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Design of a Web and Mobile Based Diet Application For Type 2 Diabetes Melitus Patients

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Abstract

Self-nutrition management plays an essential role in controlling blood glucose levels among patients with Type 2 Diabetes Mellitus (T2DM). However, conventional dietary monitoring methods are often too complex for routine community use. This second-year study aimed to design, develop, and validate a web- and mobile-based dietary companion application for T2DM patients using empirical data from the first-year study involving 175 respondents. The application design and intervention algorithms were refined through two stages of Focus Group Discussions involving experts in clinical nutrition, medicine, information technology, public health, and research methodology, followed by laboratory-based technical validation and system bug analysis. The first discussion established the application framework based on the 3J dietary principle (schedule, type, and amount), sugar–salt–fat intake screening, and daily physical activity monitoring. The second discussion enhanced the system by integrating WhatsApp- and national ID-based registration, simplifying portion measurement using local household units, focusing clinical monitoring on fasting blood glucose, and incorporating automated nutritionist referral notifications. The application achieved satisfactory content and technical validity, indicating its readiness for large-scale implementation and real-time dietary risk monitoring for patients with Type 2 Diabetes Mellitus.

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Introduction

Type 2 Diabetes Mellitus (T2DM) is one of the most prevalent chronic non-communicable diseases and remains a major public health concern worldwide because of its increasing prevalence and long-term complications. Effective self-management, particularly dietary management, is recognized as a fundamental component of glycemic control and the prevention of diabetes-related complications. International clinical guidelines consistently emphasize that adherence to healthy dietary practices, together with regular physical activity, medication adherence, and self-monitoring, is essential for maintaining optimal blood glucose levels and improving patients' quality of life (American Diabetes Association [ADA], 2025; World Health Organization [WHO], 2023). However, sustaining long-term adherence to dietary recommendations remains a significant challenge, particularly among patients receiving primary healthcare services in community settings.

The 3J dietary principle, consisting of **schedule**, **amount**, and **type of food**, has long been recommended as the foundation of dietary management for patients with T2DM. Failure to comply with one or more of these principles may result in poor glycemic control, increasing the risk of hyperglycemia and long-term metabolic complications (Sahwa & Supriyanti, 2023). Previous studies have shown that dietary non-adherence is influenced by multiple factors, including limited health literacy, treatment fatigue, inadequate family support, and difficulties in estimating appropriate food portions during daily meals (Aisyyah et al., 2022; Kurniasari et al., 2020). Consequently, patients often struggle to translate dietary recommendations into practical daily decisions.

To better understand these challenges, the first year of this multiyear research (2025–2027) employed a **quantitative correlational study with a cross-sectional design** involving **175 patients with Type 2 Diabetes Mellitus** recruited from five villages within the working area of Astambul Primary Health Center. Respondents were selected using predetermined inclusion criteria, and data were collected through structured questionnaires assessing dietary adherence based on the 3J principles. At the same time, clinical measurements included **Random Blood Glucose (RBG)** levels, previously referred to as **Glukosa Darah Sewaktu (GDS)**. The baseline study found that **91.4% of respondents demonstrated poor dietary adherence**, with a mean random blood glucose level of **212.47 mg/dL**. Multivariate analysis further indicated that dietary behavior significantly influenced blood glucose control, with food type emerging as the strongest predictor, followed by food quantity. These findings provided empirical evidence that dietary management remains a critical determinant of glycemic control among community-based patients with T2DM.

Although dietary counseling is routinely provided through primary healthcare services, conventional educational approaches that rely on printed materials or one-time face-to-face counseling often fail to support ongoing self-management. These approaches offer limited opportunities for real-time monitoring, personalized feedback, and ongoing patient engagement, particularly for individuals who need daily dietary guidance. In contrast, digital health interventions enable continuous communication, personalized dietary monitoring, automated reminders, and immediate feedback, thereby supporting patients in making informed dietary decisions during everyday activities. Previous systematic reviews have demonstrated that mobile health technologies can significantly improve diabetes self-management, medication adherence, and glycemic outcomes by facilitating continuous interaction between patients and healthcare providers (WHO, 2023; American Diabetes Association, 2025).

Despite the growing adoption of digital health technologies, relatively few applications have been specifically designed to integrate evidence-based dietary management with locally relevant food portion measurements and multidisciplinary clinical recommendations for Indonesian patients with T2DM. Most existing applications focus primarily on calorie counting or glucose recording and do not incorporate validated dietary algorithms based on the 3J dietary principle or consensus from multidisciplinary healthcare professionals. This gap indicates the need for a more comprehensive

digital solution that combines empirical clinical evidence, behavioral dietary management, and user-centered design into an integrated self-management platform.

Therefore, the second year of this multiyear research focuses on designing and developing the algorithmic framework of a web- and mobile-based dietary companion application for patients with Type 2 Diabetes Mellitus. The application was developed using empirical findings obtained during the first-year field study and refined through multidisciplinary expert validation involving clinical nutritionists, physicians, nursing specialists, information technology experts, public health practitioners, and research methodologists. This study presents the formulation of application input variables, the consensus-building process through Focus Group Discussions (FGDs), and the development of the user interface (UI) and user experience (UX) that form the foundation of the digital intervention.

The novelty of this study lies in developing an evidence-based dietary companion framework that integrates empirical clinical findings, the 3J dietary principle, multidisciplinary expert consensus, and user-centered interface design into a single computational model for T2DM self-management. Unlike previous studies that evaluated dietary adherence or digital health interventions separately, this study systematically transforms field-based clinical evidence into a validated algorithm that supports personalized dietary monitoring and decision-making. This integrated framework is expected to strengthen digital health literacy, improve long-term dietary adherence, and facilitate sustainable blood glucose management among patients with Type 2 Diabetes Mellitus.

Research Methods

Research Design and Framework

This study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model as the framework for developing the digital dietary companion application. The ADDIE model was selected because it provides a systematic and iterative process for designing, validating, and refining educational and health technology products. The present study focused on the first three phases of the ADDIE model-Analysis, Design, and Development-conducted during the second year of the multiyear research project (2026). The expected output of this phase was a validated prototype of a web- and mobile-based dietary companion application for patients with Type 2 Diabetes Mellitus (T2DM), ready for field implementation and effectiveness testing in the subsequent research phase.

The Analysis phase was conducted from January to February 2026. This phase utilized empirical data obtained from the first-year study involving 175 patients with Type 2 Diabetes Mellitus from five villages within the Astambul Primary Health Center service area. The baseline study findings were analyzed to identify functional requirements, define system specifications, and transform the dietary variables based on the 3J principles (schedule, amount, and type of food) into measurable computational input parameters for the application.

The Design phase was carried out from March to April 2026 through two Focus Group Discussion (FGD) sessions involving 10 multidisciplinary experts: two clinical nutritionists, two physicians, two nursing specialists, two information technology experts, one representative from the District Health Office, and one research methodology expert. The first FGD focused on identifying the functional requirements, application workflow, intervention components, and dietary monitoring algorithms. The second FGD evaluated the prototype design, user interface (UI), user experience (UX), clinical decision rules, and system architecture. The team incorporated suggestions from each FGD into the prototype through two iterative revision cycles until all experts reached consensus.

During the Development phase (May–June 2026), the educational content and clinical recommendations incorporated into the application were evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Tool. Educational materials were considered acceptable when they achieved

a minimum content validity score of 75% from the expert panel. Subsequently, the application algorithms were translated into program logic using if–then–else decision rules to automate dietary assessment, fasting blood glucose monitoring, dietary recommendations, and referral alerts for nutritionists. Technical validation was performed through laboratory-based system testing, including functionality testing, navigation testing, and bug analysis. The prototype was considered technically feasible when all critical system functions operated successfully without major errors, and all identified critical bugs were resolved before proceeding to the next stage of the multiyear research.

The subsequent Implementation and Evaluation phases of the ADDIE model, including usability testing, field implementation, and effectiveness evaluation among patients with Type 2 Diabetes Mellitus, will be conducted during the third year of the research program.

Research Subject

The subjects involved in the second year of design research (2026) are determined based on the needs of system development (*Research and Development*), which focuses on the Astambul Health Center Working Area. The main research subject is sourced from an expert *judgment* panel that is directly involved through *the Focus Group Discussion* (FGD) technique. The panel consists of nutritionists to validate dietary components, medical experts to validate blood sugar regulation, and IT programming experts responsible for designing and building application architectures in programming languages.

In addition to the expert panel, this phase also involves representatives of people with Type 2 Diabetes Mellitus (DM) at the domestic or household level, especially patients with low levels of education or nutritional knowledge. Involving this target group aims to conduct a limited trial of the readability of daily questionnaires and the functionality of interactive digital auxiliary media before wider application in the next stage of research.

Instruments and Data Collection

Data collection in the second year of research (2026) focuses on two main data sources to meet system design needs. The first data source was obtained directly from a panel of nutritional, medical, and information technology (IT) experts through minutes and a draft evaluation of the FGD results. This expert data is used to compile monitoring instruments, align algorithms, and validate clinical decision rules in computer programming languages.

The second data type is local portion visualization data, collected by reconstructing consumption portion data into concrete visualizations based on local household measuring tools (URT), such as the size of rice cubes, bowl sizes, or pieces of side dishes. This practical visualization data is then integrated into the digital *user interface*, making the application more interactive, easier to understand, and better able to minimize bias in interpreting meal portions by ordinary people at the domestic level.

Data Analysis

The data analysis in the second year of design (2026) is focused on testing the technical validity and reliability of the developed application systems. The analysis process was carried out in two main stages: first, a qualitative analysis of the FGD results was conducted with a panel of nutritional, medical, and information technology (IT) experts. Data in the form of inputs, corrections, and clinical decision *rules* were systematically tabulated to align the program logic with the principles of the 3J diet (Schedule, Type, Amount) and blood sugar level regulation.

Second, a computational technical analysis was carried out in a computer laboratory to test the performance of the application prototype. The test involved checking for system bugs (bug system check) and validating the if-then-else mathematical logic that controls the automation of the fasting blood sugar (GDP) curve and the daily warning system. The application is declared valid and reliable

if all programming language instructions run stably, do not experience errors (crashes), and produce precise visualization of local meal portions according to the input parameters entered.

Ethical Considerations

This study received ethical approval from the Research Ethics Commission of STIKES Intan Martapura, Indonesia, under Ethical Clearance No. 049/KE/BIP-SI/IV/2026, issued on 30 April 2026, before the study commenced.

All procedures involving human participants were conducted in accordance with the ethical principles of the Declaration of Helsinki. Before participating in the Focus Group Discussions (FGDs), expert validation sessions, and limited usability testing of the application prototype, all participants received complete information about the study's objectives, procedures, potential benefits, and possible risks. We obtained written informed consent from every participant before data collection. Participants were informed that participation was voluntary, that they could withdraw at any time without consequences, and that all personal information would be kept confidential and used solely for research purposes. All collected data were anonymized before analysis to protect participant privacy and confidentiality.

Results and Discussion

Results

a. Formulation of Input Variables and Application Algorithm Components

Based on first-year baseline data from 175 respondents, food type was the strongest determinant of blood sugar fluctuations, followed by the number and schedule of meals. All clinical findings as well as medical rules resulting from expert judgment are transformed into the following system computational logic matrix:

Table 1. Input Variable Specification Matrix and Application System Logic

Intervention Components	User Input Variables	System Computing Logic (*If-Then-Else*)	Application Outputs and Actions
Profile & Registration	NIK, Name, WhatsApp No., Date of Birth, Gender, Address, Education, Occupation	*If* the WA number is active & NIK is valid *And then there is the* Successful Registration (SSO System)	Patient accounts are active without complicated email verification.
Clinics & Anthropometers	Weight (BB), Height (TB), Fasting Blood Sugar (GDP)	1. Calculating BMI = BB / $(TB)^2$ (WHO Asia Pacific Standard) 2. *If* GDP > 126 mg/dL or BMI > 25 (Obesity) *Then* Status = "High Risk"	Automation of weekly GDP trend graphs and standalone BMI calculators. Remove the GDS examination option to maintain medical curve accuracy.
Physical Activity	*Checklist* of daily exercise/household activity duration	*If* the duration of the activity is < 30 minutes/day *Then* Status = "Sedentary / Poor"	Activate the Warning System: Clinical risk notifications and links to safe sports articles.

Schedule Algorithm (3J)	Meal Consumption Log Clock	*If* the input time is in the range: - Breakfast (06.00-09.00) - Lunch (12.00-15.00) - Evening (18.00-20.00) *Then* Status = "Appropriate" *Else* Status = "Not Suitable"	*Push notifications* for regular meal reminders (with concise operational definition text on the schedule page).
Algorithm Type (3J)	Food Options (*Dropdown/Checkbox*)	*If* the food choice contains Refined Carbohydrates / High Glycemic Index (GI) (>70) *then* status = "limit" *Else* Status = "Aman"	Block/warn on high-sugar/high-IG menus. Automatically recommends the Low/Medium IG Local Food Substitution Menu (Sorghum, steamed kepok bananas, breadfruit).
Total Algorithm (3J)	Total daily servings of food	*If* the portion exceeds the patient's daily calorie conversion limit (the screening result of the plant-based side dish portion begins with the Yes/No button) *Then* Status = "Overportion"	Visualization of the conversion of food portions into the form of a practical measure of the local Household Measuring Instrument (URT).

b. Results of Cross-Sector Consensus (FGD Phase I and II)

The system validation process was carried out through two online FGDs involving multidisciplinary experts:

1) FGD Phase I (April 24, 2026): Resulted in a decision to shift the main focus of the application to improving the patient's dietary knowledge and adherence (not an instant decrease in blood sugar). The system breaks down diet variables into schedule, type, and amount sub-components and adds at least 30 minutes of daily physical activity tracking. The IT team established the digital system architecture into two platforms: an Android app for patients and a web-based admin dashboard for researchers.
2) FGD Phase II (May 22, 2026). Agreed on the renewal of registration accessibility based on WhatsApp numbers integrated with NIK (*Single Sign-On*). To address the culture among elderly patients, the questionnaire was simplified using the local *food record* measure (bucket/bowl). In addition, a radical medical decision was made by removing the option of Blood Sugar At Time (GDS) and establishing Fasting Blood Sugar (GDP) as the single valid clinical parameter.

c. Realization of User Interface Flows (UI/UX) and System Flowcharts

The results of the computational visualization of the FGD agreement realize *the following logical flowchart* of the application automation system accompanying the diet of DM patients:

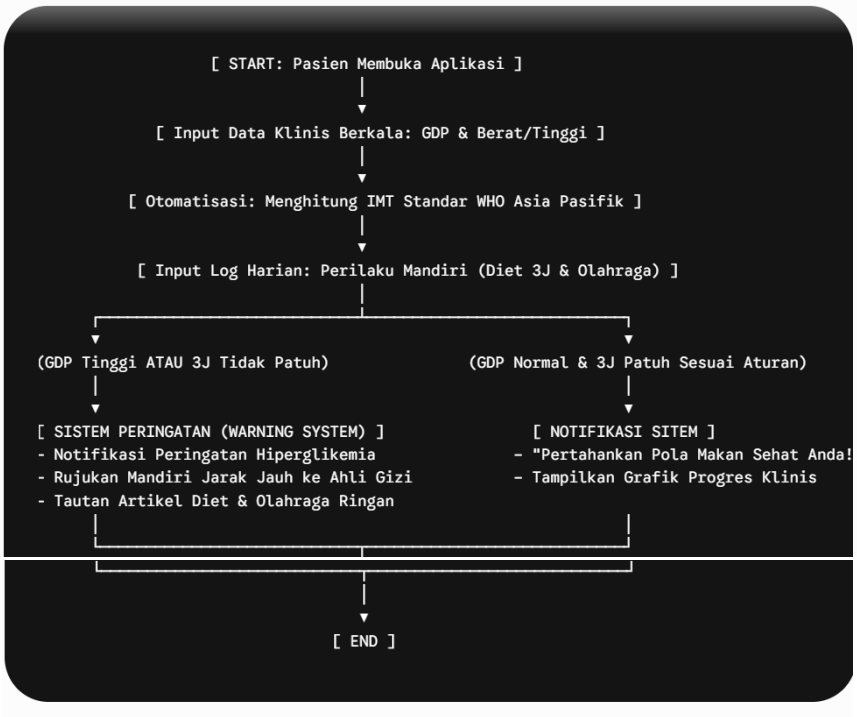

Figure 1. Workflow of the Dietary Companion Application for Patients with Type 2 Diabetes Mellitus

Discussion

The system development process indicated that computerized self-management interventions should be primarily structured around the 3J dietary principle-schedule, amount, and type of food-as the core components of daily dietary monitoring. During the second Focus Group Discussion (FGD), the expert panel agreed to replace Random Blood Glucose (RBG/GDS) with Fasting Blood Glucose (FBG/GDP) as the primary clinical monitoring parameter. This decision was not solely based on expert consensus. However, it was also supported by current clinical guidelines, which recommend fasting blood glucose as a more standardized indicator for evaluating baseline glycemic control because it is less affected by recent food intake and provides a more stable measure of metabolic status than random blood glucose measurements (American Diabetes Association [ADA], 2025; PERKENI, 2025). Therefore, fasting blood glucose was considered more appropriate for incorporation into the application's automated monitoring algorithm.

Another important component integrated into the application is meal schedule monitoring. Rather than imposing rigid meal times, the application encourages users to maintain regular meal timing in accordance with diabetes nutritional management guidelines, which recommend consistent distribution of meals and snacks throughout the day to support glycemic stability and optimize insulin response (ADA, 2025; PERKENI, 2025). Accordingly, the application provides flexible reminders for breakfast, lunch, dinner, and planned snacks that can be adjusted to individual daily routines while maintaining dietary consistency. This approach is expected to improve long-term adherence without reducing the practicality of self-management in everyday life.

Integrating the 3J dietary principle with fasting blood glucose monitoring enables the application to provide personalized dietary feedback and early warnings when users show poor dietary adherence or abnormal fasting blood glucose values. Consequently, the proposed algorithm not only facilitates dietary recording but also supports evidence-based clinical decision-making and promotes continuous self-management among patients with Type 2 Diabetes Mellitus.

Justification of Food Type Algorithm and Local Food Substitution

Based on multivariate analysis of basic data, the food type component ranks highest as the dominant predictor of hyperglycemia. Directional statistical tests confirmed a significant relationship between the consumption of high Glycemic Index (GI) foods and the incidence of hyperglycemia. People with DM with an uncontrolled diet pattern (often consuming simple carbohydrates) had up to 6 times the risk of developing severe hyperglycemia compared to the group that kept their food type (Li, Wu, Yu, & Niu, 2023).

Therefore, the application's algorithm is programmed to filter processed food ingredients. As a tactical intervention, the system included a database of recommended local food substitution menus with low (<55) and medium (55–69) IG values, such as sorghum rice, corn, steamed breadfruit, and steamed kepok bananas. This local food substitution makes it easier for patients to adopt a healthy menu without feeling alienated by foreign food ingredients (Adriani, Hastuti, & Saleh, 2025).

Automation of Physical Activity Alert System and Saturation Mitigation

The integration of sedentary lifestyle screening into the digital application's warning system is based on the clinical fact that DM patients with low physical activity are up to 7.15 times more likely to experience uncontrolled blood sugar due to decreased sensitivity of GLUT-4 receptors in muscle tissue (Suhita et al., 2021). When the user's daily data shows an activity duration of less than 30 minutes, the app automatically activates a clinical alert status that triggers a push notification outlining the risk of complications and linking to a safe sports education article.

Simplifying the registration system by integrating WhatsApp numbers without complicated email verification, combined with changing the instrument from rigid grammar to a local Household Measuring Instrument (URT) unit (such as the size of a rice cuck or vegetable bowl), has been shown to reduce cognitive load significantly. This interactive approach, centered on patient characteristics, effectively mitigates saturation f*rom long-term therapy* and bridges the limitations of digital health literacy for DM sufferers with low levels of education in rural areas (Q. Wang et al., 2022).

Conclusion

This study concluded that developing a web- and mobile-based dietary companion application successfully addressed the objective of establishing an evidence-based digital framework to support self-management among patients with Type 2 Diabetes Mellitus. The application integrates the 3J dietary principles, fasting blood glucose monitoring, physical activity assessment, and a multidisciplinary expert-validated decision algorithm into a single digital platform. These integrated features provide personalized dietary recommendations, facilitate continuous self-monitoring, and support early identification of potential health risks, thereby offering a practical approach to improving dietary adherence and diabetes self-management.

Although the application has demonstrated satisfactory content and technical validity during development, its effectiveness in improving clinical outcomes has not yet been evaluated. Therefore, future studies should focus on large-scale field implementation to assess usability, user acceptance, dietary adherence, glycemic control, and long-term clinical effectiveness among patients with Type 2 Diabetes Mellitus in primary healthcare settings.

Suggestions

This study concluded that developing a web- and mobile-based dietary companion application successfully achieved the objective of establishing an evidence-based digital framework to support self-management among patients with Type 2 Diabetes Mellitus. The application integrates the 3J dietary principles, fasting blood glucose monitoring, physical activity assessment, and a multidisciplinary expert-validated decision algorithm into a single digital platform. These integrated features provide personalized dietary recommendations, facilitate continuous self-monitoring, and support early identification of potential health risks, thereby offering a practical digital solution to improve dietary adherence and diabetes self-management in primary healthcare settings. Although the application demonstrated satisfactory content and technical validity during development, its effectiveness in improving clinical outcomes remains to be evaluated through field implementation. Therefore, future studies should assess the application's usability, effectiveness, user acceptance, and long-term impact on dietary adherence, glycemic control, and self-management among patients with Type 2 Diabetes Mellitus in larger, more diverse populations.

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