The role of diet compliance, vitamin C intake, physical activity and nutrition education on blood sugar levels of diabetes mellitus patients type 2 during the covid-19 pandemic

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ABSTRAK

Latar Belakang*: Diabetes melitus tipe 2 (DMT2) adalah gangguan metabolik yang ditandai dengan peningkatan kadar glukosa darah, mempengaruhi kualitas sumber daya manusia, dan meningkatkan biaya perawatan kesehatan. DMT2 juga merupakan komorbiditas COVID-19 .*
Tujuan: *untuk menguji hubungan antara kepatuhan diet, asupan vitamin C, aktivitas fisik, dan edukasi gizi dengan kontrol glukosa darah pada pasien DMT2.*
Metode: *Studi observasional analitik dengan desain potong lintang dari bulan Maret hingga April 2021 di Rumah Sakit Idaman Banjarbaru. Sebanyak 40 pasien dipilih dari 90 populasi yang memenuhi syarat. Pengambilan sampel secara non-probabilitas. Data primer dikumpulkan melalui wawancara, sedangkan data sekunder diperoleh dari rekam medis. Gula darah puasa dikategorikan sebagai terkontrol (<125 mg/dl) atau tidak terkontrol (≥126 mg/dl). Data dianalisis menggunakan uji chi-square dengan tingkat kepercayaan 95%.*
Hasil*: Penelitian ini menunjukkan bahwa sebagian besar responden berusia 46–55 tahun (40%), perempuan (80%), dan ibu rumah tangga (52,5%). Mayoritas tidak mematuhi rekomendasi diet (60%), memiliki asupan vitamin C yang rendah (47,5%), melakukan aktivitas fisik ringan (37,5%), dan telah menerima edukasi gizi (55%). Gula darah yang tidak terkontrol diamati pada 67,5% peserta. Asosiasi signifikan ditemukan antara kepatuhan diet (p=0,000), asupan vitamin C (p=0,001), aktivitas fisik (p=0,002), dan edukasi gizi (p=0,001) dengan kadar glukosa darah. Rasio odds menunjukkan bahwa pendidikan gizi dan aktivitas fisik memiliki pengaruh terkuat.*
Kesimpulan*: Kepatuhan diet, asupan vitamin C, aktivitas fisik, dan edukasi gizi berkorelasi signifikan dengan kontrol glukosa darah pada pasien DMT2.*

Kata kunci: *kadar gula darah, kepatuhan diet, edukasi gizi, aktivitas fisik, vitamin C*

ABSTRACT

Background: *Type 2 diabetes mellitus (T2DM) is a metabolic disorder marked by elevated blood glucose levels, affecting human resource quality and increasing healthcare costs. T2DM is also a known comorbidity of COVID-19.*
Objective*:This study aimed to examine the relationship between dietary compliance, vitamin C intake, physical activity, and nutrition education with blood glucose control among T2DM patients.*
Methods: *An analytic observational study with a cross-sectional design was conducted from March to April 2021 at Idaman Hospital Banjarbaru. A total of 40 patients were selected from 90 eligible participants using non-probability sampling. Primary data were collected through interviews, while secondary data were obtained from medical records. Fasting blood glucose was categorized as controlled (<125 mg/dl) or uncontrolled (≥126 mg/dl). Data were analyzed using chi-square tests with a 95% confidence level.*

***Results**: showed that most respondents were aged 46–55 years (40%), female (80%), and housewives (52.5%). The majority did not adhere to dietary recommendations (60%), had low vitamin C intake (47.5%), engaged in light physical activity (37.5%), and had received nutrition education (55%). Uncontrolled blood glucose was observed in 67.5% of participants. Significant associations were found between dietary compliance (p=0.000), vitamin C intake (p=0.001), physical activity (p=0.002), and nutrition education (p=0.001) with blood glucose levels. Odds ratios indicated that nutrition education and physical activity had the strongest influence.*
***Conclusion:** Dietary compliance, vitamin C intake, physical activity, and nutrition education significantly correlate with blood glucose control in T2DM patients.*

***Keywords:** blood sugar levels, diet compliance, nutrition education, physical activity, vitamin C*

***Article info:** Received May 15, 2024; 1st revision June 03, 2024; 2nd revision August 22, 2024; 3rd revision September 30, 2024; 4th October 30, 2024; 5th February 07, 2025; 6th July 28, 2025 accepted October, 20, 2025; available online January 30, 2026; published January 31, 2026.*

INTRODUCTION

Diabetes Mellitus (DM) is a metabolic disease characterized by hyperglycemia that occurs due to defects in insulin secretion, insulin action or both (1). Diabetes mellitus was in the top three most diseases in South Kalimantan Province in 2017 with a total of 41,117 cases and increased to 53,806 cases in 2018(2). In 2018, the prevalence of diabetes mellitus based on a doctor's diagnosis in residents aged 15 years according to the district/city of South Kalimantan Province, Banjarbaru City was in the second top position with a prevalence of 2.28%(3). And that means that the prevalence of Banjarbaru City is above South Kalimantan Province which was only 1.8% in 2018. Diabetes mellitus is also in the top three based on data on the 10 most diseases in outpatient services in 2018 at the Idaman Regional Hospital, Banjarbaru City (4).

DM greatly affects the human quality of life and has an impact on increasing health costs, which is quite large. DM is a chronic disease that needs long-term health management involving many sectors such as medical doctor, nurses, nutritionists, and other health workers. Patients and families also have an important role in the management of diabetes mellitus (5).

In early 2020, there was a coronavirus pandemic caused by SARS-CoV-2 which is known as COVID-19 pandemic. This disease can affect almost all age groups, however, this virus was data indicate that the elderly and people with a history of chronic (co-morbid) disease are at risk of getting more frequent and worse complications from this disease. Elderly individuals with comorbidities are indeed at high risk of SARS-CoV-2 (COVID-19) infection, and this is not simply due to age—rather, it's a complex combination of physiological changes and accompanying health conditions. Specifically, declining immune function, respiratory function, and the presence of comorbidities will worsen their condition if they contract the SARS-CoV-2 virus.

The history of chronic disease includes hypertension, diabetes mellitus, cardiovascular disease, and chronic lung disease(6) . Diet is one way to control blood glucose levels in diabetic patients. According to PERKENI (Indonesian Endocrine Society), Diabetes Mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia (high blood sugar levels) caused by impaired insulin function, insulin secretion, or both. A diagnosis of diabetes mellitus is confirmed if fasting blood sugar levels are ≥126 mg/dL, or random blood sugar levels are ≥200 mg/dL accompanied by classic symptoms, or HbA1c levels are ≥6.5%(1). The American Diabetes Association (ADA) states that controlling blood glucose in an effort to reach normal or near normal levels is the main goal of diabetes control. The ADA recommends achieving controlled blood glucose levels through monitoring carbohydrate intake (7).

In addition to macronutrients, the risk of cardiovascular disease can be reduced by consuming a certain amount of antioxidants, besides that antioxidants can also improve the immune system and are able to inhibit the onset of degenerative diseases due to aging (8). High blood glucose levels in diabetic patients cause various changes in the body. One of these changes is the occurrence of an oxidation reaction that causes an increase in the formation of harmful substances called free radicals. Vitamin C is one of the secondary antioxidants and has the same way of working as vitamin E, which is to capture free radicals.

Physical activity or exercise in diabetes mellitus has great benefits, including lowering blood glucose levels, preventing obesity, playing a role in overcoming complications, blood lipid disorders, and increasing blood pressure (9,10). Nutrition education with the aim of promoting healthy living should always be carried out as part of prevention efforts and is a very important part of holistic DM management. Through proper diet can keep blood sugar levels stable, diabetic patients will have a better immune system. Strong immune systems are vital to fighting infections, including COVID-19. Regular exercise can boost blood circulation, strengthen the immune system, and reduce inflammation in the body/ infection. Vitamin C is known as an antioxidant that can boost the immune system. Vitamin C directly prevents COVID-19, vitamin C is abundant in fruits and vegetables. Good health nutrition education will help diabetics understand their illness, better manage their condition, and take appropriate preventive measures, including protecting themselves from COVID-19 (11)(11).

Based on the foregoing context, this study was carried out at the Idaman Regional Hospital in Banjarbaru City, during the COVID-19 pandemic, to ascertain the association between blood sugar levels of type 2 diabetes mellitus patients and their dietary compliance, vitamin C intake, physical activity, and nutrition education, as well as the most significant risk factor for blood sugar.

MATERIALS AND METHODS

This was an observational research with a cross-sectional study design conducted at Idaman Regional Hospital in Banjarbaru City during March-April 2021. The population in this study was 90 outpatients of type 2 diabetes mellitus at the Idaman Regional Hospital, Banjarbaru City, the sample of the study was 40 patients. The sampling technique used in this study is non-probability sampling with a purposive sampling method. Primary data was obtained through interviews using questionnaires. Interviews were conducted using: 24-hour food recall form for 2 days, food frequency form, and a meal schedule questionnaire

Compliance with the diet by assessing the exact concept of type, quantity and schedule of eating. The type of diet according to the DM diet standards provided to DM patients as needed, with calorie needs corresponding to the patient's calorie requirements within a range of ±10% calories, using food types recommended for diabetics is in accordance with the recommended standards for a diabetes mellitus diet, which is 80-100% compliant with the type and a meal schedule according to the schedule, which includes 3 main meals and 3 snacks with a 3-hour interval. The amount of vitamin C intake from food and supplements in a day compared to the Recommended Dietary Allowance (RDA) for the Indonesian People was 75 mg per day. Vitamin C intake was assessed using 2 time 1x24h food recall, and divided into three categories: Excessive: >110% RDA, Sufficient : 80-100% RDA, Insufficient: <80% RDA (7)(6).

Physical activity was evaluated by normal daily behavior, including at work, exercise, going from one place to another, or rest during the last week. Interviews using the Global Physical Activity Questionnaire (GPAQ) questionnaire. One of the instruments for measuring physical activity is the Global Physical Activity Questionnaire (GPAQ) developed by the World Health Organization (WHO). GPAQ was developed to monitor physical activity in developing countries. GPAQ consists of 16 questions that collect data from respondents on physical activity in three domains: physical activity at work, travel-related physical activity, and recreational or leisure-time physical activity. Global Physica Activities demonstrated by behaviors commonly performed daily, including during work, exercise, moving from one place to another, or resting over the past week (12).

In the context of the GPAQ, physical activity is classified based on its intensity using METs. METs (Metabolic Equivalent of Task) are units used to measure the level of physical activity based on energy consumption. One MET is defined as the level of energy consumption at rest, which is equivalent to 1 calorie per kilogram of body weight per hour (1 kcal/kg/hour).

MEQ groupings include Light Activity (1.5 - 3 METs): Low-intensity physical activity, such as walking or light housework. Moderate Activity (3 - 6 METs): Moderate-intensity physical activity, such as brisk walking or cycling at a moderate pace. Heavy Activity (>6 METs): High-intensity physical activity, such as running or lifting heavy weights. This activity

group is then calculated in MET minutes/week based on the activity group. And added up to a total of MET - minutes of activity per week. Physical activity was classified into light activity, if value <600 MET-minutes/week, Moderate Activity, if MET value 600-1499 MET minutes/week and Heavy activity if MET-minute >1499 MET(12).

Health education training related to healthy intake and behaviour for diabetic patients as one of the comorbid COVID-19 given by nutritionists, which is categorized as nutrition education 'Yes' when the patients have received education training about cormobite covid 19 by the nutritionist and no if the patients haven't received education about that.The inclusion criteria were based on hospital reports and doctors' recommendation as patients with diabetes mellitus and not accompanied by complications such as kidney, ulcer/gangrene, retinopathy and heart diseases etc. The fasting blood sugar levels obtained from the patients' medical records. Glucose control if fasting blood sugar level <126 mg/dl and uncontrolled >= 126 mg. Data analysis used Chi square test with 95% confidence level and a= 0.05. This research has been conducted on an ethical test with registration no 003/KEPK-PKB/2021.

RESULTS AND DISCUSSIONS

Characteristics of respondents description

The frequency distribution of respondents based on characteristics can be seen in **Table 1**.

Table 1. Distribution by Age, Gender, Nutrition education, and Occupation of Type 2 Diabetes Mellitus Patients at Idaman Hospital, Banjarbaru City in 2021

Characteristics of Respondents		n	%
Age (years old)	36-45	10	25
	46-55	16	40
	56-65	14	35
Gender	Male	8	20
	Female	32	80
Education	SD/Equivalent	13	32.5
	Middle School/Equivalent	3	7.5
	High School/Equivalent	14	35
	higher nutrition education	10	25
Occupation	Farm workers	1	2.5
	Retired	3	7.5
	Trader	2	5
	Civil servants, soldiers,	5	12.5
	Private employees	8	20
	Housewife	21	52.5

The results showed that the age group of patients with type 2 diabetes mellitus at Idaman Hospital Banjarbaru was mostly in the 46-55 year age group. The most age group experiencing type 2 DM is the early elderly, namely in the age range of 46-55 years. With

increasing age, the intolerance to glucose will also increase. Glucose intolerance in the elderly is often associated with obesity, reduced physical activity, reduced muscle mass, comorbidities and drug use, and has decreased insulin secretory function and insulin resistance (13).

Most of the type 2 DM at Idaman Hospital Banjarbaru was female (80%). Patients with type 2 diabetes mellitus usually occur more in women than men (14);(15). Women are at high risk of diabetes mellitus because physically women are vulnerable to increasing body mass index, menstrual syndrome (premenstrual syndrome), post-menopausal which can cause the spread of fat in the body to become easy to gather due to hormonal processes so that women are at risk of suffering from type 2 diabetes mellitus (16). Based on the patient's education, most of them nutrition education were senior high school graduates (35%). This is influenced by the environment where the patient lives, namely in urban areas, so most of them complete their education to high school but do not continue to college due to socio-economic factors. The higher a person's level of education will affect the level of knowledge, where someone with a higher level of knowledge will be able to maintain his health(17). Most of the participants in this study are housewives (52,5%). Diabetes mellitus occurs mostly in women, especially housewives because it requires little energy and does little physical activity so that it can cause fat accumulation in the body which can lead to insulin resistance and an increase in blood sugar levels in type 2 diabetes mellitus patients (16).

The frequency distribution of respondents based on dietary compliance, vitamin C intake, physical activity, nutrition education nutrition education, and patients' blood sugar levels can be seen in **Table 2**. The results showed that the highest percentage of patient's diet compliance was not applying, which was 60%. Food or diet is the main factor associated with increased blood glucose levels in patients with type 2 diabetes, especially after eating (18). Diabetes control measures to prevent complications are needed, especially by keeping blood sugar levels as close to normal as possible. However, completely normal blood sugar levels are difficult to maintain. This is because the patient lacks discipline in running a diet or is unable to reduce the number of calories in his food (19). The combination of good vitamin C intake and a physical activity routine can help diabetes mellitus patients control their blood sugar levels and prevent more serious complications.

Table 2. Frequency Distribution of Diet Compliance, Vitamin C Intake, Physical Activity, Nutrition education, and Blood Sugar Levels in Type 2 Diabetes Mellitus Patients at Idaman Hospital, Banjarbaru City in 2021

Univariate Analysis		n	%
Diet Compliance	Apply	16	40
	Not Apply	24	60
Vitamin C intake	Excessive	17	42.5
	Sufficient	4	10
	Insufficient	19	47.5

Physical Activity	Light	15	37.5
	Moderate	11	27.5
	Heavy	14	35
Nutrition	Yes	22	55
education	No	18	45
Blood Sugar	Controlled	13	32.5
Level	Not controlled	27	67.5

The results showed that most of the DM patients were not in compliance with their diet (60%). Food or diet is the main factor associated with increased blood glucose levels in patients with type 2 diabetes, especially after eating(20). Diabetes control measures to prevent complications are needed, especially by keeping blood sugar levels as close to normal as possible. However, completely normal blood sugar levels are difficult to maintain. This is because the patient lacks discipline in running a diet or is unable to reduce the number of calories in his food (21).

The results showed that the highest percentage of patients' vitamin C intake was in the less category, namely 47.5%. Patients who have less vitamin C intake, 94.7% of them have uncontrolled blood sugar levels. Lack of vitamin C intake in patients due to lack of consumption of foods that are sources of vitamin C such as vegetables and fruits. During the COVID-19 pandemic, where diabetes mellitus is a comorbid disease, vitamin C intake is very necessary to increase the patient's immune system. This strong immune system can reduce the risk of various diseases, one of which is COVID-19. The risk of cardiovascular disease can be reduced by consuming a certain amount of antioxidants, besides that antioxidants can also improve the immune system and can inhibit the onset of degenerative diseases due to aging(22).The physical activity of patients with type 2 diabetes mellitus at Idaman Hospital Banjarbaru was mostly in the mild category. A person's physical activity contributes to a 30–50% reduction in the development of type 2 diabetes mellitus(23). Physical activity can increase glucose tolerance in the blood and reduce risk factors for the incidence of type 2 diabetes mellitus. Physical activity carried out by a person will affect blood sugar levels(24) (18). Physical exercise in addition to maintaining fitness can also lose weight and improve insulin sensitivity so that it will improve blood glucose control (25).

Most patients with type 2 diabetes mellitus at the Idaman Hospital Banjarbaru received nutrition education about healthy intake and behavior for diabetes mellitus patients as one of the comorbid COVID-19 provided by nutritionists. Blood glucose levels are more controlled because DM patients know the right healthy lifestyle for DM patients such as diet, physical activity and routine control so that their blood sugar can be monitored properly. Nutrition education with the aim of promoting healthy living should always be carried out as part of prevention efforts and is a very important part of holistic DM management. Nutrition

educational materials consist of early-level nutrition educational materials and advanced-level nutrition educational materials (5).

Most patients with type 2 diabetes mellitus at Idaman Hospital Banjarbaru have uncontrolled fasting blood sugar levels. Hyperglycemia is a medical condition in the form of an increase in blood glucose levels that exceed normal limits. Hyperglycemia is one of the typical signs of diabetes mellitus (DM), although it is also found in several other conditions. Blood sugar levels can be controlled in 3 ways, namely maintaining ideal body weight, managing diet and doing sports/physical exercise. Over time, these three methods are often inadequate. Blood sugar levels may not be well controlled (5).

The frequency distribution of respondents based on dietary compliance, vitamin C intake, physical activity, and nutrition education with patients' blood sugar levels can be seen in **Table 3** :

Table 3. Relationship of Dietary Compliance, Vitamin C Intake, Physical Activity, and Nutrition education with Blood Sugar Levels in Type 2 Diabetes Mellitus Patients at Idaman Hospital, Banjarbaru City in 2021

Bivariate Analysis		Blood Sugar Levels				Total	
		Controlled		Not Controlled			
		n	%	n	%	n	%
Dietary Compliance	Apply	6	37.5	10	62.5	16	100
	Not Apply	7	29.2	17	70.8	24	100
	α = 0.05	p = 0.581		OR=1.457 (0.381-5.572)			
Vitamin C Intake	More	9	52.9	8	47.1	17	100
	Sufficient+Inssufficient	4	16.7	19	83.3	23	100
	α = 0.05	p = 0.009		OR=0.156 (0.036-0.669)			
Physical Activity	Light &moderate	11	42.3	15	57.7	26	100
	Heavy	2	14.3	12	85.7	14	100
	α = 0.05	p = 0.020		OR=9600 (1089-84640)			
Nutrition education	Yes	12	54.6	10	45.4	22	100
	No	1	5.6	17	94.4	18	100
	α = 0.05	p = 0.001		OR=20.400 (2.296-181.264)			

Among patients who were not compliant with their diet, 17 people (70.8%) had uncontrolled blood sugar. Meanwhile, the group that was compliant with their diet had an uncontrolled blood sugar proportion of 10 people (62.5%). The research results indicate that there is no significant relationship between dietary adherence and blood sugar levels in type 2 diabetes mellitus outpatients at Idaman Banjarbaru Regional General Hospital. This is because the COVID-19 pandemic increased stress levels in diabetes outpatients. In this study, stress levels could increase blood sugar, even though patients were adhering to the dietary guidelines. This is consistent with research by Antonio, 2022, which states that patients with diabetes mellitus (DM) who experience COVID-19 infection, physiological and psychological

stress can trigger hyperglycemia. This can still cause hyperglycemia even if you are following your diet (26).

There were 19 patients (83.3%) with sufficient and insufficient vitamin C intake who had uncontrolled blood sugar. There was a significant relationship between vitamin C intake and blood sugar levels in outpatient type 2 diabetes mellitus with p-value of 0.009 and an Odds Ratio of 0.156. This indicates that patients with sufficient and insufficient vitamin C intake were 0.156 times less likely to have controlled blood sugar levels compared to patients with higher intake. This is the protective effect of vitamin C on blood sugar control. This relationship is statistically significant, indicating that vitamin C intake may be an important factor in controlling blood sugar levels in type 2 DM patients at Idaman Banjarbaru Regional General Hospital. The results of this study are consistent with research conducted by Nurlita (2015), which found a relationship between vitamin C intake and blood glucose levels (23, 27). Vitamin C helps protect the body from colds (boosts the immune system), reduces stress levels, and aids in the healing process. Boosting the immune system is crucial during the COVID-19 pandemic, and vitamin C intake is a way to enhance immune strength. Especially for patients with comorbidities like diabetes mellitus, maintaining immunity is very important. This is what causes blood sugar control. Vitamin C, as an antioxidant, can improve insulin sensitivity and help lower blood glucose levels, as well as reduce oxidative stress caused by high blood sugar (24).

Patients with mild and moderate activity had uncontrolled blood sugar in 15 people (57.7%). The research results indicate a significant relationship between physical activity and blood sugar levels in outpatient type 2 diabetes mellitus patients at Idaman Banjarbaru Regional General Hospital, with a p-value of 0.020 and an odds ratio of 9.600. This shows that patients with light and moderate physical activity are 9.600 times more likely to experience uncontrolled blood sugar levels compared to patients with excessive physical activity. This indicates that physical activity plays an important role in controlling blood sugar levels in type 2 diabetes patients. When engaging in physical activity, the body uses glucose in the muscles to convert it into energy. This causes a depletion of glucose in the muscles. This depletion leads the muscles to draw glucose from the blood, causing blood glucose levels to drop. In this study, blood sugar levels were uncontrolled in women who were more active during the COVID pandemic, leading to blood sugar levels that were lower than usual.

The main problem with type 2 diabetes mellitus is the lack of response to insulin (insulin resistance), which prevents glucose from entering the cells. Membrane permeability to glucose increases when muscles contract because muscle contraction has insulin-like properties. Therefore, during physical activity such as exercise, insulin resistance is reduced. Physical activity in the form of exercise is beneficial for blood sugar control and weight loss in type 2 diabetes mellitus. The significant benefits of physical activity or exercise in diabetes

mellitus include lowering blood glucose levels, preventing obesity, playing a role in managing complications, blood lipid disorders, and increasing blood pressure (8); (19). In this study during the COVID-19 pandemic, the group with excessive physical activity showed a higher proportion of uncontrolled blood sugar compared to the group with light and moderate physical activity. Heavy activity is not balanced by increased vitamin C consumption, leading to high blood sugar. The respondents who engage in heavy activity are mostly from the occupational groups of housewives and workers.

Out of the 17 patients (94.4%) who did not receive education about COVID-19 comorbidities, all had uncontrolled blood sugar. There is a significant relationship between health education and blood sugar levels in type 2 diabetes outpatient patients at Idaman Banjarbaru Regional General Hospital, with a p-value of 0.001 and an odds ratio of 20.4. This indicates that patients who receive health education are 20.4 times more likely to achieve controlled blood sugar levels compared to patients who do not receive health education. The results of this study are consistent with the findings of research conducted by Jasmani and Rihiantoro (2016) (8). The education received by the patient is the latest information regarding healthy eating and behavior for patients with diabetes mellitus, one of the comorbidities of COVID-19, provided by a nutritionist. Health education that promotes healthy living should always be conducted as part of prevention efforts and is a very important part of holistic diabetes mellitus management.

Nutrition education received by patients is the latest nutrition education related to healthy intake and behavior for patients with diabetes mellitus as one of the comorbid COVID-19 provided by nutritionists. Nutrition education promotes healthy living, should always be done as part of prevention efforts and is a very important part of holistic management of diabetes mellitus (28).

CONCLUSIONS AND RECOMMENDATIONS

There is a correlation between vitamin C intake, physical activity and getting nutrition education significantly with blood sugar levels but dietary compliance has no significance with blood sugar level.–With the Covid-19 pandemic, many people are facing challenges in maintaining their health, especially in keeping their blood sugar levels stable. Therefore, it is important for individuals to be able to manage their diet well so that their health condition remains stable. With the right support from healthcare professionals and a good understanding of the importance of nutrition education in managing dietary habits, we can help individuals face these difficult times better.

ANKNOWLEDGE

Director of the Idaman Regional Hospital Banjarbaru, Director of the Banjarmasin Health Polytechnic and all those involved in carrying out this research.

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