefits from

exercise alone (Young et al., 2015). Therefore, while the overall trend supports the cognitive benefits of exercise, further research needs to be investigated.

Physical Function

The physical impact in the current study was evaluated by measuring physical fitness using a 2-min test calculation. The results revealed a significant gain in physical function by the increase in the 2-minute step test score after the exergame among the experimental group. Furthermore, the post-test measurement results reported significant differences between the control and experimental groups. These current results suggested that exergame interventions improved the physical fitness of the elderly.

In the current study, physical fitness levels were assessed using the 2-minute step test to provide an overview of the seniors' physical capacity. The average score before the intervention among the experimental group was 75.9, whereas the control group had an average score of 73.2, resulting in an overall average of 74.5. However, the mean difference between the experimental and control groups was not statistically significant at the baseline. On the other hand, different results were obtained after the intervention.

The mean score among the experimental group climbed to 89.5 relative to the baseline ($p < 0.05$), showing a 17.9% increase. These findings were relatively similar to studies assessing the effectiveness of training using kinetic games in improving physical fitness by 15% (Yu et al., 2020) and 23% (Choi et al., 2020). The 2-minute step test evaluates the physical fitness of the elderly by assessing their capacity to perform activities that require muscle strength, balance control, and cardiovascular endurance (Poncumhak et al., 2023).

Engaging in active physical exercise elevates heart rate and increases cardiorespiratory oxygenation and muscle metabolism, all of which improve total physical fitness (Adcock et al., 2020; Dewa Ayu Putri Hartaningrum et al., 2022). Previous studies found that older adults engaged in physical activity combined with memory games had enhancement in their physical condition and function (Gallou-Guyot et al., 2020; Schättin et al., 2016; Yu et al., 2020). Physical exercise has an impact on muscle strength and balance, depending on the type of exercise and physical components involved. This current study involved physical exercise combined with games, encouraging elderly individuals to engage by running and competing with other participants.

Additionally, participants were instructed to imitate various motions that required lower extremity muscle strength. This strategy pertains to dual-task training, which consists of exercises that integrate the sensory and motoric functions of the nervous system (Gallou-Guyot et al., 2020; Norouzi et al., 2019). The integration of sensory and motor nerves can mitigate postural instability and enhance balance (Ghai et al., 2017).

Concurrent exercise can enhance nerve function and has been proven to improve balance control, hence decreasing the incidence of falls in the elderly (Hofheinz et al., 2016; Nugraha et al., 2023). Uysal et al., found that dual-task training, including exergames, can enhance balance, lower body strength, and aerobic capacity, all associated with improved physical fitness (Uysal et al., 2023). However, some studies demonstrated the opposite, that there were no significant training effects on physical function (Adcock et al., 2020).

Maintaining lower body muscle strength in the elderly is vital not just for fulfilling everyday activities but also for preventing functional decline, weakness, disability, and the risk of falls (Bernabei et al., 2022). Muscular endurance, particularly

in walking, is a predictor of disability among the elderly (Wickramarachchi et al., 2023). Exergame in the current study promises an alternative approach to promoting physical fitness by improving body muscle endurance while simultaneously stimulating cognitive function among the elderly. Despite the varied outcomes, exercise with matching memory games presents an effective method for promoting physical activity, especially for groups that encounter obstacles to conventional exercise.

CONCLUSION

Cognitive and physical deterioration in the elderly due to the aging process is common. However, it can be prevented by implementing exercises that improve lower-body muscle endurance while simultaneously preserving cognitive function in the elderly. Exergames, which combine physical exercise and memory games, are an alternative therapy that can help the elderly enhance their cognitive function and fitness.

This study has proven that exergame training effectively enhances cognitive function and physical fitness in the elderly. Nevertheless, further large-scale investigations are needed. Physical-cognitive training should also be adapted to individual interests and preferences, considering sociocultural factors. The efficacy of exergames in groups with specific health issues requires investigation to ascertain additional benefits.

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Original Research

Child-Rearing Methods and Their Impact on Toddler Nutritional Status

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ABSTRACT

Background: *Child-rearing methods can influence the prevalence of stunting and wasting in toddlers because parental care plays a crucial role in the availability of food sources consumed by toddlers daily. Additionally, parents are the individuals closest to the growth and development of their children. The aim is to analyze the influence of the child-rearing methods reinforcement on nutritional status.*

Methods*: Analytical observational research type with a cross-sectional design using a total sampling technique with 50 respondents. Data collection using a questionnaire. ANOVA Multiple Linear Regression Test.*

Results: *The results of the analysis show that implementing feeding practices influences nutritional status, with a p-value of 0.007. There is no influence of psychosocial stimulation on children's nutritional status, with a p-value of 0.086. Healthcare practices influence nutritional status, with a p-value of 0.003. The ANOVA test results with an R square value of 0.080 conclude that the independent variable affects the dependent variable by 8%, while other factors influence the remaining 92%. The regression analysis results for the implementation of feeding practices show a p-value of 0.297, psychosocial stimulation shows a p-value of 0.789, and healthcare practices show a p-value of 0.444, indicating that none of these three variables influences children's nutritional status.*

Conclusion: *The role of the family contributes significantly and fundamentally to a child's overall growth and development. The involvement and activity of mothers in nutritional status is an effort to prevent diseases, such as regularly taking their children for complete basic immunizations and providing healthcare.*

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INTRODUCTION

The issue of malnutrition in children under five years old remains a global health problem that affects children's potential, morbidity, and mortality (Madiba et al., 2019). Nutritional issues in the form of stunting, wasting, and malnutrition are a global burden that poses risks to public health and economic losses (Getaneh et al., 2019). Stunting occurs due to an environment that does not support the growth and development of

children, as well as inadequate parenting, making it a challenge for learning and broad community involvement (Siswati et al., 2022).

Several factors that cause stunting are grouped into three categories, namely the condition of the child, mother, and environment. The child includes gender, birth weight, and existing illnesses, as well as nutritional intake, while maternal factors include the mother's knowledge and education, health condition during pregnancy, and compliance with ANC, and environmental factors such as environmental cleanliness, use of toilets, and the availability of clean water (Khura et al., 2023). Child-rearing methods can influence the prevalence of stunting in toddlers because parental care plays a crucial role in the availability of food sources consumed by toddlers daily.

Additionally, parents are the closest individuals directly related to the growth and development of their children (Atamou et al., 2023). Parenting has a threefold opportunity to influence the nutritional status of toddlers (Nuzula et al., 2017b). The risk of stunting increases as a child grows older, influenced by a lack of diverse and nutritious feeding practices, which is also related to poor breastfeeding practices before age 2 (Tesfaye & Egata, 2022). The prevalence of children aged 0-59 months with concise and short status was 37.2% in 2013 and decreased to 30.8% in 2018 (Riskesdas, 2018).

Stunting is caused by inadequate nutrition and the effects of repeated infections during the first 1000 days of a child's life, which are permanent and, in the long term, lead to disruptions in cognitive, physical, and health development, as well as an increased risk of degenerative diseases (Dessie et al., 2022). Growth and development disorders due to stunting will become permanent into adulthood, affecting morbidity and mortality (Goudet et al., 2019). Healthy and quality human resources are the principal capital of a nation in health development (Kemenkes RI, 2017).

Parents' contribution is significant in stunting due to food provision, nutritional intake, stimulation, and feeding practices (Nita et al., 2023). One of the issues that can influence the occurrence of stunting is parenting style. Parents with poor parenting practices have a higher risk of experiencing stunting compared to those with good parenting practices (Soviyati et al., 2023).

Providing specific and sensitive nutritional interventions is one of the efforts to accelerate the reduction of stunting rates and should ideally be carried out synergistically across sectors (Firdawsyi et al., 2020; Argaw et al., 2019). The necessity of integrated intervention to reduce stunting rates using a life cycle approach to address issues from prenatal, postnatal, and toddler stages (Sartika et al., 2021). Parents play a crucial role in the growth and development of children, as well as in their knowledge.

Therefore, efforts to address stunting in children should ideally focus on parents' nutritional knowledge (Putri & Rong, 2021). Child-rearing will be carried out well if it is carried out by both parents who work together in caring for the child, the wife as the main carer and the husband as the supporter (Katayama et al., 2022). Parental child-rearing attitude, including emotional warmth, parental rejection, and parental overprotection. Particularly parental emotional warmth as a subcategory of parental child-rearing attitudes that provides support for child development (Choi et al., 2024).

Banyuwangi Regency strives to address the direct causes of stunting through specific nutritional interventions by ensuring adequate food and nutritional intake, feeding, care, parenting practices, and treating infectious diseases (Perbub Banyuwangi, 2021). Another effort made by the Banyuwangi district government is the creation of various innovative programs to address the issue of stunting through the Banyuwangi

Stunting Response Movement (BTS), focusing on the intervention of providing supplementary food (PMT) for toddlers under two years old (baduta) (Pemkab. Banyuwangi, 2023).

MATERIALS AND METHOD

This research is an observational analytical study with a cross-sectional design. The independent variable of this study is child-rearing methods, which include feeding practices, psychosocial stimulation, and health care practices, and the dependent variable is nutritional status. The population is toddlers who are members of Teratai Posyandu, a part of the Sepanjang Health Center in Banyuwangi that focuses on services for toddlers. Researchers chose Teratai Posyadu because it had the highest stunting rate compared to other posyandu at Sepanjang Health Center.

The sample used was in accordance with the population at the Teratai Posyandu, with 50 respondents, and total sampling was used because the population was relatively small. This research is in the period of December 2023 to February 2024. Data about the risk of stunting was collected using a questionnaire on parenting models; the questionnaire used in this research used a development questionnaire taken from previous research (Puspitasari, 2021) that had been tested for validity with a result of 0.275 and reliability with Cronbach's Alpha test result of 0.688.

This research has previously passed the ethical feasibility test with ethical clearance number 191/03/KEPK-STIKESBWI/VIII/2023. Data was collected and tabulated, then analysed using the Chi-square test to identify the relationship between the independent variable due to dependent variable. The test for multiple linear regression analysis was ANOVA with a Durbin-Watson value between 1.5 and 2.5, which means that there is no significant autocorrelation, and the value of R2 with the higher value of R2 means that the model fits.

RESULTS

Based on Table 1, the shows the characteristics of respondents based on child-rearing, mother's age, number of children, gender, and child's age.

Table 1. Shows the characteristics of respondents based on child-rearing, mother's age, number of children, gender, and child's age

Characteristics	Frequency	Percentage
Child Rearing		
Household assistant	14	28%
Grandmother	8	16%
Mother	28	56%
Total	50	100%
Mother's age		
Teenager	14	28%
Young adults	35	70%
Late adulthood	1	2%
Total	50	100%
Number of Children		
One	13	26%
Two	21	42%
Three	16	32%

Characteristics	Frequency	Percentage
Total	50	100%
Child's Gender		
Male	29	58%
Female	21	42%
Total	50	100%
Child's Age		
Above two years	20	40%
Under two years old	30	60%
Total	50	100%

The average childcarers are mothers, totalling 28 people (56%), while carers are household staff, totalling 14 people (28%). Most carers are young adults, totalling 35 people (70%). On average, mothers have two children, with 21 respondents (42%), and the children's gender is predominantly male, with 29 boys (58%). The age of the children shows that 30 are under two years old (60%).

Table 2. Contains cross-tabulation data on implementing feeding practices, psychosocial stimulation, and healthcare practices with nutritional status

Variable		Nutritional Status				Total	%
		Very short.	Short	Normal	High		
Implementation of Feeding Practices	Enough	1	1	20	0	22	44%
	Good	0	4	15	9	28	64%
	Total	1	5	35	9	50	100%
Psychosocial Stimulus	Poor	0	0	2	0	2	4%
	Enough	1	0	13	0	14	28%
	Good	0	5	20	9	34	68%
	Total	1	5	35	9	50	100%
Healthcare Practice	Poor	1	0	5	0	6	12%
	Enough	0	0	14	0	14	28%
	Good	0	5	16	9	30	60%
	Total	1	5	35	9	50	100%

The application of moderate feeding practices among children with normal nutritional status is 20 children (40%), good psychosocial stimulation with normal nutritional status is 20 children (40%), and high health care practices with normal nutritional status is 16 children (32%).

Table 3. The influence of the implementation of feeding practices on nutritional status

	Value	df	Asymp.Sig.(2-sided)
Pearson Chi-Square	11,967[a]	3	,007
Likelihood Ratio	15,785	3	,001
Linear-by-Linear Association	3,341	1	,068
N of Valid Cases	**50**		

The Chi-square test results, with a p-value of 0.007, less than α = 0.05, indicate that maternal support influences the implementation of feeding practices with nutritional status.

Table 4. The influence of psychosocial stimuli on nutritional status

	Value	df	Asymp.Sig.(2-sided)
Pearson Chi-Square	11,068[a]	6	,086
Likelihood Ratio	15,160	6	,019
Linear-by-Linear Association	1,303	1	,254
N of Valid Cases	**50**		

The results of the X^2 test, with a p-value of 0.086, which is greater than α = 0.05, indicate that psychosocial stimulation does not affect nutritional status.

Table 5. The influence of healthcare practices on nutritional status

	Value	df	Asymp.Sig.(2-sided)
Pearson Chi-Square	19,810[a]	6	,003
Likelihood Ratio	21,572	6	,001
Linear-by-Linear Association	2,837	1	,092
N of Valid Cases	**50**		

The results of the X2 test, with a p-value of 0.003, which is less than α = 0.05, indicate that maternal support influences healthcare practices related to nutritional status.

Table 6. Summarizes the regression analysis model's summary of the application of feeding practices, psychosocial stimulation, and healthcare practices to children's nutritional status

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.283[a]	.080	.020	.59858	2.232

The R square value of .080 indicates that the independent variable affects the dependent variable by 8%, while other factors influence the remaining 92%.

Table 7. Shows regression analysis of the implementation of feeding practices, psychosocial stimulation, and healthcare practices with children's nutritional status.

Variable	Coefficient	Correlations Coefficients	Sig.
Content	1.565	5.146	.000
Application of Food Provision Practices	.239	1.056	.297
Psychosocial Stimulus	-.057	-.270	.789
Healthcare Practice	.132	.154	.444

The regression analysis results on the implementation of feeding practices showed a p-value of .297, psychosocial stimulation had a p-value of .789, and healthcare practices had a p-value of .444. Therefore, none of these three variables affect the nutritional status of children.

DISCUSSION

The application of feeding practices with the risk of stunting in children obtained a p-value of 0.007, smaller than α = 0.05. Therefore, maternal support for feeding practices influences the nutritional status of children. Poor feeding practices, the variety of types of food given is not diverse. If the child asks for one type of food every day, then the mother continues to comply with it by not offering another menu. The timing of giving is irregular; if the child doesn't want to eat, then leave it until they are asked to eat, and if the food is not finished, the mother doesn't persuade him to make other alternative foods that make them gain appetite.

The growth and development, both physical and cognitive, in children are closely related to child-rearing methods. How parents provide care, nutrition, and a supportive environment for their child's growth and development affects the risk of stunting (Nita et al., 2023). Research conducted by Khan et al., (2019) In Pakistan, it has been revealed that there are several common factors contributing to the occurrence of malnutrition in children, one of which is suboptimal feeding practices for children. Feeding by preparing healthy and highly nutritious food and controlling the portion sizes consumed during meals can effectively improve children's nutritional status (Ika et al., 2021).

Uncontrolled eating habits in children can worsen their nutritional status. Excessive snacking habits, fast food containing preservatives, and synthetic flavor enhancers should not be introduced to children (Tobing et al., 2021). Inadequate feeding practices that do not meet children's needs, whether healthy, sick, or recovering from illness, characterized by insufficient quantity, inappropriate content, and unresponsive feeding, are the main factors causing nutritional problems in children (Beal et al., 2018).

The components of parenting include feeding, nurturing, and healthcare. The implementation of child-rearing methods in preparing, providing, and serving food applied by mothers will determine the nutritional status of toddlers; therefore, the better the parenting pattern in feeding, the better the child's nutritional status will be (Rosulina et al., 2022)—efforts to optimize children's growth and development by paying attention to their daily food consumption. Nutritional food preparation begins when the mother prepares during her pregnancy until the child is born by providing exclusive breastfeeding and offering supplementary food with balanced nutritional content after the child reaches six months (Salsabila et al., 2021).

The parenting practices carried out within the household manifest by providing food sources for children that meet their nutritional needs for growth and development. The nutritional adequacy of toddlers is closely related to the role of mothers as the primary caregivers who provide and serve food for toddlers, and fathers also support it. The role of the family contributes significantly and fundamentally to the overall growth and development of children, as toddlers are not yet independent, and their needs depend on their closest caregivers.

The psychosocial stimulation provided by the mother, with a p-value of 0.086, is more significant than α = 0.05, so it can be concluded that psychosocial stimulation has no significant effect on children's nutritional status. Improving parenting skills is the most effective and sustainable strategy for encouraging children's growth and development. Efforts to optimize this involve providing attention, affection, responsive stimulation, and good nutrition to prevent developmental disorders that could lead to permanent damage (Nahar et al., 2012).

Psychosocial stimulation or encouragement can also promote children's growth and development. Mothers are more aware of the relationship between parent-child interactions and child development than fathers. Therefore, mothers tend to be more involved in practices encouraging child stimulation (Rakotomanana et al., 2023).

The WHO recommends emotional and physical stimulation for children with nutritional status disorders. Psychosocial stimulation can enhance the interaction between mother and child, which can help produce better feeding techniques; however, in the long term, it does not affect the child's motor or cognitive development (Daniel et al., 2017). Other research indicates that good psychosocial stimulation practices facilitate the provision of proper nutrition for children. The interaction between mother and child helps enhance psychosocial stimulation, which impacts nutritional fulfillment (Sharma et al., 2023).

Research conducted in India found that psychosocial stimulation provided through positive parenting practices significantly correlates with children's nutritional status and developmental index rather than just growth. Quality time management and intelligent parenting strategies are essential, especially during the formative stages of child development (David & Kumar, 2023). Growth is influenced by the child's and their caregiver's psychological and social health.

Therefore, psychosocial stimulation is related to a child's development but does not always affect the child's nutritional status, as many other factors influence this. Children have different characteristics; there are some children who do not need to be stimulated and want to eat by themselves, but some children need to be stimulated, for example, by giving the child their favorite food even though it is not healthy for the child’s nutritional needs. The psychological stimulation provided by the mother or close family members is beneficial in addressing developmental issues in malnourished children, but it is not a means to prevent nutritional problems.

The healthcare practices associated with the risk of stunting obtained a p-value of 0.003, which is smaller than $\alpha = 0.05$. Therefore, it can be concluded that maternal support influences healthcare practices concerning the nutritional status of children. The family plays a vital role in caring for each family member; therefore, strong family resilience is a foundation for fulfilling responsibilities and obligations to reduce arising issues.

Stunting is a nutritional issue that can be prevented if families have a sound defence system (Yani et al., 2023). Good parenting guides children to grow up with a healthy lifestyle. A mother is the closest person to a child from birth, providing breast milk and nutritious food for the child's growth and development and caring for all the child's needs when sick. Therefore, good maternal parenting is crucial for raising healthy children without stunting (Atamou et al., 2023).

Parents play a crucial role in the growth and development of children. Therefore, efforts to address nutritional issues in children are focused on parents' nutritional knowledge and how to care for them (Putri & Rong, 2021). The role of the family in maintaining and improving the nutritional status of its members involves carrying out healthcare functions by recognizing health issues that arise in their children, caring for sick children, deciding on appropriate actions, maintaining a healthy environment, and utilizing health services when their children need assistance. Therefore, families can promote, prevent, neglect, or improve the nutritional status of their family members (Sari et al., 2015).

Mothers' involvement in preventing nutritional status issues in children can begin as early as the first 1,000 days of life. A mother's active participation in disease prevention, such as regularly taking her child for complete basic immunizations and providing prompt and appropriate healthcare to prevent complications, is essential. A mother knows her child's nutritional needs better and whether those needs have been met or not because she is the closest person to the toddler. Therefore, she is the first to know and care for everything her child experiences.

The results of the regression analysis on the implementation of feeding practices show a coefficient value of .239 and a p-value of .297, psychosocial stimulation with a coefficient value of -.057 and a p-value of .789, and healthcare practices with a coefficient value of .132 and a p-value of .444. The R-squared value is .080, indicating that the variables of feeding practices, psychosocial stimulation, and healthcare practices influence children's nutritional status by 8%, while other factors influence 92%. Based on the analysis, parenting methods only have an 8% impact on nutritional status issues in children, as nutritional problems are multifactorial; parenting is merely one supportive factor in addressing nutritional issues.

Parenting styles in the category of feeding children are related to issues of children's nutritional status. According to previous research findings, parenting styles have a twofold chance of increasing the risk of nutritional status problems, with a p-value of 0.007, as parenting styles are also linked to the food intake mothers provide to their children (Nuzula et al., 2017a). A good parenting style parents provide their children can help optimize their growth and development. According to previous research, parenting styles influence children's nutritional status, affecting their motor development (Nuzula & Sayektiningsih, 2019).

Meanwhile, the research conducted by Syahida et al., (2022) shows that poor parenting habits carry a risk of 7.94 times higher likelihood of experiencing stunting compared to those with good parenting habits. The parenting approach of providing food involves a balanced nutritional intake according to the child's nutritional needs. The message of balanced nutrition for children is divided into two categories: for toddlers and preschoolers (Syafei et al., 2023). Parental upbringing plays a crucial role in the development and growth of children, both physically and mentally, as parents provide encouragement and motivation to their children in their behavior and daily habits (Nita et al., 2023).

Efforts to reduce malnutrition issues in children require strategies that prioritize addressing poverty, improving education and nutrition levels, and enhancing accessibility to community-based healthcare services focusing on nutritional interventions (Khan et al., 2019). A good parenting style will have a positive impact on a child's nutritional status, as children will be more vulnerable to experiencing nutritional problems that lead to an increased risk of infections and morbidity. Therefore, providing complementary feeding, hygiene practices, psychosocial stimulation, environmental sanitation, and healthcare becomes one of the causes of nutritional problems in children if not carried out correctly (Wati & Sanjaya, 2021).

Nutritional problems are a complex issue in children that have fatal impacts on their growth and development, thereby increasing the risk of morbidity and mortality. The nutritional status of children is influenced by various factors, starting from the womb, during childbirth, and even after the child reaches 59 months, which is the most vulnerable period. Due to the complexity of nutritional issues in children, the causes cannot be attributed to just one or two factors, as they are very diverse. Focusing on its

multifactorial causes, implementing nutritional problem handling in children requires cross-sectoral collaboration to optimize the implementation.

CONCLUSION

The growth and development, both physical and cognitive, in children are closely related to child-rearing methods. How parents provide care, nutrition, and a supportive environment for their child's growth and development affects the risk of stunting, but there are many other influencing factors on nutritional status. The limitation of this research is the small sample size, and it is best for further research to observe parenting patterns over a certain period of time.

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Original Research

Infant Care In The Agricultural Community Of Ethnic Blambangan Banyuwangi

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ABSTRACT

Background: *Data on infant mortality in Banyuwangi shows an increase in the last five years; data on infant breastfeeding has not been achieved either; while Indonesia's history of the Blambangan people, Banyuwangi, is recorded as healthy, strong, and thick with culture, known to be skilled in care, including baby care. Research is needed to find out the culture of infant care in the Blambanga ethnic community so that a good infant care culture can be strengthened to improve health.*

Methods: *The research used an ethnographic research design, with a sample size of 39 people; data were collected through FGDs, in-depth interviews, participatory observation, and documentation and analysed thematically using ethnographic and Colaizzi analysis. Several online applications were used in data processing and diagramming the results, and ethical principles were applied.*

Results: *The themes identified in the culture of infant care in the Blambangan community are cutting the umbilical cord, infant massage, the role of baby shamans, the use of plants as therapy, celebrations for babies, swaddling babies, feeding babies under six months, beliefs related to infant care, and environmental modifications when having children. Some cultures need to be reinforced.*

Conclusion: *The culture of good breastfeeding in the Osing Banyuwangi community, recorded in Indonesian history, must be reconstructed. The culture of good infant care needs to be reinforced to achieve better health, and this research needs to be developed to reconstruct the culture of infant care in the Osing Banyuwangi community.*

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INTRODUCTION

The Blambangan community, often called the Osing ethnicity in Banyuwangi, East Java, is known in the past to have a wealth of traditions and culture, including in healing diseases or maintaining health as a picture of the wealth of ethnic communities with an agricultural background (Nursafitri et al., 2020). In farming communities, it is strongly linked to culture, which is also possibly linked to the health status of the community; there are several health problems in Banyuwangi, one of which is infant health problems. This research was encouraged by an increase in infant malnutrition,

from 8.2% in 2020 to 8.6% in 2021, and a high rate of infant mortality, 6.4/1000 live births, with mortality in low birth weight cases 44/1000 live births, in Banyuwangi, where the Osing community lives (Badan Pusat Statistik Banyuwangi, 2022).

In the last five years, the infant mortality rate has increased; namely, in 2019, it was 4.7 per 1000 live births; in 2020, it was 5.1; in 2021, it increased to 5.8; in 2022, it was 6.4; and in 2023, it increased pretty high, namely to 9.2 per 1000 live births (Badan Pusat Statistik Banyuwangi, 2023). Nur et al., (2023) stated that cultural practices in traditional communities were the cause of high infant mortality in Banyuwangi, such as the culture of visiting babies in the Osing ethnic community in Banyuwangi, "Sambang bayi," which causes babies to be at risk of contracting diseases carried by guests visiting families who have babies. Likewise, Ashari's, (2021) research results in Palu stated that culture is a factor in the failure to provide exclusive breastfeeding.

However, the view that seems to blame the existing culture in the community should be changed because culture is an asset for health workers to be able to get closer to the community and to be able to strengthen healthy behaviour by using appropriate culture and the need to improve cultural behaviour while respecting the values and cultural beliefs that exist in the community (Nyaloko, 2023). Well known, culture is a significant social modality, as values and norms, to individuals or families to make decisions to attain their living needs, which can also shape healthy living behaviours. Although Indonesian people are awarded a plentiful diversity of culture, only a few studies give attention to how culture can influence practices and perceptions of healthy living behaviours, especially those related to infant care.

Whereas inquiry into cultures as community repositories of knowledge and practices on healthy living is significant, as in part, it is discovered by Kane et al., (2023) with their study on how social and cultural factors shape healthcare-related spending within families and households. Many studies in the Osing community about the culture related to the arts, politics, religion, and culinary, but nearly nothing related to healthy living behaviours. As we know, only one study in the Osing community about the culture related to healthy living behaviours (Rasny et al., 2017). Although the study did not focus on infant care exclusively, it found that there were traditional behaviours in the community in the past that can be maintained.

However, they are almost extinct because they are forgotten and tend not to be done anymore by the community. There is an empty study on healthy living behaviours, particularly related to infant care, that is based on the culture in the Osing community, and about Rasny's study, there are challenges to further exploring and reviving Osing culture to find the significance of values and norms to healthy living behaviours. Identifying cultural values and norms as a basis of healthy living behaviours in the Osing community is significant to developing knowledge and practice and promoting culturally congruent care about infant care.

Health problems in the Banyuwangi community related to the increasing infant mortality rate need to be handled properly, and handling that includes the community actively and describes the community's identity, especially the community's culture. It is necessary to read the historical records of the Banyuwangi community. However, there are almost no documents on the history of health in the Banyuwangi community, but historical records regarding the famous people of Banyuwangi origin, namely the Blambangan people, currently called the Osing ethnicity, are strong, gallant, and have skills in health care, written by Dutch researchers and documents stored in Dutch libraries (De Stoppelaar, n.d.; Scholte, 2009; Stoppelaar, 2009), some of which have

been translated by Banyuwangi culturalists, or by writers in Javanese language magazines published before Indonesian independence, have documented this (Jayanagara, 1934).

The Blambangan people call themselves the Native Javanese. The most appropriate name for them is the Blambangan people. However, the fighting spirit of the Blambangan people has never been extinguished; the descendants who exist today are tribes that are physically strong and have personalities, develop quickly, hold fast to customs, and readily accept new civilizations. Tall body sizes are found in men, striking yellow colour is found in women, and the harmony of the size of their body parts and faces proves their origin as a noble race in ancient times (Scholte, 2009).

Scholte's quote above clearly describes how healthy the Banyuwangi people were in the past—likewise, they stated that the Banyuwangi people have muscular bodies. The existence of a strong, muscular body is recognized as the result of exceptional health care from the Banyuwangi people. It is said in Jayanagara, (1934) and Djajadiningrat et al., (1927) that Blambangan mothers were trusted to be babysitters and even to breastfeed the King's baby.

There has been no research that finds out about the cultural behaviour of infant care in the Blambangan Banyuwangi community to adapt these cultural behaviours according to current healthcare needs and strengthen and improve culture to improve infant health in Banyuwangi, so cultural research is needed in Banyuwangi people who are Blambangan or Osing ethnicity. Regarding that, the ethno-agro-nursing approach is relevant to be implemented for framework research. Ethno-agro-nursing approach is developed on nursing service management, and nursing care is based on cultural values and norms in the community of an agricultural background.

Practically, ethno-agro-nursing means identifying and evaluating cultural values and norms related to nursing care to promote and increase healthy living behaviours in the community. This research has been carried out using a qualitative ethnographic design. Spradley, (1997) in nursing with an ethnonursing study (Ariza et al., 2024; McFarland & Alamah, 2015) and agricultural health nursing study (International Labour Office Staff, 2012) or ethno-agro-nursing study, this study was the first to use the term ethno-agro-nursing, namely the study of cultural nursing in a particular ethnic community with agricultural background, namely to explore the meaning and significance of healthcare behaviour practiced by the Osing tribe, based on culture and from a background as an agricultural community (Beseler, 2024).

MATERIALS AND METHODS

The population of this ethno-agro-nursing research is the Osing tribe, Banyuwangi, with a sample size of 39 people, and data collection ends when data saturation is reached. Informants have been selected based on the following criteria: as people who come from Osing ethnic families, are domiciled and are part of the Osing ethnic group directly, and have direct experience with receiving treatment or being an actor in infant care according to Osing tribal culture or experiencing by directly seeing the behaviour of caring for infants. Data collection tools include audiovisual and audio recorders to obtain a complete picture of the results of interviews with informants and the implementation of FGDs or direct involvement of researchers in observing cultural behaviour.

Interview guidelines were used for the objectives of this study. Researchers became skilled tools in efforts to collect data during semi-structured interviews, FGDs,

and documentation reviews carried out during field observations and direct observations of health behaviour in the Osing tribe community. They were involved in direct interactions with the community in Kemiren Village. Data collection began from February to October 2024 using snowball sampling, and the research was conducted in the coverage area of the Singonjuruh, Singotrunan, and Paspan Health Centers for Kemiren Village; the determination of informants started from recommendations from health centre health workers. Subsequent informants were obtained from previous informants, with researchers conveying the informant criteria to them.

The results of the FGD and interview recordings were changed into transcripts using the online pinpoint application, while the observation results were manually transcribed into data. The data set has been analyzed using the ethnographic stage and Colaizzi's method, namely marking words or sentences that are meaningful or have meaning, then grouping them into levels of theme, sub-theme, sub-sub-theme, and category. After that, the results of forming the theme for the category were validated by the informants by conducting a small dissemination, and from the validation results, they were re-analyzed and re-analyzed related to the completion of the theme for the categories.

The researcher has also made a diagram to facilitate understanding of the presentation of research results using the help of the online application draw.io. This research has received an ethical certificate from the Faculty of Dentistry, University of Jember, Certificate No. 2594 / UN.25.8 / KEPK / DL / 2024, by carrying out research ethical values.

RESULTS

The informants are members of the Osing Banyuwangi ethnic community who are traditional community figures, well-known Osing cultural practitioners, scientists of the Osing Banyuwangi ethnic group, and traditional health practitioners and health cadres. Most of the participants are older and predominantly female—most work as self-employed individuals, with only a tiny portion employed in government or private sectors. The participants are relatively evenly distributed across the three areas of Kemiren, Singonjuruh, and Singotrunan.

Table 1. Demographic profile of the participants

Description	Frequency	Percentage
Age		
Less than 50 years old	17	44%
More than 50 years old	22	56%
Gender		
Male	13	33%
Female	26	67%
Job		
Government Officials	3	8%
Private Workers	2	5%
Self Employed	34	87%
Residence		
Kemiren	12	30%
Singonjuruh	13	33%

Description	Frequency	Percentage
Singotrunan	14	36%

The culture of infant care in the Osing Banyuwangi community begins with newborns. It continues throughout the infant's life, from traditional umbilical cord care, the role of traditional midwives in infant care, the presence of social joy in supporting the presence of new members in the community, the use of natural resources for infant care, as well as swaddling care and feeding with cultural beliefs for infant health, as well as the involvement of the entire family, including in environmental modification.

Theme 1: Umbilical Cord Cutting

Based on interviews during FGDs, it was found that the Osing community believes that cutting the umbilical cord is more hygienic using "*welat"* (bark of bamboo) rather than a knife. The informant's statements support this:

"The umbilical cord cut with the bark of bamboo is cleaner than using scissors". - Informant 2

"The umbilical cord is not cut with a knife because knives can rust; hence, it was cut with the bark of bamboo in the past. Then turmeric is applied to prevent infection". - Informant 3

Theme 2: Infant Massage

FGD results also emphasize preventing and treating minor ailments, such as fever, starting from the first month of a baby's life and continuing up to one year. The massages focus on specific areas like joints and muscles rather than the entire body.

"*Heeh*, Yes, my first child was like that, so from him (shaman) I was told; anyway, I was taught to hold the child's armpit; yes, the first one was hot (fever). If your child is like this, do not get too tired. So if it is the first child, it is routine if I have a little fever; I (go) run there like that, so finally "*Alhamdulillah,"* until now I have never known a doctor. - Informant 1.

"Every month (massage), before one every month before 1 year, I still use baby massage, starting from the age of 1-month-old children, who are also one month and every month (massaged)". - Informant 3

"On the joints, not all massages; if you meet it, the whole body is massaged; if the masseuse in my place only gets a massage, the joints..."—Informant 4

"The message in my place is instead only *the* veins (muscles) that might cause heat where it is slightly massaged until now Mom until my third child..." - Informant 5

Theme 3: Role of Traditional Healers

FGD results also indicated that the Osing community still trusts traditional healers (*dukun*) to treat infants. Informants stated:

Infant massage by elders is good because they massage the legs with the baby lying prone. After such a massage, the baby with headaches and bloating recovers quickly. Previously, massage used onions, but now it uses hand lotion. - Informant 2

Santet (black magic) itself, which we thought could make people sick or even kill, here is related to health, including baby healers and massage therapists, - Informant 35

Theme 4: Use of Plants as Medicine for Infants
The Osing community believes that certain wild plants, such as the "*awar-awar"* (leaves fern-like plant), can reduce infant abdominal heat, supported by informant responses:

Usually, "*awar-awar"* leaves are placed on the baby's abdomen to reduce heat, - Informant 2

After bathing, the baby is rubbed with chewed *beras kencur* (rice rhizome kencur) all over the body except the face to keep the baby warm. - Informant 35

Theme 5: Celebrations for Infants
Birth is one of three important events in the human life cycle. For the Osing people, birth should always be accompanied by traditional rituals full of symbolism and can symbolize various things ranging from good wishes to morality lessons.

Subtheme 1: Newborn Celebrations
Pregnancy and childbirth are considered stages of life that must be experienced worldwide, so many community groups focus on the cultural aspects of these two events. One of the Osing people's traditions that are believed to accompany a person's birth is holding a "*syukuran"* or "*slametan"* (celebration with means of praying) with "*jenang abang"* (soft candy made from brown sugar).

"*Jenang abang* is the definition of mother Adam and Hawa; if there is a *slametan* there must be *jenang abang*. The white flower shows honesty and intelligence; the yellow symbolises beauty; the *abang* (red) represents life force; the ring (black) provides guidance from God; the blue rank, and the brown means a lot of knowledge and experience. It means living in harmony with the neighbors' differences; it builds unity, not conflict, right? Well, that's name *mawa tunggal dados*, presents *tumpengan*, flowers, and *jenang abang*. Well, there is *tumpengan* (cone-shaped rice). *Tumpeng peteteng* (chicken straddling), *pitik dibeleh* (*pecel pitik*) (chicken dish with young coconut). So every ritual of *jenang abang* is not left out..." (Informant-9)
The Osing people believe that there are rituals that can cure the baby of an illness, so *slametan* (celebration as an expression of gratitude for being spared from bad things) is a repelling of lousy luck, as stated by the following informant:
"...*slametan jenang abang* is done so that the baby will recover from *timbelen* (runny eyes)..." - Informant 35

Subtheme 2: Seven-month Celebrations
The Osing community also believes in a seven-month *slametan* (celebration), which signifies that the baby is ready to learn about life. This is evidenced by information from the following informant:

After 7 months, the baby starts *mudun lemah* (learn to walk by getting down on the floor), meaning that the baby can sit up, then there is a ritual called *Jenang Lintang* (star porridge) with the hope that the child will become a star. *mudun lemah* means that it is time for the baby to learn to know the world, learn to crawl, and stand up - Informant 2

Theme 6: Swaddling Infants

According to the Osing community, newborn babies are swaddled immediately and can cause the shape of sturdy legs. This is evidenced by the answer from the informant, who said that:

"...newborn babies are immediately swaddled so they will have sturdy legs..."

Baby swaddling is done so that the baby's body has a sense of security, comfort, and warmth. This feeling of security can help the baby sleep soundly and reduce the baby's sense of shock. The statement that babies who look thin and have legs like the letter O can be straightened by swaddling is a myth.

Theme 7: Feeding infants under six months

The Osing community has a habit of feeding newborns, as evidenced by the informant's statement that:

"...people often feed bananas to newborn babies..."

"After the newborn is born, they are feeding a banana stew that has been mashed; if it has been a few days, the banana will be mixed with mashed rice as well. - Informant 2.

"...people often feed bananas to newborns..."

Parents from Osing ethnic families give the mother chewing soft food to infants under 6 months by chewing first. This is supported by the informant's answer, which states that:

"...in the past, to provide a smooth texture of food, the mother usually chewed the food first and then gave it to the child..."

Theme 8: Beliefs Related to Infant Care

The Osing ethnic group believes a child's intelligence depends on their parents' teaching. This belief aligns with the statement made by an informant as follows:

A baby has no thoughts yet; it is still empty, or called *suwung* (empty, pure, white), and what it will be filled with in the future depends on who fills it, namely the parents. That is why the *suwung* ceremony is a ritual to fill the baby with prayers for safety. - Informant 2.

Theme 9: Environmental Modification When Having a Baby

The Osing community holds several beliefs that are thought to protect babies from spells or supernatural influences. As stated by an informant:

After birth until *selapan dino* (nine days), there must be a fire using wood that does not extinguish for 24 hours a day in front of the house. At dusk, dry coconut leaves are burnt around the house to ward off mystical disturbances because babies are"sensitive"—Informant 2.

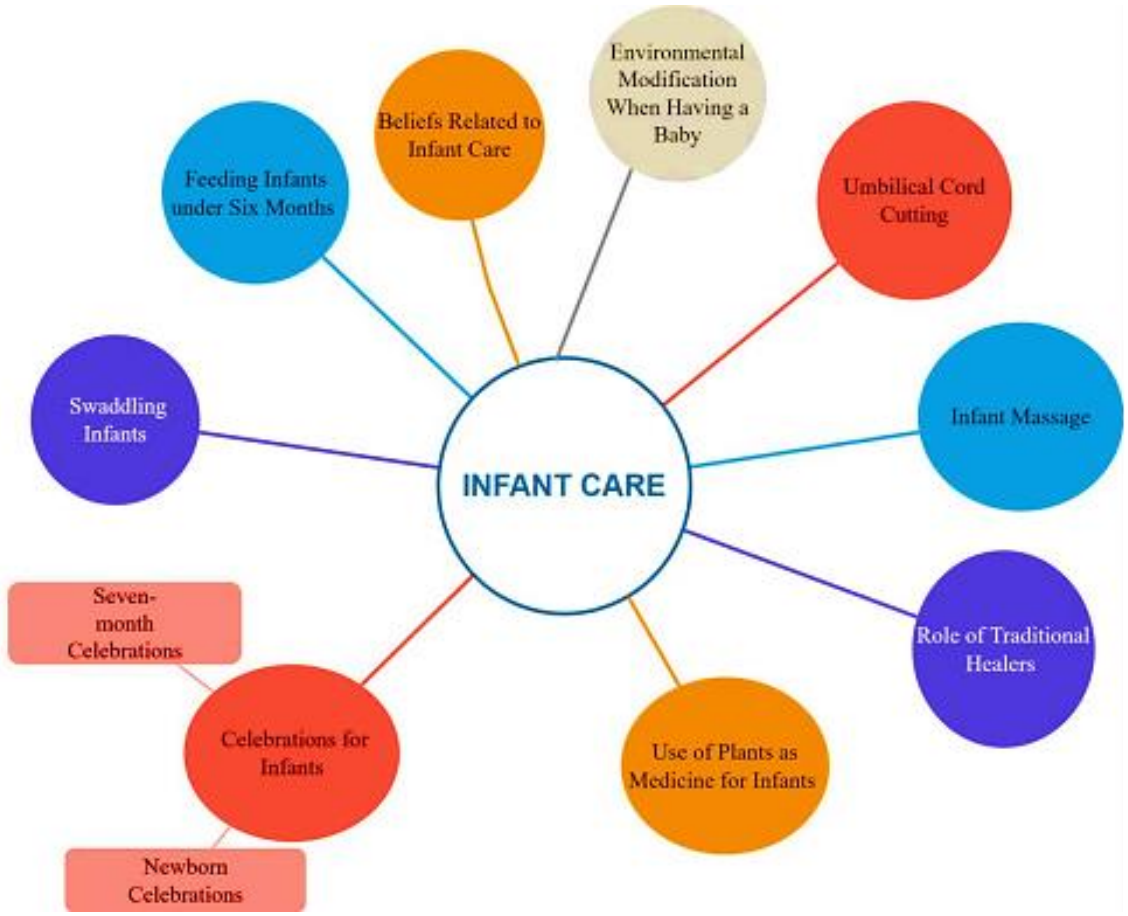
The category of leaving a baby while sleeping by placing a *kinangan* (betel box) and a *penebah* (thresher from broomstick) beside them – Informant 2.

To put the baby to sleep, if you want to leave, place *kinangan* and *penebah* beside them for protection. That is what the elders"say"—Informant 3.

Besides the baby's bed, there must be a *penebah*, which is said to protect from evil spells - Informant 35.

Wrapping a black cloth around the headboard of the baby's bed.

A black cloth is wrapped around the headboard of the baby's bed to ward off evil spells - Informant 35.



Scheme 1. This scheme illustrates the key topic of infant care, which is divided into nine interconnected themes and two sub-themes on the celebration of infant themes

DISCUSSION

Birth is one of three important events in the human life cycle (Hannum, 2023). For the Osing people, birth should always be accompanied by traditional rituals full of symbolism and can symbolize various things ranging from good wishes to morality lessons (Nyaloko, 2023). Pregnancy and childbirth are considered stages of life that must be experienced worldwide, so many community groups focus on the cultural aspects of these two events. Growth and development will increase individual abilities. Brain development at an early age increases children's skills to remember things and analyze problems (Syahailatua & Kartini, 2020).

The infancy period is a golden and critical phase of a person's development (Syahailatua & Kartini, 2020). It is considered a critical period because infants are susceptible to their environment, and it is regarded as a golden period because it is brief

and cannot be repeated. A child's growth and development are influenced by temporary and permanent environmental factors, affecting their growth and development speed and quality. Adequate caregiving necessary for a child's physical growth includes providing sufficient nutritional intake, protecting the child from infectious diseases, and safeguarding against early and advanced symptoms of health disorders (Hanifah & Farida, 2023).

Baby massage in the Banyuwangi community is an effective and reliable external therapy for treating various diseases. Touching the baby can cause various positive changes in the baby. Touch can cause the baby to calm down and be comfortable. Proper massage can help improve a baby's appetite and enhance the quality of their sleep. Massaging babies will accelerate motor development because baby massage is a touch or stimulation therapy useful for stimulating motor development (Merida & Hanifa, 2021).

Touch will also stimulate blood circulation so that more fresh oxygen will be delivered to the body's brain and throughout the body so that there will be a balance between the limbs and the brain, which helps accelerate motor development in babies. Infant massage stimulates the release of hormones in the body, which regulate various functions such as appetite, sleep, memory and learning, body temperature, mood, behaviour, blood vessel function, muscle contraction, and the endocrine system (including metabolism, growth, and puberty), as well as helping manage depression. Infant massage can begin right after birth and be performed daily until the baby is 6-7 months old. World Health Organization, (2022) recommends gentle whole-body massage, which may be considered for healthy newborns for its possible benefits to growth and development.

According to the Osing community, newborn babies are swaddled immediately and can cause the shape of sturdy legs. Baby swaddling is done so that the baby's body has a sense of security, comfort, and warmth. This feeling of security can help the baby sleep soundly and reduce the baby's sense of shock (Agussafutri et al., 2023). The statement that babies who look thin and have legs like the letter O can be straightened by swaddling is a myth. Swaddling has been done since infancy, just born, but so far, the benefits of swaddling have not been scientifically proven.

When the fetus is still alive, breathing movements dominate in the abdominal area, and after birth, the dominant breath is still in the stomach. Over time, the dominant breath movement will become established in the chest cavity. Especially when using swaddles, anything too tight will make the baby uncomfortable and uncomfortable to breathe. Baby swaddling should not be done firmly and tightly because it can cause the baby to have difficulty breathing and overheating. Therefore, try to swaddle the baby using a thin swaddle that is warm enough for the baby.

The Osing community has a habit of feeding newborns, and proper feeding is essential to achieve optimal growth and development and prevent malnutrition in infants and young children. We recommend breastfeeding alone for the first 6 months and giving solid or complementary foods when the child is 6 months old. Breast milk is the best source of nutrients that can improve the health of mothers and children. Breastfeeding in infants is very important, especially in the early period of life (Carretero-Krug et al., 2024; Jayanti et al., 2024; Panjkota Krbavčić & Vukomanovic, 2021; UNICEF, 2018).

Therefore, infants are exclusively breastfed for the first 6 months without adding and/or replacing with other foods or drinks. Babies over 6 months old already have a

chewing reflex, so they can be given complementary foods. Unlike babies who are less than 6 months old (UNICEF, 2018; Weber et al., 2023), babies will be at risk of digestive disorders and infectious diseases that result in growth development with poor nutritional status if forced to be given complementary foods before 6 months of age as well as providing support from peer groups for exclusive breastfeeding. Breast milk is an important food source for babies, as it is the complete nutrition needed for baby growth. The nutrient content of breast milk is better and sufficient for the baby's growth needs than formula milk (Aryani et al., 2021; Kemenkes, n.d.; UNICEF, 2019).

This study found that the Osing community believes cutting the umbilical cord is more hygienic using a slice of bamboo than a knife. However, improper umbilical cord care can have a negative impact. The impact is that the baby will experience neonatal tetanus, which can result in death. Tetanus can occur due to umbilical cord care that does not meet hygiene requirements, such as cutting using unsterilized bamboo or scissors.

The use of bamboo is not appropriate because bamboo can be a medium for transmitting germs that can cause infection (Silaban et al., 2023). The principle of open technique cord care is clean, dry, and not covered with anything, after which the baby is immediately wrapped in cloth. How to care for a dry umbilical cord is by cleaning and caring for the umbilical cord and wrapping it with sterile gauze, keeping the umbilical cord clean and dry to prevent infection until the cord is dry and detached by itself (Silaban et al., 2023).

This is in contrast to the results of this study, which still uses traditional healers to assist in infant care. Giving support may be an important component of interpersonal relationships with considerable value to health and well-being. Kartika et al., (2019) carried out empowerment with a cultural approach related to efforts to increase exclusive breastfeeding; giving, rather than receiving, promotes longevity. Interventions designed to help people feel supported must be redesigned to emphasize what people do to help others (Ulferts, 2020).

It is miserable that the introduction of the culture of infant care in the Osing ethnic group, especially those rooted in the history of the Banyuwangi community, has almost disappeared, even in the community itself. This researcher had difficulty tracing the type of plant that is believed to increase breast milk, known as the purple leaf in historical records, or records on how infant self-care, such as how shamans can massage babies, are not yet clearly known, including the reasons for the cultural behaviour of cutting the umbilical cord, swaddling babies, or feeding babies too early; even the picture of the superior culture of breastfeeding is not traced in this study so that further development of this cultural research is needed (Yadollahi et al., 2020). There are several limitations in the study that has been conducted, namely: insufficient time for data collection, especially the time used for observation; almost no references regarding the health behaviour of the Osing Banyuwangi community; and the lack of researcher ability in the Osing Banyuwangi language.

CONCLUSION

The Osing ethnic community has a rich culture that supports health maintenance, including infant care. Traditional health behaviours need to be preserved, and some need to be improved by proven modern health science. This study found that there are several infant care behaviours in the Osing community, namely umbilical cord care, baby massage, baby shamans involved in baby care, use of plants for baby medicine, a

celebration to welcome the baby, baby swaddling, baby feeding for babies less than 6 months, beliefs based on traditional customs regarding baby care, and environmental modifications that support baby care.

Infant care behaviours in the Osing community, in general, can support health and show family and community involvement in infant care, which shows a sound support system in the community; it is a strength that needs to be maintained in this modern era. There is a need to develop this research by researching baby care behaviour that supports health, such as massaging babies or providing good breast milk, to be reconstructed in society.

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Original Research

Family-Centred Nursing Theory and the Functional Consequences Model Improve Diabetes Self-Management in Elderly Diabetics

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ABSTRACT

Background: *The self-care management of older diabetics is inconsistent and exhibits low adherence. This incident may be influenced by the elderly's disease management capabilities and familial involvement, which may not be conducive to their health and care. This study aimed to develop a management plan for elderly diabetes mellitus that emphasizes self-efficacy and family involvement.*

Methods: *This research employed an explanatory survey design with a cross-sectional methodology. The probability sampling method, particularly simple random sampling, was employed to choose respondents for this study from a cohort of 100 individuals with diabetes mellitus and their families. We created a thorough assessment questionnaire for diabetes mellitus management in the elderly, utilizing the functional consequence model and family-centred nursing theory as the research framework. The statistical method employed was SEM-PLS.*

Results: *The outer model analysis revealed that all indicators of each construct were valid, with a factor loading value of > 0.7. The inner model analysis revealed that the variables family structure, family function, family stressors, elderly risk factors, age-related changes, and elderly consequence functions had a significant effect with a t-value of >1.96 and p-value <0.05.*

Conclusion: *The diabetic mellitus management model, which is based on self-efficacy and familial support, improves self-care management among the elderly. Nurses should adopt the diabetic mellitus management model to increase patient autonomy and educate families on how to support their loved ones, thereby improving the self-care practices of elderly adults with diabetes.*

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INTRODUCTION

Indonesia, which is a developing country, has an increase in life expectancy, which has an impact on the increase in the number of elderly people, where the elderly are a vulnerable group to experience health problems along with increasing age, namely

the beginning of a decline in function. One of the health problems that has a high prevalence in the elderly is diabetes mellitus (Arini et al., 2022). The significant increase in prevalence surely intensifies the burden on families, society, and the government. This may be due to the disease management practices of senior individuals with various non-communicable diseases, who frequently demonstrate reduced adherence to their treatment regimens, necessitating more substantial intervention from the government and society to improve their quality of life and health (Ratnawati et al., 2018).

Diabetes self-care management involves education, diet, physical activity, drug therapy, monitoring blood sugar levels, and foot care (Putra et al., 2023). Diabetes mellitus management behavior in the elderly is needed to prevent complications and ultimately improve the quality of life of elderly people with diabetes mellitus (Trisnadewi & Suniyadewi, 2022). In this study, we employed the family-centred nursing model and the functional consequences model to create a diabetes mellitus management model. This approach not only emphasizes the family approach but also emphasizes the self-sufficiency of elderly individuals with diabetes mellitus.

The family constitutes the most intimate environment for the elderly, significantly affecting their responses to diabetes mellitus (Nugroho & Banase, 2023). One theory supporting family involvement in disease treatment is family-centered nursing, which posits that the family is crucial to delivering nursing services, enabling the elderly to achieve optimal management of diabetes mellitus (Teli, 2019). Friedman explains that family structure and function play an important role in changing family members' behaviors to care for their health (Friedman & R. Bowden, 2010). Family involvement can help the elderly increase awareness and control of diabetes mellitus (Rostaminasab et al., 2023). However, the weakness of this theory lies in its disregard for the daily activities of the elderly.

This study aims to enhance the paradigm for addressing diabetic mellitus management in the elderly, utilizing Miller's functional consequences theory method. Miller's functional consequence theory emphasizes an individual's behavior in doing daily tasks that influence survival and enhance quality of life in managing diseases (Miller, 2018). This theory complements how the elderly's ability to fulfill daily activities contributes significantly to their disease management behavior (Yusriana et al., 2018). The ability of the elderly to perform daily activities, as outlined in the Self-Care Deficit Nursing Theory, supports disease management by enhancing independence, adherence, and well-being.

Family-centered nursing involves families as key partners through education and shared responsibilities, ensuring holistic and sustainable care (Abdel Razeq et al., 2024; Landry et al., 2023). Family-centered nursing is an approach where healthcare providers consider the family as an integral part of the patient’s care (Kuo et al., 2012). It emphasizes collaboration between nurses, patients, and their families to create care plans that respect the family's role in the patient’s life (Landry et al., 2023). This approach ensures that care is tailored to meet not just the patient's needs but also the family's preferences, beliefs, and cultural backgrounds. Nurses work to empower families, enhancing their abilities to care for the patients and participate in decision-making (Abdel Razeq et al., 2024).

The researcher evaluated the necessity for a holistic diabetes mellitus care approach, considering both the perspective of the patient and that of their family. This

study aims to create a diabetic mellitus treatment paradigm that incorporates self-efficacy and family engagement through the integration of two theories.

MATERIALS AND METHOD

In the second phase of this explanatory survey research employing a cross-sectional approach, data collection was conducted through structured questionnaires administered to a representative sample of participants. This method facilitated the simultaneous assessment of both independent and dependent variables at a single point in time, enabling the analysis of potential causal relationships between variables within the study population. The cross-sectional design was particularly advantageous for identifying associations and generating hypotheses regarding the underlying mechanisms of the observed phenomena.

The study population was all elderly people and families living with elderly people with diabetes mellitus in one of the public health centers in Jember. The population for this study consisted of 198 individuals. A probability sampling technique, specifically simple random sampling, was used to select the sample. To perform randomization in selecting a sample from a population of 198 individuals, start by assigning each individual a unique number from 1 to 198.

From a population of 198 individuals, the researcher wanted to determine the sample size with an error rate of 7% (0.07); using the Slovin formula, the result was 100.4. Because the sample size must be a whole number, it is rounded to 100 individuals. Thus, for a population of 198 individuals and an error rate of 7%, a sample of 100 individuals is required. Use a random number generator tool or software, which can be accessed online, to generate 100 unique random numbers within this range. Ensure that each number is selected only once to avoid duplicates in the sample.

Then, match the generated numbers to the corresponding individuals in the population list. These selected individuals will form your sample, ensuring that everyone has an equal chance of being chosen, thereby maintaining the randomness and representativeness of the sample. The study included elderly individuals aged 45 years and older, with a history of diabetes mellitus for at least one year, who were able to communicate effectively and willing to sign an informed consent form. Elderly individuals with dementia were excluded from the study.

The variables in this study consist of independent variables including X1 = assessment of family structure containing (X1.1 = communication patterns & processes, X1.2 = role structure, X1.3 = power & value structure, X1.4 = value and norm structure), X2 = assessment of family function containing, (X2.1 = affective function, X2.2 = economic function, X2.3 = family care function), X3 = assessment of family stress containing (X3.1 = long-term stress), while the assessment of the elderly consists of X4 = assessment of elderly risk factors containing (X4.1 = pathological conditions, X4.2 = lack of information), X5 = assessment of age-related changes (X5.1 = decreased physiological function, X5.2 = potential for psychosocial and spiritual growth), X6 = assessment of elderly consequence functions containing (X6.1 = decreased quality of life and health function), thus the dependent variable is Y1 = diabetes mellitus management behavior.

The research instrument used a questionnaire that included respondent characteristics and a comprehensive nursing assessment of diabetes mellitus management in the elderly. The instrument was developed based on the Functional Consequences Model and Family-Centered Nursing Theory. The validity test results

show that all items that have an average calculated r (0.215) with a calculated r greather than the table r (0.195) are considered valid for use in this study. The reliability test results show a Cronbach's alpha of 0.85, exceeding the minimum threshold of 0.70, indicating that the instrument is reliable and consistent.

The data analysis in this study employed descriptive analysis to gain a comprehensive understanding of the characteristics of the respondents, their diabetes mellitus management behavior, and the factors that align with Miller and Friedman's theory. Furthermore, we conducted an inferential analysis to make decisions in this case, seeking a relationship between variables based on the proposed hypothesis. We used SEM-PLS (Structural Equation Modelling—Partial Least Square) as the statistical test.

The analysis of the structural equation model in PLS consists of an inner model that specializes in the relationship between latent variables (structural models) with indicators and an outer model that specializes in the relationship between latent variables (measurement models) with indicators. The model evaluation process is divided into three we evaluate the outer model based on the validity and reliability of the indicator, deeming it valid if the outer loading value exceeds 0.5 and the t-statistic value exceeds 1.96. We test reliability using indicators from the constructs that make up the model. 2).

The evaluation of the inner model aims to determine the magnitude of the influence or causal relationship between variables in the study, specifically by obtaining the R square value or coefficient of determination. 3) Hypothesis testing. The KEPK of Universitas dr. Soebandi has issued an ethical service letter for this study, bearing the number 570/KEPK/UDS/V/2024.

RESULTS

Figure 1. appears to be a structural equation modelling (SEM) path diagram. It represents relationships between latent variables (depicted as blue circles) and their observed indicators (yellow rectangles). Each observed variable is connected to its latent variable with corresponding factor loadings (numerical values on arrows). The figure also shows the path coefficients (values on the arrows) between latent variables, explaining their direct influence on each other. The value inside each latent variable ircle is likely its R-squared value, indicating the proportion of variance explained by its predictors.

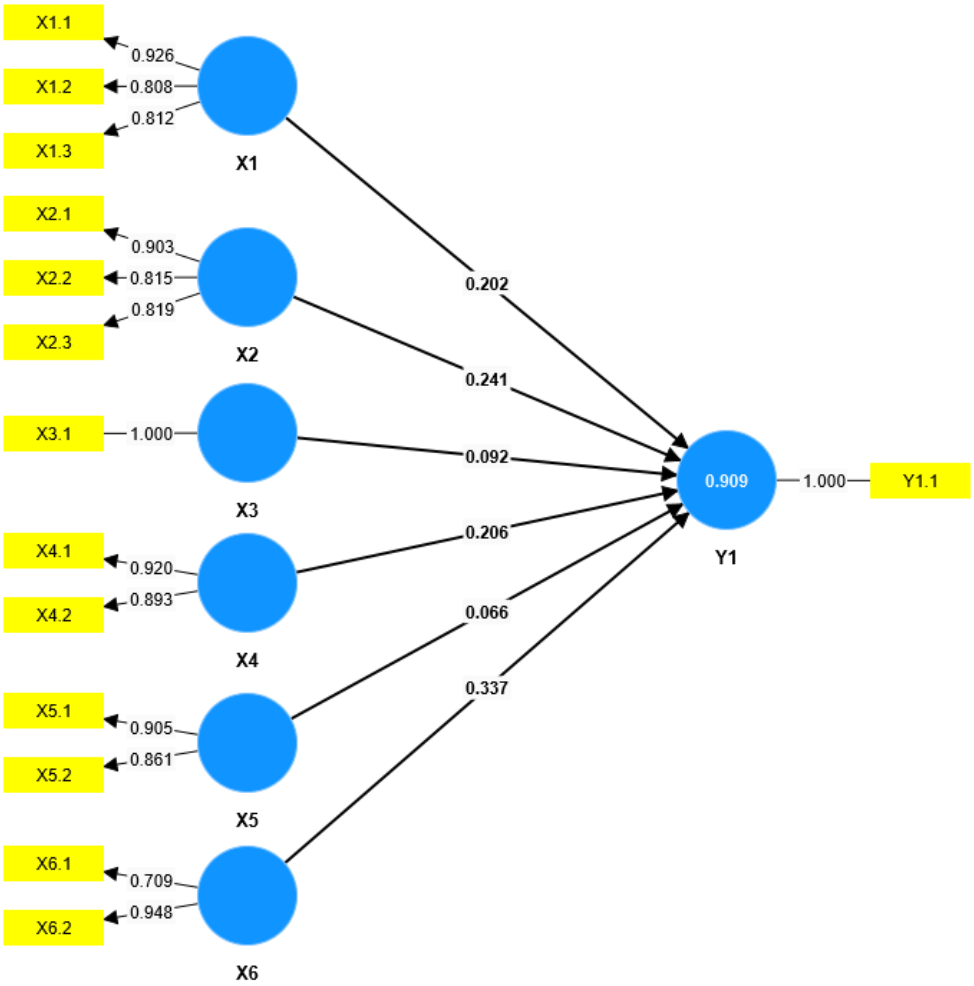

Figure 1. Construct Outer Model

This figure illustrates a structural equation model (SEM) highlighting the relationships between six latent variables (X1 to X6) and their observed indicators, as well as their influence on the outcome variable (Y1). Each latent variable, represented by a blue circle, is measured through multiple observed variables (yellow rectangles) with corresponding factor loadings (numerical values on arrows), indicating the strength of association. The path coefficients between latent variables, shown on the connecting arrows, represent the direct effects of one variable on another. The R-squared value within the dependent variable (Y1 = 0.909) indicates that 90.9% of its variance is explained by the predictor variables. This model provides insights into the interconnections and explanatory power of the constructs involved.

Table 1. Measurement Model (Outer Model)

Variabel laten		Variabel observed		Loading Factor	AVE	Composite Reliability
X1	Family Structure	X1.1	Communication Patterns and Processes	0.926	0.723	0.887
		X1.2	Role Structure	0.808		
		X1.3	Structure of Values and Norms	0.812		
X2	Family	X2.1	Affective Function	0.903	0.717	0.883

Variabel laten		Variabel observed		Loading Factor	AVE	Composite Reliability
	Functions	X2.2	Economic Function	0.815		
		X2.3	Family Care Function	0.819		
X3	Family Stressors	X3.1	Long Term Stressor	1.000	1.000	1.000
X4	Elderly Risk Factors	X4.1	Pathological Conditions	0.920	0.822	0.902
		X4.2	Information Assessment	0.893		
X5	Age-Related Changes	X5.1	Physiological Function	0.905	0.780	0.876
		X5.2	Potential for Psychological and Spiritual Growth	0.861		
X6	Elderly Consequence Function	X6.1	Quality of Life	0.709	0.701	0.821
		X6.2	Health Function	0.948		
Y1	Diabetes Self-Care Management	Y1.1	Diabetes Self-care Management	1.000	1.000	1.000

Table 1 shows that all indicators produce loading factor values greater than 0.7. Therefore, we declare all indicators valid to measure their variables based on convergent validity. The calculation of composite reliability values declares all indicators reliable for measuring their variables, with values greater than 0.7.

Table 2. Measurement Model (Inner Model)

Variable	SSO	SSE	Q^2 (=1-SSE/SSO)	R Square Adjusted
Diabetes Self-Care Management (Y1)	100.000	15.432	0.846	0.903

Table 2 indicates that the model yields a predictive relevance (Q^2) value exceeding zero, signifying its efficacy, while the modified R-squared value is 0.903, or 90.3%. This suggests that 90.3% of the variance in the Diabetes Mellitus Management Behaviour variable (Y1) can be elucidated by the variables Family Structure Assessment (X1), Family Function Assessment (X2), Family Stress Assessment (X3), Elderly Risk Factor Assessment (X4), Age-Related Change Assessment (X5), and Elderly Consequence Function Assessment (X6). The influence of the variables Family Structure Assessment (X1), Family Function Assessment (X2), Family Stress Assessment (X3), Elderly Risk Factor Assessment (X4), Age-Related Change Assessment (X5), and Elderly Consequence Function Assessment (X6) on the Diabetes Mellitus Management Behaviour variable (Y1) accounts for 90.3% of the contribution. The remaining 9.7% is attributable to additional variables not addressed in this study.

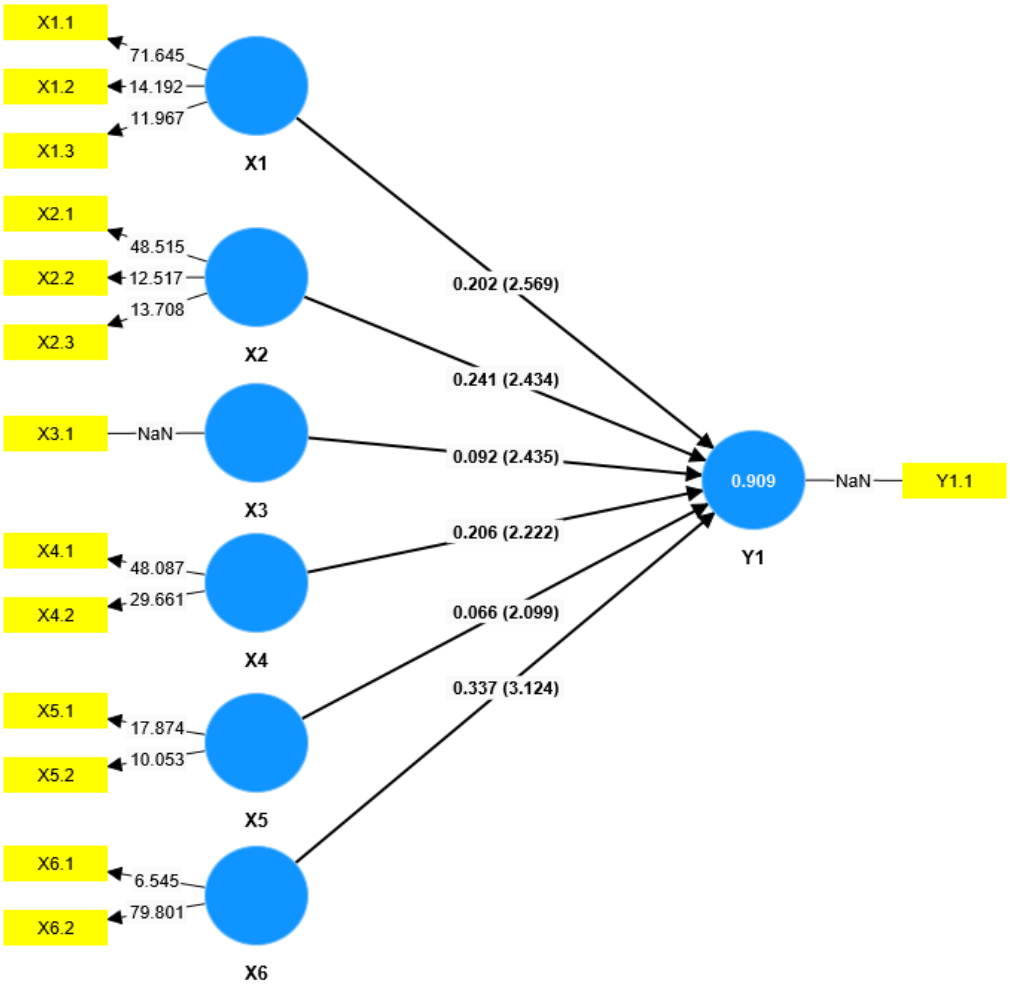

Figure 2. Construct Inner Model

The path coefficients between latent variables and the dependent variable (Y1) are presented along with their t-statistics, showing the strength and statistical significance of the direct effects. The R-squared value inside the latent variable Y1 (0.909) suggests that 90.9% of the variance in Y1 is explained by its predictors.

Table 3. Hypothesis Testing

Direct Effect	Coefficient	T Statistics (|O/STDEV|)	P Values
Family Structure (X1) → Diabetes Mellitus Management Behaviour (Y1)	0.202	2.569	0.010
Family Functions (X2) → Diabetes Mellitus Management Behaviour (Y1)	0.241	2.434	0.015
Family Stressors (X3) → Diabetes Mellitus Management Behaviour (Y1)	0.092	2.435	0.015
Elderly Risk Factors (X4) → Diabetes Mellitus Management	0.206	2.222	0.026

Direct Effect	Coefficient	T Statistics (|O/STDEV|)	P Values
Behaviour (Y1)			
Age-Related Changes (X5) → Diabetes Mellitus Management Behaviour (Y1)	0.066	2.099	0.036
Elderly Consequence Function (X6) → Diabetes Mellitus Management Behaviour (Y1)	0.337	3.124	0.002

Table 3 indicates that family structure, family function, family stressors, elderly risk factors, age-related changes, and elderly consequence functions exert a substantial influence, as evidenced by a t-value over 1.96 and a p-value below 0.05.

DISCUSSION

This study found that family involvement is significant in influencing the behavior of diabetes mellitus management carried out by the elderly. The results obtained were R^2 Adjusted = 0.903 (>0.75), with a high R^2 Adjusted value indicating that the model could explain most of the variance in the data, taking into account the number of independent variables used. Family involvement in diabetes management is very important because support from the closest environment, especially the family, can affect the success of managing this disease (Kristianingrum et al., 2018).

Family-Centred Nursing Theory and the **Functional Consequences Model** highlight the significant role of the family in managing chronic diseases like diabetes (Abdel Razeq et al., 2024). By involving families in the care process, nurses can help create a supportive environment that empowers both patients and their families to manage the disease more effectively (Kuo et al., 2012). Family support, education, and encouragement are essential for mitigating the functional consequences of diabetes, leading to improved health outcomes and a better quality of life for patients (Baig et al., 2015).

The family can provide important emotional and psychological support for people with diabetes mellitus, especially the elderly (Pamungkas et al., 2017). This support can increase patient motivation to carry out proper care and deal with the stress associated with the disease (Mphasha et al., 2022). The family can improve healthy living behavior in people with diabetes mellitus (Badriah & Sahar, 2018). They can help with meal planning, physical activity, and pharmacological therapy, as well as diabetic foot care, all of which are very important in diabetes management.

Open communication within the family can increase a sense of security and encourage patients. Families who can understand the patient's condition and needs will provide emotional comfort and strengthen the spirit of undergoing treatment (Baig et al., 2016). Stress is a factor that can worsen diabetes because it can increase blood sugar levels (Safaruddin & Permatasari, 2022). Families can help patients manage stress by creating a comfortable, supportive, and harmonious environment (Busebaia et al., 2023). Positive coping mechanisms from the family can help the elderly face chronic diseases as a shared problem, thereby improving their disease management behavior (Setyoadi et al., 2023).

Family involvement as the main source of motivation can provide positive encouragement for patients (Rahmah et al., 2023). This presence can be in the form of

moral support in following a treatment program, as well as providing encouragement to achieve better health targets. Families must play a role in avoiding stigma or discrimination against diabetes patients (Grabowski et al., 2017). Full acceptance and equal treatment will help patients feel more comfortable and confident. The active role of the family in all aspects of diabetes management can help patients maintain a more stable health condition and reduce the risk of serious complications (Busebaia et al., 2023).

Nurses have an important role in increasing family involvement in the management of diabetes mellitus. Nurses are responsible for providing education to patients and their families about diabetes mellitus, including in the management of the disease (Alshammari et al., 2021). Nurses also play a role in providing emotional support to patients and families. They can help overcome the anxiety and stress that often accompany a diagnosis of diabetes, as well as motivate to maintain adherence to treatment and lifestyle changes (Vandali, 2019).

By involving families in the care process, nurses can strengthen their role as primary supporters of patients. Well-educated families tend to be better able to provide the support needed to achieve good blood sugar control. Through this approach, nurses not only help patients in diabetes management but also empower families to play an active role in the health care of their members who suffer from diabetes mellitus. This study also found that the elderly's self-efficacy, which includes elderly risk factors, elderly consequence functions, and age-related changes, can affect the behavior of elderly people with diabetes mellitus in managing their disease.

The elderly's self-efficacy greatly influences their self-care behavior in managing their disease (de Sousa et al., 2020). Elderly with high self-efficacy are more likely to carry out diabetes mellitus management (Klinis et al., 2022). High self-efficacy can motivate the elderly to take more active action in managing diabetes, which in turn can help them control their health conditions better (Qin et al., 2020). Conversely, the elderly with low self-efficacy may have difficulty in managing chronic diseases, which can have an impact on decreasing quality of life (Mukhopadhyay et al., 2023).

Age changes have a significant impact on the function of body organs in the elderly, especially for those with diabetes mellitus (Jiang et al., 2023). As age increases, various physiological and anatomical changes occur, which can worsen the health condition of the elderly and affect the management of their disease (Jiang et al., 2023). In the elderly with diabetes, this decline in organ function can be more complex because diabetes accelerates damage to several organs (Jiang et al., 2023).

Overall, empowering the elderly through increasing self-ability and family involvement in self-care at home is an important step in managing diabetes mellitus. Elderly people who have good self-ability in managing diabetes, such as regulating diet, monitoring blood sugar levels, and recognizing signs of hypoglycemia or hyperglycemia, will be better able to control their disease independently (Setyoadi et al., 2024). These management efforts can prevent serious complications and improve their quality of life.

Family involvement in caring for the elderly with diabetes is very helpful in providing emotional and physical support. Families can help ensure elderly compliance with treatment, accompany them when monitoring blood sugar, and regulate diets that are appropriate to their condition (Thongduang et al., 2022). Self-care performed by the elderly and their families at home allows for a more personalized and holistic approach, considering that each individual may have different needs (Nikpour et al., 2022).

This includes stress management, physical activity, and other healthy lifestyle habits that support diabetes control. By empowering the elderly and involving their families in self-care, diabetes complications such as neuropathy, nephropathy, or retinopathy can be prevented or minimized, as the elderly are better trained to recognize early symptoms of complications (Thongduang et al., 2022). Through empowerment, the elderly feel more empowered and less dependent on others, which improves their self-confidence and overall quality of life.

In addition, this intervention can also reduce the burden on the healthcare system by reducing the number of complications due to diabetes. The **Family-Centered Nursing Theory** highlights the role of family support in managing diabetes, while the **Functional Consequences Model** focuses on how self-efficacy and aging affect the elderly's ability to manage the disease. Together, they suggest that empowering the elderly with self-care and involving family in diabetes management improves disease control, prevents complications, and enhances quality of life.

CONCLUSION

Self-ability and family involvement in managing diabetes mellitus influence the behavior of the elderly. We can use this diabetes mellitus management model to explain health behavior in elderly individuals with diabetes mellitus. Family involvement in providing care is the primary factor that can enhance diabetes mellitus management behavior in the elderly, as it contributes to the decline in self-ability that accompanies aging. As a nurse, it is important to involve the family in the management of diabetes mellitus in the elderly.

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