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Original Research

Development and Validation of Android-Based Mobile App for Self-Controlling Excess Body Fluids in Chronic Renal Failure Patients Undergoing Hemodialysis

Virgianti Nur Faridah[1], Nur Hidayati[1*], Abdul Rokhman[1], Bagus Dwi Saputra[2], & Saiful Bachri[3]

[1]*Faculty of Health Sciences, Universitas Muhammadiyah Lamongan, Lamongan, Indonesia*
[2]*Faculty of Sciences Technology and Education, Universitas Muhammadiyah Lamongan, Lamongan, Indonesia*
[3]*Dyalisis Unit, Hospital of Muhammadiyah Lamongan, Lamongan, Indonesia*

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Abstract

Introduction: Chronic renal failure patients undergoing hemodialysis commonly experience excess fluid volume in the body. It is necessary to provide media which can be independently employed by the patients to control body fluids and prevent fluid overload. The purpose of the study is to develop an android-based application "Sabahat Dialisis", as well as conducting validity test, reliability test, and application usage tests on users.

Methods: This research utilized a Research and Development (R&D) design consisting of two stages. In Stage 1, an Android-based application was developed and its validity and reliability were assessed by five experts in dialysis. Stage 2 involved conducting trials of the application with 30 chronic renal failure patients in the Dialysis Unit to evaluate its usability.

Results: The application component proved to be valid (I-CVI=1) and reliable (Cronbach's alpha=0.768). The results of the application use trial on 30 hemodialysis patients indicated that 83.3% considered the application easy to understand, the menu/features were easy to use and operate (83.4%: 86.7%), 76.7% of users were satisfied with the application, the application was useful, in accordance with the needs of hemodialysis patients, and easy to learn (90%), 86.7% were easy to operate, and 76.7% recommended the application for use in hemodialysis patients.

Conclusion: Sahabat Dialisis application is valid, reliable, and usable for chronic renal failure patients undergoing hemodialysis to control fluid in the body and avoid fluid overload.

*Corresponding Author:

e-mail: nur_hidayati@umla.ac.id

INTRODUCTION

The global prevalence of chronic kidney disease (CKD) is on the rise and poses a significant public health challenge. CKD impacts more than 50 million individuals globally, with over 2 million patients needing hemodialysis as a form of renal replacement therapy. While the prevalence in developing nations is not extensively documented, in the United States alone, approximately one million individuals are affected by CKD, and this number is steadily increasing. CKD constitutes a substantial cause of both mortality and morbidity worldwide [1].

Hemodialysis is typically used as a life-saving therapy for patients with end-stage kidney disease, but its long-term use and cost are associated with affordability issues for patients, their families, and the healthcare system. [2]. Hemodialysis (HD) aims to replace kidney function, thereby extending survival and improving the quality of life for patients with chronic kidney failure. It is a renal replacement therapy process that utilizes a semi-permeable membrane (dialyzer) to mimic the nephron's function. This process removes metabolic waste products and corrects fluid and electrolyte imbalances in patients with kidney failure [3].

The prevalence of chronic kidney disease (CKD) continues to rise steadily. According to the Global Burden of Disease study, CKD contributed to 956,200 deaths worldwide, marking a 134% increase since 1990 [4]. Indonesia is a country with a high number of chronic kidney disease (CKD) patients; the Indonesian Society of Nephrology (PERNEFRI) estimates that there are 70,000 CKD patients in Indonesia. This number is expected to continue increasing by approximately 10% annually [5]. According to the Basic Health Research (Riskesdas) data (2018), the prevalence of chronic kidney disease (CKD) in Indonesia is 0.38% of total diagnoses, with hemodialysis accounting for 19.33% of these diagnoses [6].

During hemodialysis, patients are instructed to adhere to guidelines, such as restricting daily fluid intake to no more than 600 ml. However, many kidney failure patients undergoing hemodialysis still exceed this recommendation, leading to fluid volume overload in the body characterized by swelling in specific parts of the body. This occurs due to the kidneys' reduced ability to excrete fluid. One of the factors influencing patients to exceed fluid intake guidelines is limited knowledge. This knowledge gap may stem from personal issues affecting dietary habits, resulting in patients frequently disregarding recommended fluid intake guidelines [7].

A preliminary study conducted at Muhammadiyah Hospital in Lamongan found that among all chronic kidney disease (CKD) patients undergoing hemodialysis, totaling 144 patients, 90% experienced fluid overload. Data from the hemodialysis unit indicated that patients consistently exceeded their dry weight before scheduled dialysis sessions. This suggests that many CKD patients struggle to control their fluid intake effectively.

Factors influencing fluid intake control include patient-related factors and healthcare service-related factors. Patient-related factors encompass characteristics such as age, gender, race, marital status, education level, duration of illness, knowledge level,

employment status, perceptions, motivation, and smoking habits. On the other hand, healthcare service-related factors include hemodialysis facility conditions, access to hemodialysis centers, costs, scheduling, and staff skills. These factors collectively play a role in determining a patient's ability to effectively manage fluid intake [7]. Excess fluid in patients requires attention and preventive measures. To prevent further complications from fluid overload, it is essential to implement nursing interventions through fluid management strategies [8].

One approach to maintain stability and monitor the effectiveness of managing fluid overload is by monitoring intake and output using a fluid balance chart [9]. Nevertheless, this card has drawbacks due to its conventional nature and reliance on healthcare support. There is a pressing need for innovation to create a more efficient tool that can be used autonomously and accessed easily. Enhanced accessibility is anticipated to empower individuals in managing fluid overload effectively. Patients increasingly seek creative, innovative, effective, and user-friendly alternatives. One possible approach is to create a Self-Controlling Body Fluid Excess application named "Sahabat Dialisis". The instrument's quality will be developed based on user perspectives regarding functionality, utility, and usability. This application features several components, including a login menu, personal information/profile, examination schedule, output fluid, input fluid, data recapitulation results, and recommendations. The aim of this research is to develop and validate a new mobile application called "Sahabat Dialisis", equipped with simple features for independent use by chronic kidney disease patients undergoing hemodialysis.

METHODS

Design

This study employed a research and development methodology to create and evaluate specific products [10]. It is exploratory in nature, aiming to uncover new areas by designing an information system [11]. The research was conducted in two stages. The first stage involved developing the "Sahabat Dialisis" application and assessing its internal consistency and Individual Content Validity Index (I-CVI). The second stage focused on user testing of the application.

Samples

The study sample consisted of 6 experts in hemodialysis from Muhammadiyah Lamongan Hospital, including 1 internal medicine specialist consultant in hemodialysis and 5 experienced hemodialysis nurses with more than 5 years of experience. The objective was to measure the internal consistency and content validity index of the application.

The application trial was conducted with 30 chronic kidney disease patients undergoing hemodialysis at Muhammadiyah Lamongan Hospital, recruited voluntarily and selected based on inclusion and exclusion criteria. Inclusion criteria for users were regular hemodialysis patients with stable condition, outpatient status, and ownership of an Android smartphone. Exclusion criteria included hospitalized hemodialysis patients,

altered consciousness, and/or unstable hemodynamics.

Stage I: Developing Sahabat Dialisis Application

The Sahabat Dialisis application was developed by IT experts in March-April 2023. It is an Android-based self-control application designed to assist clients in monitoring their daily fluid intake needs and detecting excess fluid on a daily basis at home using their smartphones. The application's content was structured by the research team and reviewed collaboratively with nurses specializing in hemodialysis who understand the necessary data and menu items within the application with features such as login menu, profile, dialysis schedule, input for fluid intake, output for fluid output, and summary of input results.

Validity testing was conducted using the Individual Content Validity Index (I-CVI) scores by 6 experts in the field of hemodialysis. Reliability was assessed using internal consistency reliability (Cronbach's alpha), where internal consistency is considered good if the average I-CVI value is $\geqslant$0.83 for the 6 experts.

Stage II: Application trials

The second stage involved testing the application with 30 chronic kidney disease patients undergoing hemodialysis at Muhammadiyah Lamongan Hospital. Patients who participated as users provided informed consent before being recruited. Each user was provided with an account and password to log into the application by researcher, allowing them to explore and use all features for a continuous 24-hour period.

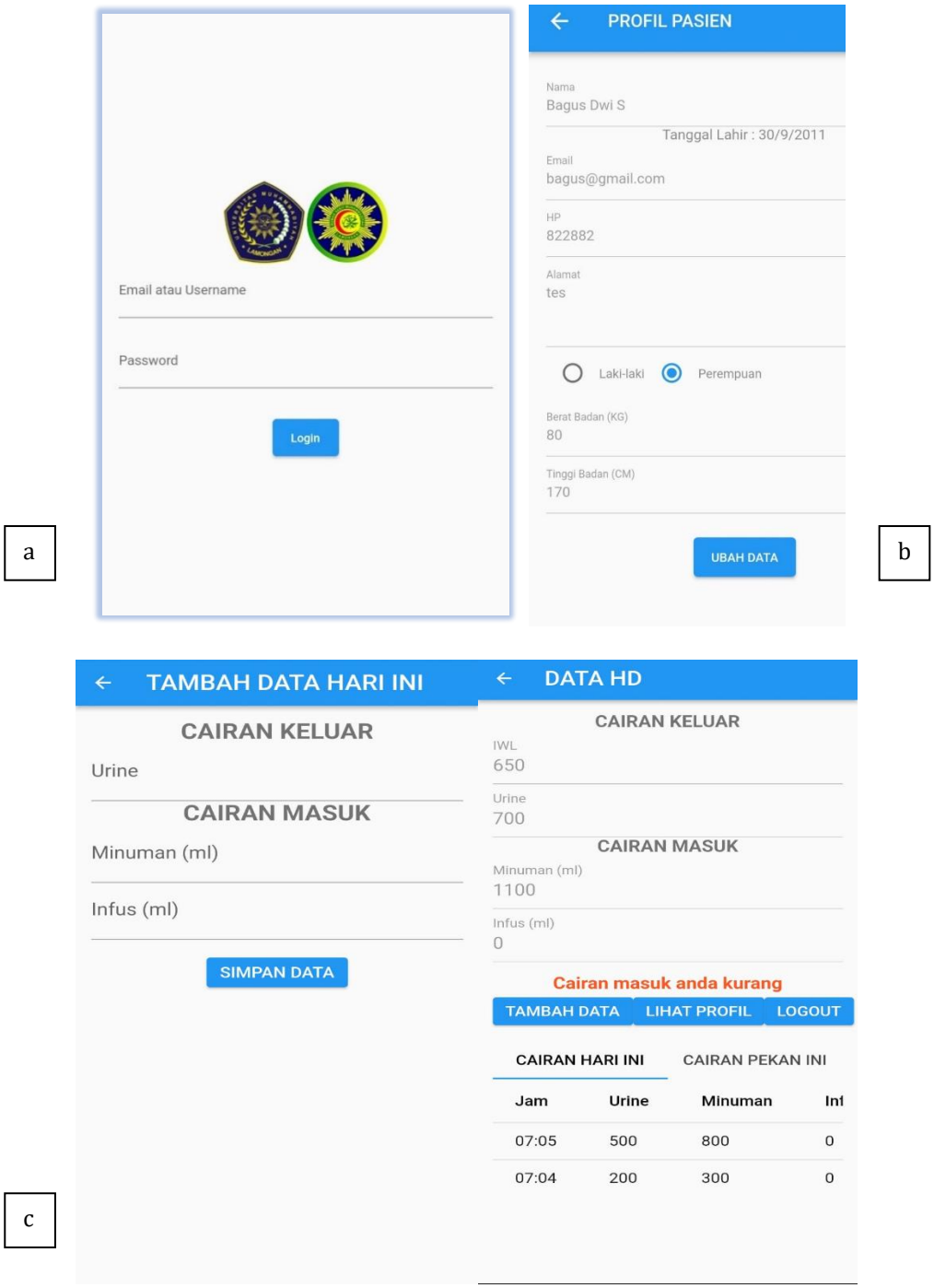

Fig. 1. "Sahabat Dialisis" Android Application

After logging in using the username and password provided by the admin (a), the user can fill in the profile menu (b) to view and change personal data, then fill in the examination menu which contains a choice of dialysis schedules (morning, afternoon, or evening), and the fluid menu to fill in the daily intake and output of fluid (c). In this fluid menu, there is a record of fluid data in the last 7 days and a list of fluids entered on that day so that the user know his body fluids'

condition, whether it is deficient or excess (Fig. 1).

Following the testing of all application features and contents, respondents were then asked to complete a questionnaire about their experience with the application, which consisted of 7 questions and 1 question regarding recommendations for improvement.

Research Instruments

The instruments utilized in this study included the “Sahabat Dialisis” application and a questionnaire developed by the researchers. Following the completion of the application, validity and reliability testing were conducted using internal consistency reliability (Cronbach’s Alpha).

There were two types of questionnaires used in this research. The first questionnaire was distributed to six experts to measure the CVI and I-CVI scores. This questionnaire consisted of 7 items about the application content, rated on a scale from 1 to 4, where 1 represented "Not relevant," 2 indicated "Somewhat relevant and requires a lot of changes," 3 denoted "Quite relevant, but needs a little modification/change," and 4 signified "Very relevant." Additionally, there were 3 questions about the features/menus (interesting/somewhat interesting/less interesting/not interesting), recommendations (continue without modification, continue with minor modifications, continue with major modifications, and discontinue), and open-ended questions for expert feedback.

The System Usability Scale (SUS) questionnaire used in the application trial for users consisted of 7 questions assessing various aspects of application usage: menu/features (2 questions), satisfaction level (1 question), application usability (2 questions), usefulness (1 question), and recommendation (1 question). Responses were rated on a scale of 1-5, where 1 indicated "Strongly Disagree," 2 indicated "Disagree," 3 denoted "Neutral," 4 signified "Agree," and 5 represented "Strongly Agree," with a minimum total score of 0 and a maximum score of 100.

Additionally, there was 1 question regarding user recommendations for the application, with 4 options: the application can be used without modification, with minor modifications, with major modifications, or cannot be used. Before administering the questionnaire, validity and reliability testing were conducted. The validity test indicated that the 7 questions had a calculated r-value ranging from 0.822 to 0.966, which exceeded the table r-value (0.361), indicating that the questionnaire was valid. The reliability test showed a Cronbach’s alpha value of 0.977, indicating that the questionnaire was reliable.

Data Analysis

Research data obtained from questionnaires filled out by dialysis experts were analyzed using Microsoft Excel to calculate the I-CVI score for each question item. Meanwhile, the data from the questionnaires filled out by the users were analyzed using the System Usability Scale (SUS) formula to derive percentages and descriptive statistics.

The formula of SUS score [10] [11]as below:

$$\bar{x} = \frac{\sum x}{n}$$

$\bar{x}$: $mean$

$\sum x$: $Total\ number\ of\ Score$

n : $Number\ of\ Sample$

Ethical Clearance

Before commencing the research, the research proposal received ethical approval from the Ethics Committee of the University of Muhammadiyah Lamongan, under No.251/EC/KEPK- S3/04/2023 issued on March 3, 2023

RESULT

The development of the "Sahabat Dialisis" application commenced in March-April 2023. Stage 1 involved creating the application. Internal consistency reliability and content validity index tests were conducted with six dialysis experts in May 2023 (Table 1). The results from Table 1 indicated that all 7 application items showed an I-CVI score of 1, indicating excellent acceptance, and demonstrated good internal consistency reliability (Cronbach's alpha = 1) or an average I-CVI score of ≥0.83 with 6 experts.

Step 2: After the application was validated and deemed reliable, a trial was conducted with 30 CKD patients undergoing hemodialysis. After testing all features and completing the application, users were asked to fill out a questionnaire. The results of the System Usability Scale (SUS) score are shown in Fig. 1: 83.3% of users found the application easy to understand, 83.4% stated that the application's menus/features were easy to use, 76.7% expressed satisfaction with the application, 90% indicated that the application met the needs of hemodialysis patients, 90% found the application easy to learn, 86.7% found it easy to operate/use, and 90% stated that the application was beneficial for hemodialysis patients. The SUS scores ranged from a minimum of 76.7 to a maximum of 90, with an average score of 85.73, indicating that the application is suitable and effective for use.

Based on user recommendations, it can be concluded that 76.7% of users recommend continuing to use the application for hemodialysis patients without any modifications, 20% recommend minor improvements, 3.3% recommend significant improvements to the application, and none of the users recommended against using the application.

Table 1. Validity of *Sahabat Dialisis* Application by Expert ***(n=6)***

Content	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	I-CVI
Profile	4	4	4	4	3	3	1
Login	4	4	4	4	3	4	1
Schedule Appointment	4	4	4	4	3	4	1
Fluid Intake Menu (Input)	4	4	4	4	3	3	1
Fluid Output Menu (Output)	4	4	4	4	3	4	1
Summary of Input/Output Results	4	4	4	4	4	3	1
Benefits for CKD Hemodialysis Patients	4	4	4	3	4	4	1

Score:
Relevant = 4
Quite relevant, need a little modification= 3
Somewhat relevant, need a little modification= 2
Not relevant = 1

Table 2. Characteristics of Users (n= 30)

Variables	**Characteristics**	**n**	**%**
Gender	Male	14	46.7
	Female	16	53.3
Age (y/o)	20-30	3	10
	31-40	6	20
	41-50	8	27
	51-60	10	33
	>60	3	10
Duration of hemodialysis	< 1 year	5	16.7
	1-5 year	19	63.3
	>5 year	6	20

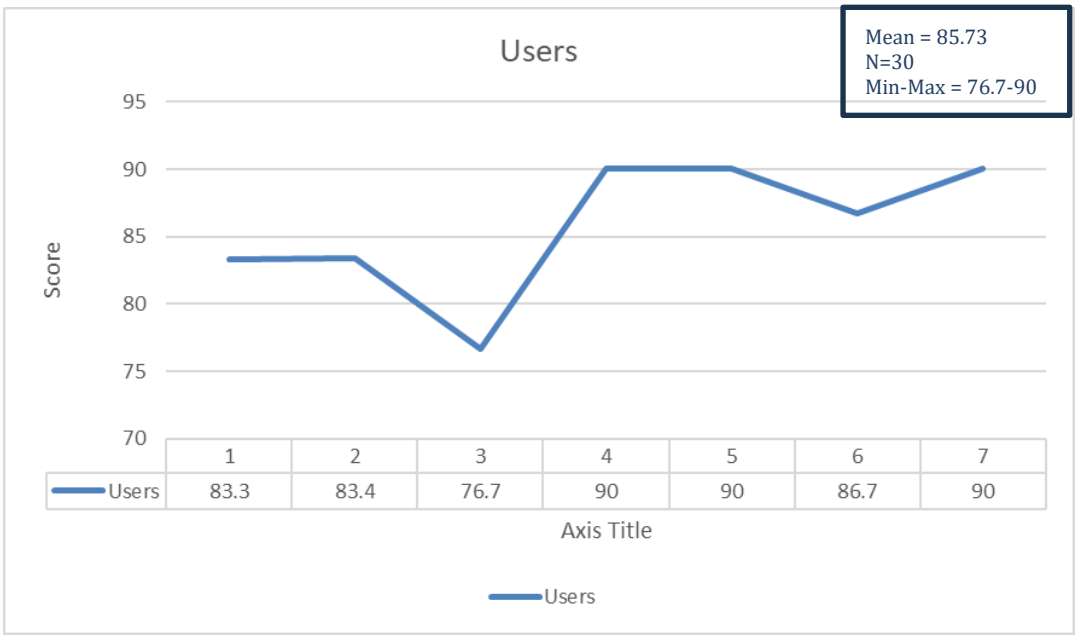

Fig. 1. The mean score of personal user application

DISCUSSION

The “Sahabat Dialysis” application has proven to be valid and reliable. This application was developed to assist clients with CKD undergoing regular hemodialysis in effectively managing their fluid balance. It addresses the common issue where CKD patients often do not know their recommended fluid intake and struggle with fluid control compliance. According to Wijayanti [14], 52.63% of respondents exhibit poor behavior in controlling body fluids, with fluid intake being a significant contributing factor to Interdialytic Weight Gain (IDWG).

In field studies, there is a need for an application that can help CKD clients monitor fluid intake and control their fluid balance. The application provides alerts to CKD patients when their fluid intake exceeds the allowed maximum limit. This is achieved by clients or their families entering data on fluid intake and output when the client consumes food or drinks. To enhance accessibility and further develop the application, assessment by experts and users is necessary before widespread implementation among CKD clients.

Digital interventions can serve as tools to enhance the reciprocal relationship between patients and healthcare practitioners, thereby improving patient-centered care. [12]. Analysis within the application is also crucial for future trials to assess the impact of application usage on outcomes. The in-app analysis should track usage frequency and individual feature usage separately. This will help in understanding whether the self-monitoring features within the application are preferred by users. [13]. Previous research has also revealed that mobile applications have proven beneficial in supporting self-care. However, they often fail to consider user needs, leading to user discontinuation of the application. [14]. In the "Sahabat Dialysis" application, there is a feature that provides alerts when the fluid intake of chronic kidney disease (CKD) patients undergoing hemodialysis exceeds the recommended amount. This allows CKD patients to effectively manage their fluid intake.

Patients with chronic kidney disease undergoing hemodialysis are advised to limit their daily fluid intake [15]. Fluid restriction is associated with thirst sensation in CKD patients undergoing hemodialysis [16]. Thus, the fluid intake of CKD clients on hemodialysis must be carefully monitored because thirst is no longer a reliable indicator of hydration. [17]. Self-efficacy level towards fluid control is quite high and most of the patients' responses at post-program are good at post-program. [18]. Albayrak & Cinar [19] stated that the average total score obtained from fluid control in hemodialysis patients is 56.55 ± 6.37. This score indicates that the knowledge, behavior, and attitudes of hemodialysis patients regarding fluid control are generally positive, with a negative decline.

LIMITATION

This application can only be used on Android phones and is in Indonesian and can only be operated online (there is an internet connection).

NURSING IMPLICATION

This application can be used by chronic kidney disease patients undergoing hemodialysis to evaluate the intake and output of fluids over 24 hours, thereby anticipating daily fluid overload, indirectly preventing complications and death.

CONCLUSION

"Sahabat Dialisis" application is proven to be valid, reliable, and can be used by chronic kidney disease patients undergoing hemodialysis in order to evaluate the amount of fluid in and out so as to prevent fluid overload. It is hoped that this application will be applied to a larger number of hemodialysis patients and analyzed for its widespread use.

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