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Development of a Diabetes Mellitus Monitoring Information System in Health Monitoring and Health Decision Making

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ABSTRACT Individuals with diabetes mellitus are more likely to experience acute and chronic health complications including oral diseases. However, there are still many of them who do not carry out routine controls and do not record the history of examination results, resulting in a lack of monitoring of their health. Information systems in the health sector can be utilized in managing health information as an effort to monitor risk factors that allow complications of oral and dental disease. In addition, there is no information system that focuses on monitoring dental health in patients with diabetes mellitus. The development of SIP DM-DENT Monitoring is focused on monitoring general health and dental health in patients with diabetes mellitus. This study aims to produce SIP DM-DENT Monitoring for people with diabetes mellitus that is feasible in monitoring health and providing health recommendations based on the results of their health checks, especially in controlling blood sugar and dental health. This research combines descriptive and analytical types of research called R&D to develop a new product output with the stages of information gathering, design making, expert validation, product testing and product results. The data collected is primary data using interview questionnaires and Linkert questionnaires. Sampling using purposive sampling technique obtained a sample of 35 respondents. The data obtained were analyzed using ICC test and descriptive statistics. The average result of the expert validation assessment was 85.76 with a decent category. The ICC test results show a p-value of $0.00 < 0.05$ which means the system is feasible to use. While in the product test assessment, the average respondent agrees that the system provides information and is easy to use. Based on this research, it shows that SIP DM-DENT Monitoring is feasible and effective in monitoring the health of people with diabetes mellitus and providing health recommendations for them.

INDEX TERMS Diabetes Mellitus, Health Monitoring, System Information

I. INTRODUCTION

Diabetes mellitus is the most common disease in the world. It affects about 21 million people or about 7% of the world's population, of which about 6.2 million are undiagnosed with diabetes mellitus[1]. These numbers are increasing substantially. It is predicted that one in three individuals born in 2000 will have diabetes mellitus[2]. Based on the 2019 International Diabetes Federation (IDF) Atlas report, Indonesia is ranked as the 7th country with adults suffering from diabetes mellitus in 2019, 2030 and 2045[3]. This is supported by the increase in diabetes mellitus patients in

Indonesia, which originally had a prevalence of 6.9% in 2013 to 10.9% in 2018[4].

Individuals with the systemic disease diabetes mellitus face a shorter life span and are more likely to experience acute and chronic health complications[5]. Therefore, awareness of the increased risk of diabetes mellitus must be created, not least the increased risk of people with diabetes mellitus experiencing oral and dental disease and the support or motivation for them to have oral and dental disease control through self-care and professional monitoring[6]. Oral health problems in people with diabetes mellitus include xerostomia,

gingivitis, periodontal disease and tooth loss[7]. However, the most common oral health problem is periodontal disease[8]. Based on Chen's (2023) research of 68,365 diabetes mellitus patients, 49% of them suffer from periodontitis [9]. Alahmari's research (2023) shows the prevalence of periodontitis in patients with type II diabetes mellitus at 46.4% [10].

Periodontal disease that can arise as a complication of diabetes mellitus needs to be considered. Young adults with diabetes mellitus have twice the risk of developing periodontal disease than young adults without diabetes mellitus. In addition, one-third of diabetics have severe periodontal disease with attachment loss of 5 mm or more[11]. Glycemic control is a determining factor for the incidence of periodontal disease in people with diabetes mellitus[12], [13].

The era of revolution 4.0 affects the use and utilization of technology in various fields of daily life, including in the health sector[14]. Information systems in the health sector can be utilized in managing health information and indicators to achieve health development goals. This can also be applied in health monitoring in patients with diabetes mellitus.

Previous studies have only focused on monitoring blood sugar in patients with diabetes. Handoko Research (2023) develops an Internet of Things and android-based blood sugar monitoring system for people with diabetes mellitus. The system makes it easier for patients to check blood sugar levels regularly [15]. Meanwhile, Rhogui's research (2021) uses machine learning algorithms to monitor blood sugar levels of people with diabetes mellitus [14]. However, effective management of diabetes mellitus goes beyond strict glycemic control. A comprehensive approach to patient health monitoring is necessary to optimize quality of life for individuals with this chronic condition. In this study addresses a frequently neglected aspect of diabetic care, namely oral health. We aim to develop an information system dedicated to monitoring oral and dental health in diabetic patients. This system is intended to enhance dental health outcomes and prevent potential complications associated with dental disease in this population. Development of a monitoring information system for patients with diabetes mellitus developed to identify oral health problems that occur in people with diabetes mellitus. It also aims to produce a feasible and effective health monitoring system innovation in monitoring dental health and tooth brushing compliance in people with diabetes mellitus.

The development of the Diabetes Mellitus monitoring information system (SIP DM-DENT Monitoring) in this study was developed by adopting health monitoring methods through the use of digital technology which allows access to data from anywhere and anytime, and allows more sophisticated data analysis by utilizing artificial intelligence [16]. Data analysis by a system that utilizes machine learning by collecting blood sugar and dental health monitoring collected in the DM-DENT Monitoring SIP is used to help identify previously undetected patterns and provide

recommendations for good health management. Previous research has shown that machine learning in health monitoring in patients with diabetes mellitus is able to predict the risk of complex health complications [17], [18]. In addition, the development of the SIP DM-DENT Monitoring utilizes the use of a website that can be accessed through Android, Windows or IOS operating systems. The use of a website that can be accessed with any operating system can allow patients to monitor their health easily, without being constrained by technological limitations [19], [20].

The method used in this research on the development of health monitoring applications for people with diabetes mellitus is the research and development (R&D) method. This method is used to develop or produce a new model/product output through the stages of information gathering stage, design, expert validation and revision, model effectiveness trials and product results. Information collection is the first step to identify and analyze problems experienced in the implementation of dental and oral health monitoring in diabetes mellitus patients conducted through observation and interviews with the field of disease prevention and control at the Health Office, dental and oral health practitioners, general practitioners and the coordinator of the chronic disease management program at the community health center and through literature Reviews.

Data from information collection is used to design SIP DM-DENT Monitoring tailored to the needs of people with diabetes mellitus. The development of the Diabetes Mellitus monitoring information system (SIP DM-DENT) uses the Rapid Application Development method using the Data Flow Diagram (DFD) logic model. The development of information systems using the RAD method with the DFD logic model is intended to be able to develop information systems faster with better product quality. RAD emphasizes iteration and prototyping, allowing for building and testing iterative versions of systems quickly and easily adapting to the needs of feedback. So that if there are additional features needed, system changes do not take long. The use of DFD logic models helps visualize data flows and system processes, making it easier for teams to understand and design systems more quickly and helping to identify potential problems and inconsistencies in system design from the start.

SIP DM-DENT Monitoring is designed for dental health workers to increase the role of organizing promotive, preventive efforts in the field of dental health, especially those related to increasing knowledge of dental health maintenance and increasing the ability to brush teeth. In addition, this information system can be accessed by patients to be able to monitor the progress of sugar control, control of drugs consumed and oral health checks, increasing the degree of oral hygiene and improving the quality of life of people with diabetes mellitus through direct contribution by people with diabetes mellitus in monitoring their health.

II. MATERIALS AND METHODS

The information collection stage is carried out to be able to identify problems experienced by people with diabetes mellitus related to the implementation of their health monitoring. The implementation of information collection is carried out by observation and interviews as well as through literature review. Observations and interviews are used to see direct problems that occur in the field. While the review literature is used to obtain supporting information from literature related to health monitoring in patients with diabetes mellitus.

The model design stage includes the stages of developing SIP DM-DENT Monitoring in accordance with the results of information collection. The development of the Diabetes Mellitus monitoring information system (SIP DM-DENT Monitoring) uses the Rapid Application Development method using the Data Flow Diagram (DFD) logic model. The use of RAD with the DFD method offers advantages in system development that increase development efficiency, save time and resources and greater flexibility. In addition, system development using RAD methods with DFD logic models helps in focusing key data flows related to DM monitoring, such as data collection, analysis, and recommendations.

Design the SIP DM-DENT Monitoring model which is developed into a monitoring information system, then expert validity tests are carried out. Expert validation tests are conducted to test the feasibility of the product to experts before the product is used in the general public. The collection of feasibility test data was carried out by providing questionnaires to experts, then a revision stage was carried out on the SIP DM-DENT Monitoring. While the product trial stage is carried out on people with diabetes mellitus. This stage is carried out to test how much respondent satisfaction in using SIP DM-DENT Monitoring. Product trials were conducted using the Pre-experiment research method with a one group pre-posttest design.

Sampling techniques at the information collection stage using purposive sampling techniques obtained respondents consisted of general practitioners, dentists, coordinators of chronic disease management program activities, health offices and technology programmers in hospitals. The sample was selected based on inclusion criteria, namely individuals who play an active role in the management of diabetes mellitus management, both practitioners and policy holders. Doctors and dentists play a role in revealing the relationship between diabetes mellitus and oral health and providing information about the appropriate monitoring system for people with diabetes mellitus. The coordinator of the chronic disease control program and the health department play a role in providing information related to health monitoring management and applicable policies and requirements that can be implemented in the system. While the technology programmer at the hospital provides information about menu features that are suitable for health monitoring for people with

diabetes mellitus. The results of the data obtained are then used as a reference in making an information technology-based dental health monitoring information system that is suitable for development in individuals with systemic diabetes mellitus.

Samples at the expert validation test stage used purposive sampling techniques. Sample respondents of the expert validation test were health practitioners, diabetes mellitus experts, information technology experts and oral health promotion experts. Expert validation of health practitioners is intended to assess how feasible and appropriate the system can be applied in the field. Validation of diabetes mellitus experts to assess the features in the system are in accordance with the needs of people with diabetes mellitus in monitoring their health independently. Validation of information technology experts is intended to assess the suitability of features and the ease of features displayed for users. Meanwhile, validation of dental and oral health promotion experts is aimed at assessing the suitability of health monitoring features and educational materials available in the system. The sample selection at the product trial stage used purposive sampling technique on diabetics who met the inclusion criteria. Inclusion criteria at this stage include patients with type I and type II diabetes mellitus, patients with diabetes mellitus who still have teeth, experience periodontal disease, have a device to access the website (android, IOS or windows) and can access the website. Based on the results of calculations using the Slovin, from a population of 38 people with diabetes mellitus, a sample of 35 respondents was obtained.

This research has obtained ethical permission from the Research Ethics Commission of the Poltekkes Kemenkes Semarang with Ethical Approval number No. 0100.EA/KEPK/2024. Before data collection, respondents were given an explanation before the study regarding the purpose of the study, the stages of data collection, the identity of the respondent which was only known by the researcher, the freedom to choose research participation without coercion, the obligations and benefits of research participants and prospective respondents were given informed consent to be able to determine whether or not they were willing to become respondents. The informed consent given contains a statement of willingness to participate or refusal to participate in the research with the signature of the prospective respondent. Respondents who are willing will be given a research questionnaire that has been prepared. The data collection instrument for the information gathering stage used an open-ended interview questionnaire with 8 questions about the problems in monitoring the health of people with diabetes mellitus, especially oral health and the data needed in the development of the DM-DENT Monitoring SIP. The open-ended interview questionnaire was aimed at getting as detailed answers as possible that support the completeness of information, improve the quality of the data needed and get more in-depth information. The feasibility test standard for

experts to test information systems is based on the ISO 9126 standard with 18 questions. Indicators of the ISO 9126 standard model include Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability. The system assessment instrument uses a closed questionnaire with 10 questions with category ratings strongly agree, agree, disagree and strongly disagree. The selection of closed questionnaires is intended to obtain accurate results and consistent data between respondents. The questionnaire designed is tailored to the research objectives to obtain data on the needs of health monitoring in people with diabetes mellitus and user satisfaction with the system developed. Validity and reliability tests of the questionnaire have been carried out using Cronbach's product moment correlation test.

The data analysis used includes descriptive statistical analysis by describing the results of data collection obtained and interclass correlation coefficient (ICC) test. Data analysis on information collection uses descriptive analysis because the data obtained is quantitative data from interviews and observations. Data from expert validation tests used the ICC test to assess inter-expert reliability and assess the extent to which test scores are consistent when given to different experts. While the results of data collection at the product test stage used descriptive statistical analysis by describing the percentage results of data acquisition. Before the analysis test is carried out, the data that has been obtained is checked for completeness, then coding is given to the data to facilitate data processing. Furthermore, the data tabulation stage is carried out into a predetermined table and conducts an analysis test.

III. RESULT

A. RESULT OF INFORMATION GATHERING

Information collection was carried out by interviewing the field of disease prevention and control at the Health Office, dental and oral health practitioners, general practitioners and the coordinator of the chronic disease management program at the community health center. Information collection using an open questionnaire instrument of 8 items. Questions given are related to the implementation of health monitoring in patients with diabetes mellitus, policies that apply in health management in patients with diabetes mellitus, the incidence of dental and oral disease in patients with diabetes mellitus and management of preventive measures for complications of dental and oral disease in patients with diabetes mellitus. This interview guide is made based on the need to collect information related to health monitoring in people with diabetes mellitus that has been in effect today. Based on the results of the interviews, the following conclusions were obtained from the interviewees' answers:

1. Health monitoring for people with diabetes mellitus is checking blood sugar and blood pressure every month during chronic disease management program activities. The results of laboratory tests are usually consulted with a specialist. Recording the results of the examination in

the form of printout data recap and there is no record that can be monitored independently by the patient.

2. Health education for patients with diabetes mellitus is carried out directly through chronic disease management program activities as well as through posters and during consultations with doctors. In addition, educational activities are also carried out during activities such as national health days. The educational material provided is about PHBS and healthy lifestyles.
3. Dental examination activities specifically for patients with diabetes mellitus do not yet exist. Dental examinations are carried out when patients come to the dental clinic independently.
4. Dental health education for patients with diabetes mellitus is carried out through posters, during consultations and during chronic disease management program activities. However, the provision of education has not been carried out routinely
5. Policies related to chronic disease management program activities that are directly related to dental health do not currently exist. Both are regulated in different regulations, but are still related in terms of health promotion and prevention. Dental health is regulated in Minister of Health Regulation No. 89/2015, while chronic disease management program activities are regulated in Presidential Regulation No. 12/2013.
6. The monitoring information system can provide services, references and facilitate people with diabetes mellitus in doing.
7. The menu that can be displayed in the diabetes mellitus monitoring information system is the examination history menu, both dental and oral examinations and diabetes mellitus control examinations. In addition, menus that can be added include recommendations and education. Menu selection is expected to use a menu that is easy for users to operate.

Information collection was also carried out through a systematic review of several journals on monitoring information systems, diabetes mellitus and dental nursing care, with the result that the prevalence of undiagnosed diabetes mellitus and prediabetes is increasing[21]. Systematic review is carried out to strengthen data and information regarding health monitoring that has been carried out in patients with diabetes mellitus and the incidence of manifestations of dental and oral disease in patients with diabetes mellitus. Besides this, diabetes and periodontitis have a two-way relationship that affects each other[22]. High blood sugar levels from uncontrolled diabetes can create an environment in mouth that favors the growth of bacteria that cause gum disease. In turn, inflammation and infection in the gums from periodontitis can raise blood sugar levels and make it more difficult to control diabetes. Prevention of periodontitis in patients with diabetes mellitus and vice versa requires primary health care through promotive and preventive actions. One way that can be done as an effort in primary health care is by developing

a digital decision-making system[23]. The development of digitalization in oral health care is quite good, but in terms of relating dental health to general health, it still needs development. Updates in improving the function of decision-making systems include the incorporation of health dimensions and customization of the end-user interface. Health monitoring currently plays a role in providing solutions and empowering patients independently to manage their health with health professionals who remain informed and facilitate access to medical care[24].

B. DEVELOPMENT OF DIABETES MELLITUS MONITORING INFORMATION SYSTEM (SIP DM-DENT MONITORING)

Development of Diabetes Mellitus monitoring information system (SIP DM-DENT Monitoring) using Rapid Application Development method using Data Flow Diagram (DFD) logic model. The stages carried out include:

1. NEEDS PLAN

This stage aims to identify the needs of an information system in order to achieve the goals previously set.

2. SYSTEM DESIGN PROCESS

This stage aims to make improvements if there are still discrepancies in system design between users and analysts.

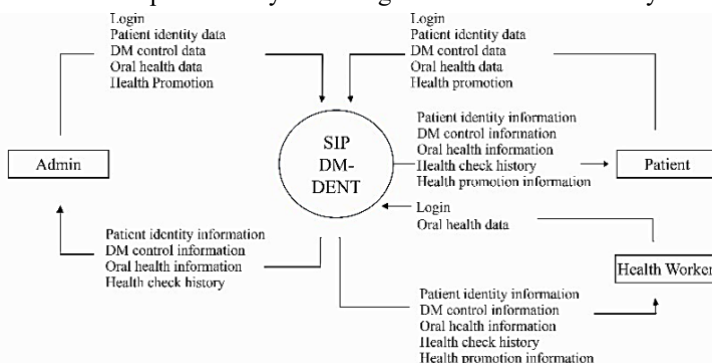


FIGURE 1. Content diagram of SIP DM-DENT Monitoring

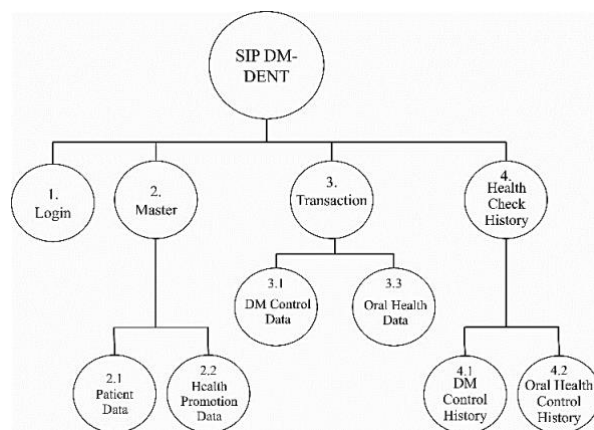


FIGURE 2. Level Diagram of SIP DM-DENT Monitoring

3. SYSTEM OUTPUT

The output menu display includes a login menu, dashboard display, patient biodata, diabetes mellitus

control menu, oral examination menu, tooth brushing compliance checklist menu, dental health education menu and website guide menu.

C. EXPERT VALIDATION

Expert validation consists of diabetes mellitus experts, oral health promotion experts, information technology experts and health practitioners. The assessment was carried out using a product feasibility analysis questionnaire based on ISO 9126 standards. While the statistical test used is the interclass correlation coefficient test.

TABLE 1

Expert validation		
Mean	Category	p-value
85.76	Feasible	0.00

The feasibility of the system from the average assessment results of expert validators resulted in a value of 85.76 with a decent category, a p-value result of 0.00 shows that SIP DM-DENT Monitoring is feasible in monitoring dental health and brushing compliance in patients with diabetes mellitus.

D. SYSTEM USAGE ASSESSMENT

Assessment of the system was carried out on 35 respondents with diabetes mellitus with inclusion criteria, namely patients with type 1 and type 2 diabetes mellitus, diabetics who can use technology or who have difficulty using information technology, but are assisted by a companion in filling in the website, patients with diabetes mellitus who have gingivitis and still have teeth.

form of diagrams to	Agree	17	48,6
facilitate health	Disagree	0	0,00
monitoring			

Table 2

System Usage Assessment				
No	Question	Category	n	%
1.	Provide convenience in obtaining dental health information for people with diabetes mellitus	Strongly Agree	18	51,4
		Agree	17	48,6
		Disagree	0	0,00
2.	Able to produce information that is easy to understand	Strongly Agree	14	40,0
		Agree	21	60,0
		Disagree	0	0,00
3.	Stages on the system are easy to understand and access independently	Strongly Agree	11	31,4
		Agree	24	68,6
		Disagree	0	0
4.	The system provides all the features needed in monitoring health in people with diabetes mellitus	Strongly Agree	20	57,1
		Agree	14	40,0
		Disagree	1	2,9
5.	The information system helps in making better decisions related to my own health	Strongly Agree	18	51,4
		Agree	17	48,6
		Disagree	0	0,00
6.	Filling in the results of diabetes control checks makes it easy to find out the blood pressure checks that have been carried out	Strongly Agree	12	34,3
		Agree	23	65,7
		Disagree	0	0,00
7.	Filling in the results of diabetes control checks makes it easy to find out the blood sugar checks that have been carried out	Strongly Agree	14	40
		Agree	21	60
		Disagree	0	0,00
8.	Completing the health check results makes it easy to know the dental health that has been done	Strongly Agree	14	40
		Agree	21	60
		Disagree	0	0,00
9.	Completing the tooth brushing checklist helps in monitoring tooth brushing compliance	Strongly Agree	14	40
		Agree	21	60
		Disagree	0	0,00
10.	Able to generate health monitoring data in the	Strongly Agree	18	51,4
		Agree		

IV. DISCUSSION

A. RESULT OF INFORMATION GATHERING

Information collection was carried out using the interview method to the field of disease prevention and control of the Health Office, dental and oral health practitioners, general practitioners and program coordinators of the chronic disease management program at the community health center. The result of the information collection is that health monitoring for people with diabetes mellitus includes checking blood glucose levels and blood pressure which is routinely carried out every month. This routine examination is held in conjunction with the chronic disease management program activities. Recording and reporting of health checks in the chronic disease management program activities are still limited to printout data recap and there is no recording and reporting that can be monitored by people with diabetes mellitus independently. The recapitulated examination results include the results of blood glucose, blood pressure, weight and height of each individual. Blood sugar level monitoring that has been carried out includes monthly fasting blood sugar checks and HbA1c checks which are carried out every six months.

The results of interviews related to dental examination activities for people with diabetes mellitus have not been carried out during the chronic disease management program activities. In addition, educational activities carried out in chronic disease management program activities are still limited to clean and healthy living behavior material and healthy lifestyles, while oral health education is still limited and only carried out on certain schedules. This results in a lack of knowledge of patients with diabetes mellitus related to oral health maintenance, resulting in a lack of awareness and the emergence of oral health problems. Prevention of oral and dental disease in patients with diabetes mellitus can be done through providing education related to oral and dental health problems in patients with diabetes mellitus [25].

The prevalence of patients without a diagnosis of diabetes and prediabetes is very high and underestimated. The increased severity of periodontitis in patients with diabetes as well as the increased cortisol levels in patients with periodontitis, especially in patients with diabetes, emphasize the dysregulation of the immunoinflammatory system[21], [26].

Efforts that can be given to be able to prevent the occurrence of dental and oral diseases in patients with diabetes mellitus are by developing a monitoring information system that can be carried out independently by people with diabetes mellitus. This is reinforced by previous research journals

which state that information systems that can help provide solutions that suit patient needs are needed to be able to simplify self-care by empowering patients themselves to manage their health. Digital decision support system (DDS) assists general practitioners to increase the chance visit recommendation[23], [27]. While in terms of features that can be developed based on the results of interviews and previous research journals, it contains several things such as an examination control menu that displays a history of examination results that have been carried out by people with diabetes mellitus, a health education menu that is able to increase knowledge so that it can increase awareness in managing a healthy life and recommendations for treatment actions.

B. DEVELOPMENT OF DIABETES MELLITUS MONITORING INFORMATION SYSTEM (SIP DM-DENT MONITORING)

Individuals with diabetes mellitus have a high risk of other health complications including oral health. The manifestation of oral disease that often occurs in patients with diabetes mellitus is periodontal disease. It is caused by several complex mechanisms and determined by common etiopathogenetic factors and overlapping phenomena due to its high prevalence character[28]. These two diseases have a reciprocal relationship that affects each other. Diseases of the oral cavity that often occur in people with diabetes mellitus are periodontal disease. High blood sugar levels will increase the risk of inflammation in the gums and result in infection of periodontal tissue. While periodontal disease that is not treated immediately can affect the increase in blood sugar levels and make diabetes mellitus control more difficult and worsen diabetes mellitus symptoms that appear in the oral cavity. Clinicians should consider periodontal disease when patients have continuously high levels of glycated hemoglobin and dentists should consider patients with diabetes mellitus or pre-diabetes with unstable periodontitis. Oral health workers must check the condition of the patient's gums and record the results of the examination, so that the patient's oral health can be monitored[11]. Therefore, good health monitoring management is needed in people with diabetes mellitus, both monitoring blood sugar control and dental health, one of which is through a health monitoring information system.

Health monitoring in people with diabetes mellitus is currently still limited to manual health monitoring so it is difficult to update in real time, resulting in the lack of safe and accurate data storage. The use of technology in health can help solve these problems and improve the efficiency of health monitoring management. SIP DM-DENT Monitoring was developed to meet these needs. This is an effort to reduce the occurrence of complications in people with diabetes mellitus in dental health.

Technological developments provide innovation and change in health services[29]. Indonesia currently includes the development of technology in health in one of the pillars of health transformation aimed at improving the degree of

public health[30]. The utilization of technology as a way of health monitoring can help provide accurate data and improve the health status of the community[16].

SIP DM-DENT Monitoring was developed as a website that can assist in monitoring the health of people with diabetes mellitus related to basic health monitoring in people with diabetes mellitus and monitoring oral health. The information system menu displayed in SIP DM-DENT Monitoring presents a user biodata menu, diabetes mellitus control menu, oral examination menu, tooth brushing compliance checklist menu, dental health education menu and health monitoring charts presented on the user dashboard. Each menu is tailored to the health monitoring needs of patients with diabetes mellitus based on the results of information collection from various parties including managers of the Disease Eradication Prevention Division of Semarang City Health Office, dentists, general practitioners, program activity coordinators of the Chronic Disease Management Program and hospital programmers.

C. EXPERT VALIDATION

Expert validation was conducted to diabetes mellitus experts, health promotion experts, information technology experts and also health practitioners to assess the feasibility of SIP DM-DENT Monitoring as a health monitoring information system for people with diabetes mellitus to prevent manifestations of oral disease. The feasibility of the system from the average assessment results of expert validators resulted in a value of 85.76 with a feasible category, the p-value result of $0.00 < 0.05$ shows that SIP DM-DENT Monitoring is feasible in monitoring dental health and tooth brushing compliance in patients with diabetes mellitus.

This is evidenced by the results of the validator's assessment and the development of an information system that is in accordance with the needs based on the results of information collection. The expert validation stage is important in developing information systems with the aim of producing information systems that have benefits for users both in providing health monitoring information and increasing user knowledge[31], [32]. The assessment of information systems is reviewed from the aspects of functionality, reliability, usability, efficiency, maintainability and portability which are based on the ISO 9126 information system assessment. ISO 9126 is an international standard used to evaluate the quality of software[33]. ISO 9126 is a software quality assessment standard issued by the International Organization for Standardization[34].

The application of an information technology-based monitoring information system that follows the 4.0 era can assist in monitoring the results of examinations carried out by people with diabetes mellitus, besides that it can also overcome the prevention of health complications. In SIP DM-DENT, which was developed based on the needs of people with diabetes mellitus related to oral health, it can help in reducing and preventing oral health problems experienced by people with diabetes mellitus through

monitoring the results of dental and oral health conditions. Health information system-based health monitoring helps users access, manage and update information in real time[35]. Fluctuating graphs of examination results enable remote monitoring and supervision that can be accessed independently by users. Continuous glucose monitors (CGMs) provide real-time blood sugar data, allowing better tracking of trends and fluctuations compared to conventional monitoring using a monitoring book[36], [37].

D. SYSTEM USAGE ASSESSMENT

Assessment of the use of the system on respondents aims to determine how much satisfaction respondents have in using the Diabetes Mellitus Monitoring Information System (SIP DM-DENT Monitoring). Based on the table of system assessment results, oral health information that can be obtained in SIP DM-DENT Monitoring includes dental diseases in patients with diabetes mellitus, how to maintain dental health, how to brush teeth properly and correctly, dietary food for dental health and diabetes mellitus and dental care actions in patients with diabetes mellitus. The assessment results in the system assessment data frequency table show that the majority of respondents feel that SIP DM-DENT Monitoring makes it easy to obtain information related to oral health for people with diabetes mellitus. A good information system must be able to provide user convenience in obtaining information. People do not need to waste time looking for information through complicated interfaces or mountains of data. Information systems should present information in a way that is clear and easy to find[38]. If it is easy to find the information they need, people will be more likely to use the system regularly. This is important to be able to increase system usage.

The assessment results in the system assessment data frequency table show that the majority of respondents feel that the DM-DENT Monitoring SIP is able to produce information that is easily understood by respondents. Respondents' assessment of the material provided in the system includes the results of blood sugar control checks, blood pressure, oral health checks, dental health education materials for people with diabetes mellitus and monitoring of tooth brushing compliance. The information provided in the monitoring information system must be easily understood by users so that when users understand the data, they can make informed decisions about how to solve problems or carry out health actions[39]. If information is presented clearly, users do not need a technical background to understand the situation. This empowers more people to contribute to problem solving.

The stages on the system are easy to understand and access independently, so users have no difficulty in accessing each menu on the website. Features provided by the website through menus that are easy to use and understand by respondents include simple language and no distractions in the system. When the features are clear and intuitive, users can actively participate in their own care. They can access their medical history and understand test results. A

complicated interface can lead to errors when entering data or using functions[39]. An easy-to-use health information system can minimize errors, improve patient safety and data accuracy.

The DM-DENT SIP helps to make better decisions related to the respondent's personal health. This includes decisions on actions related to diabetes mellitus management as well as oral health actions based on the health recommendations in the system that appear after the respondent enters the examination results in the information system. By providing this data in a clear and accessible way, health information systems empower patients (after consulting with their healthcare providers) to make informed decisions regarding treatment options, medication use, and overall health management[40].

The diabetes mellitus control menu has a feature in the history of recording the results of diabetes mellitus control checks, namely blood sugar and blood pressure checks that have been carried out. The recording of examination results that have been inputted in the information system can be seen in full in the history of recording blood sugar and blood pressure control. Meanwhile, the oral health examination menu has features in the history of recording oral health examinations, namely DI, CPITN, number of teeth, number of cavities and gingivitis conditions that have been carried out. The recording of examination results that have been inputted in the information system can be seen in full.

The tooth brushing checklist menu can help monitor compliance and provide motivation to brush teeth regularly. Fluctuating diagrams of health examination results provide convenience in obtaining information and monitoring health both in monitoring blood sugar and oral health presented in the form of line diagrams.

E. DIABETES MELLITUS MONITORING INFORMATION SYSTEM (SIP DM-DENT MONITORING)

Management of health monitoring management in patients with diabetes mellitus includes control of blood sugar, blood pressure, physical activity, drug consumption and food diet[41]. Development of SIP DM-DENT Monitoring as one of the efforts to help monitor health in people with diabetes mellitus. The features contained in this system are developed in accordance with the health monitoring needs of people with diabetes mellitus in general which is added with dental and oral health monitoring. The importance of health monitoring in people with diabetes mellitus is to control and monitor health conditions regularly to prevent complications that can arise due to the disease. Health monitoring is included in efforts to prevent and manage disease, ensure health conditions are controlled, and support appropriate treatment in accordance with the development of the patient's condition.

The development of health monitoring through technology can help improve the quality of health monitoring. Technology can help people with diabetes mellitus in monitoring health conditions more effectively and efficiently, and allow them to more actively participate in the

management of the disease. By using technology, people with diabetes mellitus can collect health data more easily and quickly, and receive more precise and personalized care. Technology can also help people with diabetes mellitus avoid complications of the disease, such as kidney failure and visual impairment, by monitoring health conditions more closely and quickly[29], [31].

The innovation developed in the form of a Diabetes Mellitus Monitoring Information System (SIP DM-DENT Monitoring) which has the use as health monitoring for people with diabetes mellitus independently by the individual and for health workers. In addition, SIP DM-DENT Monitoring is a medium for promoting oral health in people with diabetes mellitus as an effort to prevent the manifestation of oral disease. The display contained in the DM-DENT Monitoring SIP includes:

1. LOGIN PAGE

The login page is used to provide access rights between users, namely people with diabetes mellitus and health workers. The procedure for being able to access the system is that users and admins must enter their respective usernames and passwords that have been registered previously.

2. DASHBOARD DISPLAY

The Dashboard menu is used as the main display that shows a diagram of the examination results that have been carried out by people with diabetes mellitus. This diagram is used as health monitoring related to the index debris number and blood sugar in the previous examination which can be adjusted to the desired examination time range.

Regular monitoring of blood sugar levels and debris index are essential for diabetic patients to manage their condition effectively and prevent complications. This monitoring helps individuals understand their blood sugar and oral health condition, evaluate the overall treatment goals, assess the impact of lifestyle changes, and identify factors that may affect blood sugar levels and oral health disease [41].

Dental health is closely linked to diabetes, as high blood sugar levels can increase the risk of oral infections and other dental problems. Regular monitoring of dental health can help identify potential issues early on and prevent complications. The graphical display can also provide healthcare providers with valuable insights into a patient's condition, allowing them to adjust treatment plans and make more informed decisions about patient care [14]. Seeing positive trends in glycemic control through recording blood sugar test results can increase patient motivation and adherence to diabetes mellitus treatment plans. This can help patients achieve their desired glycemic control targets.

3. BIODATA MENU

The patient biodata menu contains patient identity consisting of name, username, email address, place of birth, date of birth, cellphone number, profile photo,

gender and address. Patient biodata can facilitate data integration across different healthcare systems and services, enabling a more comprehensive understanding of a patient's health status and treatment history.

Patient biodata can support patient-centered care by providing healthcare providers with a more complete understanding of a patient's medical history, preferences, and value. It can inform decision-making by providing healthcare providers with a more accurate and comprehensive picture of a patient's health status, enabling them to make more informed treatment decisions.

4. DIABETES MELLITUS CONTROL MENU

The diabetes mellitus control menu contains a history of examination results that have been carried out by people with diabetes mellitus before. In this menu can be added independently or by the admin the results of the examination that has been done. The examination results that can be added include the date of the examination, the type of blood sugar examination (temporary blood sugar examination or fasting blood sugar examination), blood sugar level, HbA1c examination, blood pressure, consumption of diabetes mellitus medication, and choice of physical activity in a day. After filling in the test results, users will be given health recommendations related to the test results.

Recording the results of blood sugar checks is an important component in the management of diabetes mellitus. For people with diabetes, monitoring blood sugar levels regularly and accurately is key to achieving optimal glycemic control and preventing serious complications[41]. Recording the results of blood sugar checks helps record and track blood sugar control of people with diabetes mellitus. By recording the results of regular blood sugar checks, DM sufferers can see patterns and trends in their blood sugar levels. This information is important for assessing the effectiveness of DM therapy and identifying factors that may affect blood sugar levels, such as diet, physical activity, and stress[42].

Recording the results of the HbA1c examination is one of the important indicators in measuring and monitoring glycemic control in patients with diabetes mellitus. HbA1c reflects glycemic control over the past 2-3 months, in contrast to self-blood sugar tests that only show blood sugar levels at the time of the test. This provides a more comprehensive picture of the effectiveness of diabetes mellitus therapy and helps identify patterns of glycemic control over time[43].

Regular monitoring of blood pressure helps detect hypertension at an early stage and allows early intervention to control blood pressure. Good blood pressure control is an important part of overall diabetes mellitus management and can help improve glycemic control[44].

Recording drug consumption serves to remind taking medication according to the prescription. In addition, it provides information about the drugs consumed. Information about the patient's adherence to treatment and side effects experienced can help doctors to make adjustments to the diabetes mellitus treatment plan as needed[41].

5. DENTAL AND ORAL EXAMINATION MENU

The oral and dental examination menu contains a history of examination results that have been carried out previously. In this menu, new examination results can be added either independently by patients with diabetes mellitus or by health workers. The examination results that can be added include the date of examination, Debris Index, CPITN, number of teeth, number of loose teeth, number of cavities and gingivitis conditions.

Poor oral health can affect blood sugar control, as inflammation in the mouth can increase blood sugar levels and vice versa. Regular dental check-ups can help detect oral health complications early on, allowing for prompt treatment and prevention of more severe consequences. Good oral health can contribute to better blood sugar control, as a healthy mouth can help regulate blood sugar levels[45].

6. TOOTH BRUSHING COMPLIANCE CHECKLIST MENU

The tooth brushing compliance checklist menu contains a calendar that is used as a record of compliance in brushing teeth. When the date on the calendar is clicked, the option will appear to have brushed your teeth in the morning or at night. After filling in the tooth brushing compliance is added, the calendar will appear recording the tooth brushing that has been done.

Good oral hygiene practices can significantly improve the quality of life for diabetes patients by reducing pain, discomfort, and anxiety related to oral health issues. Recording related to brushing teeth can help increase high motivation for diabetics in maintaining dental hygiene. Motivation to maintain good oral hygiene practices is crucial for diabetes patients, as it can help them adhere to their treatment plans and manage their condition effectively[46].

7. DENTAL HEALTH EDUCATION MENU

The dental health education menu contains material related to dental health promotion in patients with diabetes mellitus. This menu contains material related to dental disease in patients with diabetes mellitus, how to maintain dental health, how to brush teeth properly and correctly, dietary food for dental health and diabetes mellitus and dental care measures in patients with diabetes mellitus.

Patient education on the importance of oral hygiene practices in diabetes management can empower patients to take a more active role in their health. Education on oral health is essential for diabetes patients to prevent oral complications, reduce blood sugar levels, improve

quality of life, reduce the risk of systemic complications, and improve patient outcomes[47].

8. WEBSITE GUIDE MENU

The website usage guide menu contains instructions on how to use the website properly and correctly so that you can do the tutorial to use the website independently

V. CONCLUSION

The development of the SIP DM-DENT Monitoring focuses on collecting information related to oral health related to people with diabetes mellitus and to produce a feasible and effective health monitoring system innovation in monitoring dental health and tooth brushing compliance in people with diabetes mellitus. SIP DM-DENT Monitoring was developed as an effective and feasible website to help monitor the health of people with diabetes mellitus related to basic health monitoring in people with diabetes mellitus as well as monitoring oral health. The development of health information systems on health monitoring can assist in providing solutions in solutions that suit the needs of patients to be able to simplify self-care by empowering patients themselves to manage their health.

The application of an information technology-based monitoring information system that follows the 4.0 era can assist in monitoring the results of examinations carried out by people with diabetes mellitus, besides that it can also overcome the prevention of health complications. In SIP DM-DENT, which was developed based on the needs of people with diabetes mellitus related to oral health, it can help in reducing and preventing oral health problems experienced by people with diabetes mellitus through monitoring the results of dental and oral health conditions.

The information system menu displayed in the DM-DENT Monitoring SIP presents a user biodata menu, diabetes mellitus control menu, oral examination menu, tooth brushing compliance checklist menu, dental health education menu and health monitoring charts presented on the user dashboard.

The development of information systems in this study uses the RAD method where errors are still found on the website due to server errors. So it needs repeated checks on the system. For further research, further development can be carried out related to other systems related to improving oral health that are integrated with other general health. In addition, it is necessary to develop a system that utilizes sound in providing information, recommendations and guidance in the system.

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