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Designing a Smart Monitoring System to Facilitate Remote Monitoring Services Using a Design Thinking Approach

Herfaida Nadia Ningrum, Dino Caesaron, Nadia Daliana and Ilma Mufidah
Department of Industrial Engineering
Telkom University
Bandung, Indonesia
nadia2dida@gmail.com, dinocaesaron@telkomuniversity.ac.id, ndaliana5@gmail.com, ilmamufidah@telkomuniversity.ac.id

Abstract
Chronic kidney disease (CKD) is among the most prevalent non-communicable diseases worldwide. Non-communicable disease-related premature mortality is prevalent in low- and middle-income nations such as Indonesia. According to government data, 718,783 CKD cases of chronic kidney disease were listed in 2018. In such instances, hospitals assume a critical function. Dialysis therapy may be considered as a treatment option. Patients undergoing hemodialysis must exhibit the capacity to adapt to various treatment protocols to mitigate undesirable fluctuations, including those caused by hypertension-induced abrupt declines in blood pressure, excessive salt consumption, and fluid overload. Therefore, hospitals and patients are responsible for monitoring and ensuring the patient's condition throughout the treatment. Consequently, design thinking and quality function deployment methods have been applied for the development of high-fidelity wireframes for intelligent monitoring. Between 2018 and 2022, the study was conducted at a hospital in Indonesia, where 3,428 patients underwent 25,313 procedures. The efficacy of the design was evaluated using a usability test, and it received a good score.

Keywords
Chronic kidney disease, Hemodialysis, Smart Monitoring Systems, Design Thinking, Quality Function Deployment

1. Introduction
Non-communicable diseases (NCDs) arise from genetic, physiological, environmental, and behavioral factors and cause 41 million deaths annually, accounting for 74% of global deaths. Chronic kidney disease (CKD) is a prevalent non-communicable disease that results from negative human activities that affect kidney health. The WHO Health Organization estimates that 70% of these deaths occur in low- and middle-income nations, including Indonesia. The incidence of CKD in Indonesia reached 713,783 cases in 2018, with an increasing number of cases of end-stage renal disease (ESRD). Patients with CKD require specialized care because of their diminished well-being and increased anxiety. The treatment options include peritoneal dialysis (PD), hemodialysis (HD), and kidney transplantation. HD, but not a cure, removes fluids and waste products when kidneys fail. In Indonesia, HD is the most common treatment, with 664.33 new patients undergoing hemodialysis from 2012 to 2018 and 135,486 active patients undergoing hemodialysis.

1.1 Case Study
Hospitals must provide quality health care services to patients with CKD. A hospital in Bandung, Indonesia provides hemodialysis treatment services with 10 internal medicine doctors, 15 general practitioners, and 35 nurses. The facility has 56 machines and treats 3,428 patients through 25,313 procedures between 2018-2022. Patients undergoing HD must adapt to treatment protocols, including regular HD procedures, dietary modifications, salt restriction, and non-smoking, to prevent complications such as blood pressure fluctuations and fluid overload. Studies show 30-50% of

non-adherent dialysis patients experience increased symptoms, medical complications, reduced quality of life, and 30% higher mortality risk. Therefore, monitoring is crucial for HD treatment.

1.2 Research Background

Direct observations were used to assess the usefulness of the system for remote patient monitoring. Interviews with the HD unit supervisor revealed obstacles: communication relies on social media messages, causing miscommunication, and medical officers' involvement is limited due to other duties. Patients prefer physical visits to online communication, although hospital patients often receive only basic medical intervention. A March 2023 survey of 227 patients showed 157 resided in Bandung and 70 outside the city. Santos and Arcanjo (2012) found that insufficient dialysis units in large areas were the main barriers to care access, requiring long-distance travel. This process requires effective communication channels for families to monitor patient conditions continuously. Remote information systems help prevent adverse events in patients. Jebraeily et al. (2019) confirms that information systems support treatment monitoring and assess hemodialysis efficacy. Health-based systems in remote dialysis enable timely intervention and may reduce the number of emergency visits due to acute complications (Ni et al., 2019).

1.3 Research Focus

The hospital has failed to deliver effective information between medical staff and patient families regarding hemodialysis treatment. This study aimed to develop a smart monitoring system for the remote monitoring of hemodialysis patients' conditions in real time. The system will monitor and minimize the adverse effects of physical symptoms in HD patients by notifying the medical staff during emergencies. This study focuses on the user interface (UI) design and user experience (UX) in smart monitoring systems. Design thinking, a user-centric framework, enables the development of health-service systems through user comprehension. The design-thinking approach combines quality function deployment (QFD) to meet user needs and define technical characteristics. QFD successfully builds health applications from doctors' perspectives and develops technological features based on patients' needs, including hospital alignment, emergency systems, and medical support systems.

2. Literature Review

Several studies have been conducted to develop smart monitoring systems. Design thinking was used to create a patient empowerment application that improved heart failure self-management and reduced hospitalization via mHealth. The Home Health Hub was designed to manage patient vitals and access healthcare information for older individuals. The "Dear Dietary" application records health progress of adolescents through healthy lifestyle programs and balanced nutrition. Design thinking creates the UI/UX of a student complaint-handling application by examining functional requirements and analyzing process improvements. The QFD approach study aimed to improve hospital outpatient services by identifying improvements based on patient demands.

3. Methodology

This study used a mixed methods approach. Qualitative data are interpreted using procedures such as interviews, observations, and questionnaires (Mohajan and Mohajan, 2018; Zohrabi, 2013). Quantitative methods collect numerical data in units (Apuke, 2017). Qualitative data were gathered through interviews with medical personnel, patient families, and observations. The quantitative approach used QFD to evaluate the relationships between needs and technical characteristics. According to (Nassaji, 2015), this research explains phenomena using words and data to answer who, when, where, and how. This study employed an inductive approach, which generates broad truths from specific observations (Malhotra, 2017), starting with patient family statements and developing conclusions through triangulation methods. Data collection used cross-sectional studies that examined population data at a specific time point (Wang and Cheng, 2020). Non-probability sampling with a purposive technique was used to select respondents from patients' families and medical personnel in hemodialysis treatment.

3.1 Research Steps

Data collection involved observations, in-depth interviews, and surveys with families and medical personnel. Data from the triangulation methods were processed using the design-thinking method. The study will follow the five phases of design thinking: Emphatize (utilizing user personas to depict intended users), Define (defining user persona needs with empathy mapping aspects), Ideate (generating problem through the application of QFD), Prototype (designing lowh & high wireframe prototypes), Test (UI effectiveness evaluation using the SUS), which was adapted from (Mueller-Roterberg, 2018; Pressman, 2018). The empathizing stage begins with an interview material summary and persona building. For long-distance hemodialysis challenges, persona design presents target users with biography, goals, and pain points. The defined step creates user personas and classifies problems into the main categories. Empathy mapping categorizes user demands into Says, Thinks, Do, and Feel (Pileggi, 2021) regarding hemodialysis therapy hurdles. Pain points represent challenges, whereas gains show user expectations. The empathy map revealed gaps between personas based on users, needs, and insights. The ideal stage develops solutions for problems identified in the defined stage using Quality Function Deployment (QFD). The QFD HOQ framework includes need statements, technical requirements, specifications, planning matrix, correlation, relationship, and requirements ranking (Ardani et al., 2023; Kim et al., 2022; Weijie, 2020). Prototype design incorporates solutions using HOQ results to develop high-fidelity design with elements like colors, fonts, and logos (Li et al., 2021). The testing stage evaluates efficacy through usability testing (Alwashmi et al., 2019; Reeves, 2019), using System Usability Scale to assess system usability (Gao et al., 2020; Sasmito et al., 2019).

4. Results and Discussion

This section presents a design approach for smart monitoring using design thinking and QFD tools. The process begins with identifying customer needs, followed by prototyping.

4.1 Identification of Needs

A survey of 50 patient families showed that 54% faced communication challenges with hospitals during critical situations, 62% found remote monitoring inadequate, and 78% struggled with post-HD lifestyle monitoring. Interviews with five patient families and five medical workers using 29 and 25 questions, respectively, helped classify personas. Direct observations were then conducted to identify additional user demands.

4.2 Developing Smart Monitoring Systems Designs

The first step is to empathize, which is accomplished by creating a user persona, a representative group comprising one person representing the patient's family and one person from the medical team. Clara, a 21-year-old patient's family member, represents persona 1. He brought his family to him at least twice per week. According to him, hospital communication access remains restricted in controlling changes in the patient's physical symptoms following the procedure, making it impossible to provide proper treatment to his family. Denis, persona 2, is a medical worker responsible for patient action, education, and counseling. He was perplexed about understanding the patient's state after completing the health therapies recommended by the nurse. Because of the two personalities, it can be stated that they require effective, efficient, and appropriate communication access. From the empathize stage, proceed through the define stage to create pain and gain to explain the challenges and solutions expected while creating a remote monitoring system. **Table 1** summarizes the pain and gain of the first person.

Table 1. First persona's pain and gain

Pain	Gain
1) Poor hospital-family communication regarding HD patients' issues. 2) Delayed care for patients traveling long distances after HD. 3) Families struggle managing distant patients' symptoms due to limited healthcare knowledge.	1) Integrated communication between families and medical staff enables easier home treatment with quick responses. 2) Developing error-free system for families to report patient conditions.
Families lack awareness of patient's HD schedule.	1) Calendar reminders for HD schedules. 2) Improving family understanding of HD schedules to reduce dropouts.
Limited family knowledge of distant patients' symptoms.	1) Efficient communication access for family patient care. 2) Communication access for medical consultations. 3) Patient symptom detection system with data privacy.
Distance makes timely medical treatment difficult.	Communication access enables quick medical staff responses from home, reducing hospital visits.
Concern for patients developing symptoms away from hospital.	Enhanced medical staff-family collaboration for information sharing.
Limited remote HD treatment information.	Clearer online HD treatment information needed.

Families struggle with patient diet and lifestyle management.	1) Enhanced family education on monitoring HD patients' diet, fluid intake, and lifestyle. 2) Emphasizes family's role in patient monitoring.
Patient suggestions increase family anxiety.	1) Regular HD monitoring as per nurse instructions. 2) Prioritize clear information exchange between families and medical staff.

The mapping of pain and gain from the standpoint of the medical personnel was sustained. The gains and losses associated with Persona 2 are presented in **Table 2**.

Table 2. Second persona's pain and gain

Pain	Gain
Nurses face challenges monitoring patients' conditions remotely due to limited access. Patient non-compliance and denial about HD treatment hinder optimal care.	1) A checklist system helps maintain stability and monitor patients remotely. 2) Provide intensive digital education on HD importance for kidney failure patients. 3) Provide life motivation to HD patients. 4) An easy intervention system enables quick, appropriate treatment. 5) Organize health awareness campaigns on HD care limitations and patterns. 6) Improve remote monitoring of critical conditions.
Patients often forget HD procedure schedules.	Enhanced reminders create health awareness and improve quality of life.
Remote treatment response is challenging when patients have complaints.	1) Build intensive collaboration between medical staff and families for effective remote symptom information. 2) Develop integrated communication system between medical staff and families for real-time treatment responses.
It is difficult for nurses to provide responsive treatment if patients experience complaints from a distance.	1) Schedule patient monitoring via digital platforms. 2) Emergency service system helps manage remote patient deterioration.
Limited access to clear remote hemodialysis information exists.	1) Develop platform providing complete HD treatment information. 2) Prioritize clear information distribution between families and medical staff. 3) Ensure information is understandable for elderly patients.

A need statement is derived from the pain points and gains of the user. Technical characteristics describing the capabilities needed to fulfil this statement were obtained from the literature and user interviews. Both are presented in **Table 3**, which will be processed at the ideal stage using QFD tools.

Table 3. Need statement and technical characteristics

Need Statement	Technical Characteristics
The application's ability to provide information effectively and Efficient. **(N1)**	The application displays information regarding company profiling and an overview of HD. **(T1)**
Easy to use application (user friendly) and clear classification. **(N2)**	Arranging the application page layout neatly and symmetrically. **(T3)** The application screen design is simple but attractive. **(T4)** Non-confusing letter fonts and appropriate. **(T5)**

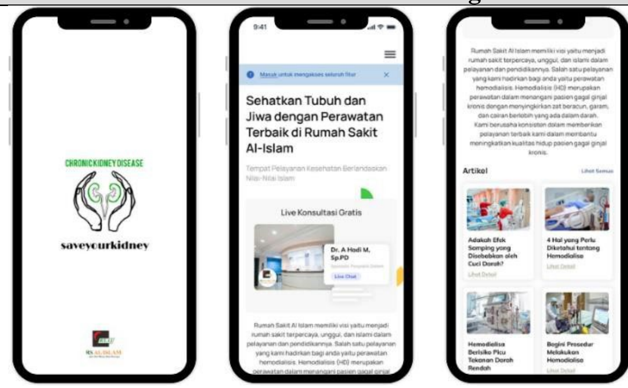
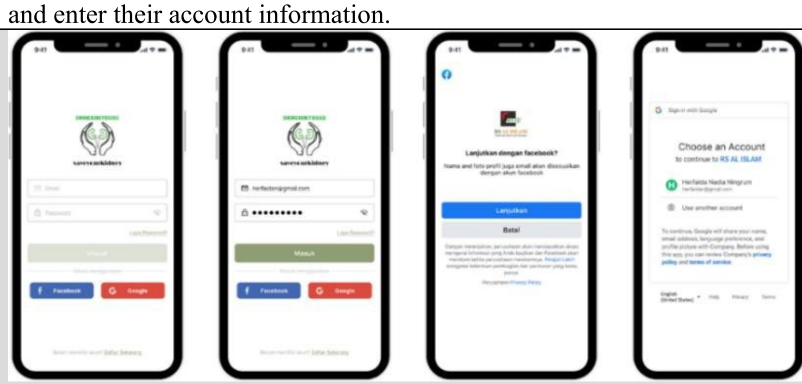
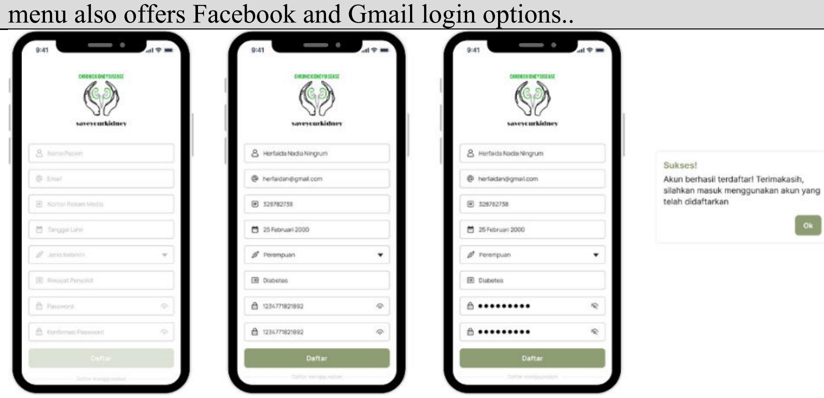
	Selection of colors that are appropriate and attractive. **(T6)**
Application capabilities in online consultations with medical personnel responsively and in real time. **(N3)**	Live Chat feature with Medical Personnel. **(T7)** Chat online with medical personnel. **(T8)**
The application has a trusted security system. **(N4)**	Availability of profile page. **(T9)** Using login via email. **(T10)** Using login via Facebook. **(T11)**
Application capabilities in managing HD schedules. **(N5)**	Calendar system for management weekly maintenance. **(T12)** Reminder for treatment. **(T3)**
The application's ability to convey the patient's condition in real time, precisely and accurately**. (N6)**	Symptom delivery icon. **(T14)**
Adequate application capabilities and integrated with personal data patient. **(N7)**	Compliance with patient personal data. **(T15)** Notification when there is an error in writing. **(T16)**
Application capabilities that provide information regarding maintenance HD clearly. **(N8)**	HD Treatment Article. **(T17)**
The application's ability to help monitor nursing care, and fluid limitations in patients. **(N9)**	Checklist (Diet Control). **(T18)** Fluid dose reminder. **(T19)**
The application's ability to provide educational & motivational features life for patients. **(N10)**	HD Article Notification. **(T20)**
The application's ability to provide emergency services for patients. **(N11)**	Creating an Emergency Support System feature. **(T21)**
Application capabilities with a good system. **(N12)**	Availability of Contact Helpdesk. **(T22)**

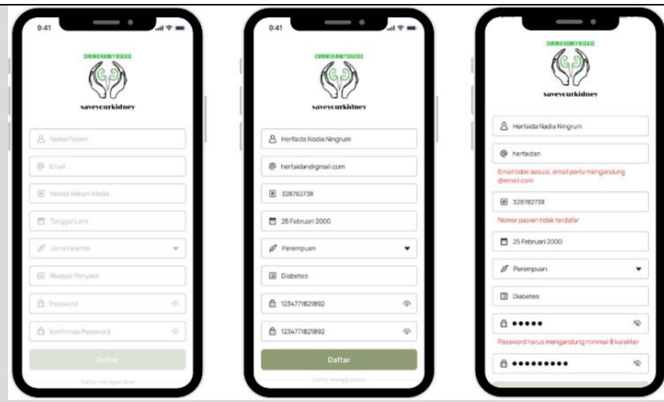
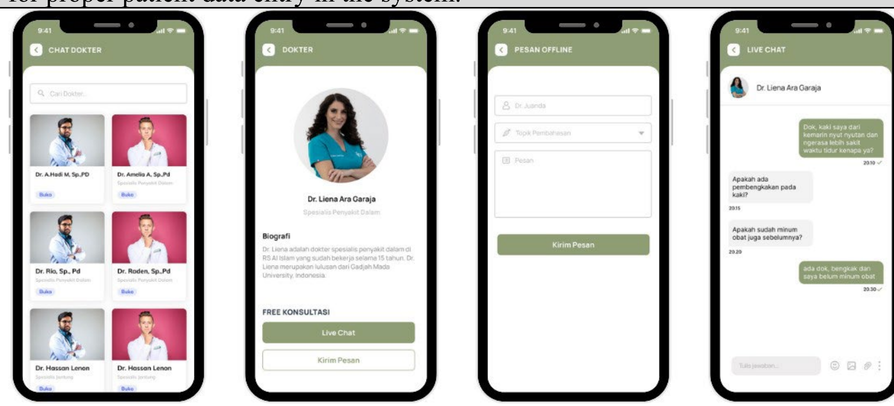
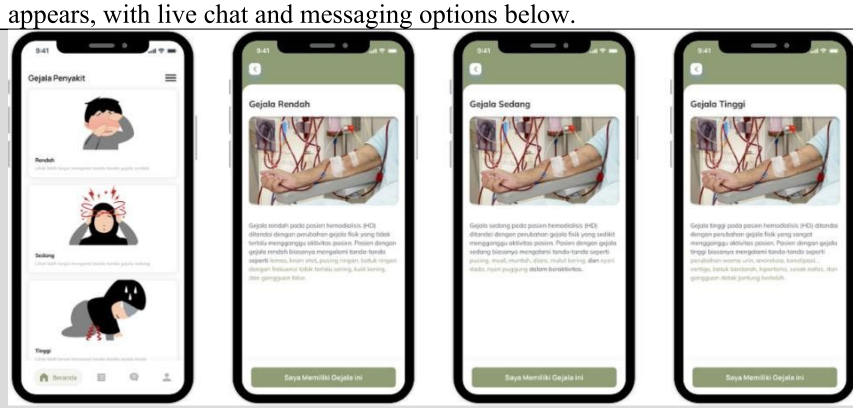
Determining the weight of the need statements requires calculations in the planning matrix. Questionnaires using the Likert scale were distributed to 30 users to assess their satisfaction and importance levels. The weights were divided by the respondent count to derive the values. Goal-value computation represents anticipated customer performance considering satisfaction and interests. The improvement ratio is calculated by dividing the goal value by customer satisfaction. The sales point value determines the fulfillment of requirement attributes. Physical weight is determined by multiplying the improvement ratio and sales point values with customer importance. A higher basic weight indicates greater requirement significance. The normalized raw weight was calculated by dividing the individual raw weights by the total raw weight. These results determine the ((HOQ) rankings.

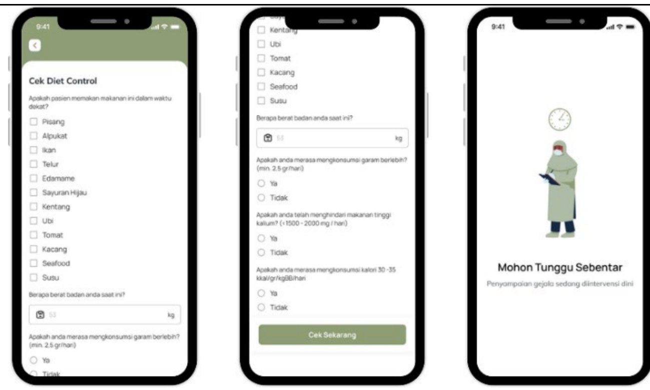
HoQ includes several components: relationship matrix, correlation of technical qualities, and technical matrix determination. The relationship matrix assesses the connections between required attributes and technical qualities and converts them to numerical values indicating the link intensity. The relationship strength values were categorized as 0 (no relationship), 1 (minimal), 3 (moderate), and 9 (strong). The correlation between technical qualities determines each target characteristic's impact on others using the symbols √ (moderately positive), √√ (strong positive), X (moderate negative), and XX (strong negative). For priority ranking, the contribution and normalized contribution values were established for each technical attribute. The contribution value was determined by multiplying the relationship matrix value by the normalized raw weight for each attribute and summing these values. The normalized raw weight was calculated by dividing the raw weight by total raw weight. Finally, rankings are generated for each attribute to identify the primary aspects of smart monitoring system design.

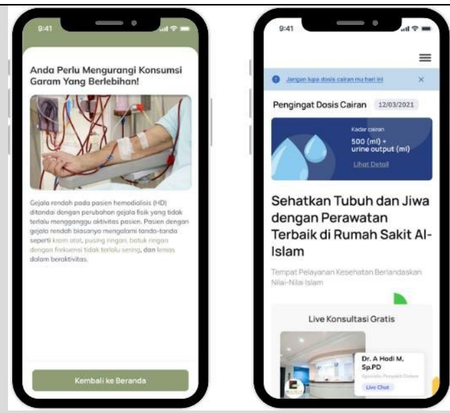
The prototype stage was developed based on user preferences and House of Quality priorities. The initial phase involves conceptualizing the user interface layout, followed by incorporating colors and icons, and establishing page linkages. Table 4 presents the comprehensive design for each technological aspect of the smart monitoring system.

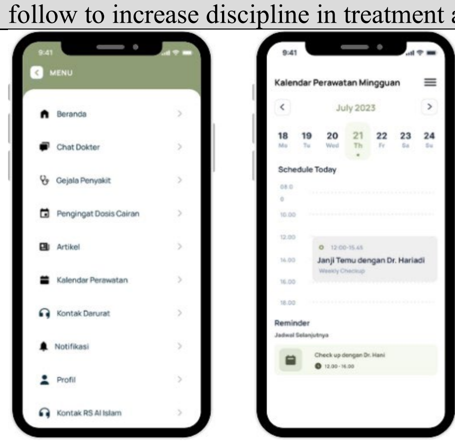
Table 4. Prototype design

Technical Characteristics	Design
Information regarding company profile and general description of HD	 The homepage displays a concise overview of hemodialysis treatment and Hospital's profile. To access all functionalities, users must click "sign in" to reach the login page and enter their account information.
Login to the application using the Facebook page and email	 Users must enter email and password to access the application homepage. The login menu also offers Facebook and Gmail login options..
Compliance with patient personal data	 Users must register by entering their name, email, medical record number, birth date, gender, medical history, and password details for account creation.

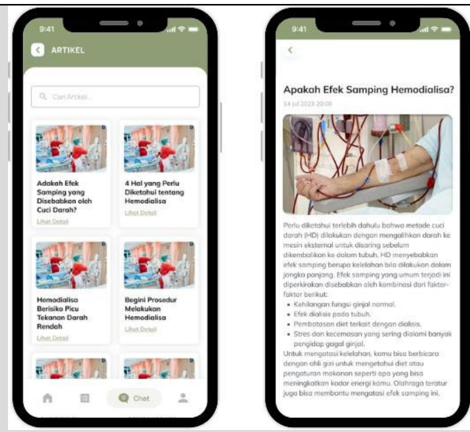
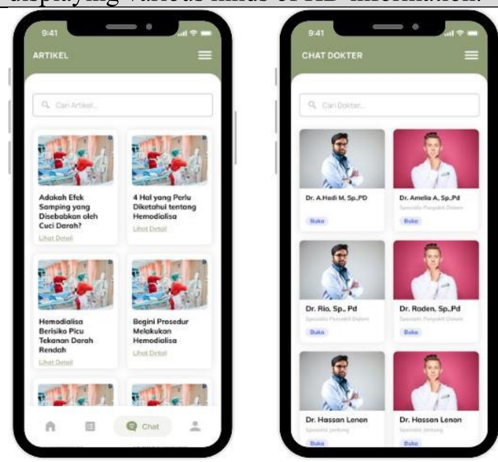
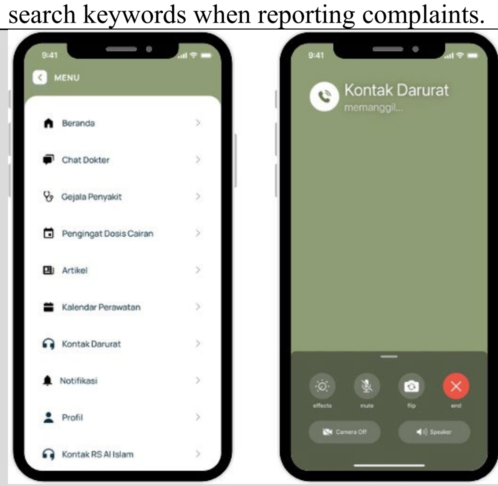
Notification when there is a writing error	 When users enter incorrect registration data, the page displays red text with directions for proper patient data entry in the system.
Online chat and live feature with medical personal	 Users select their preferred doctor to inquire about the patient. A doctor's biography appears, with live chat and messaging options below.
Symptom delivery icon	 Symptoms are classified as low, medium and high, describing the physical conditions that occur in patients.

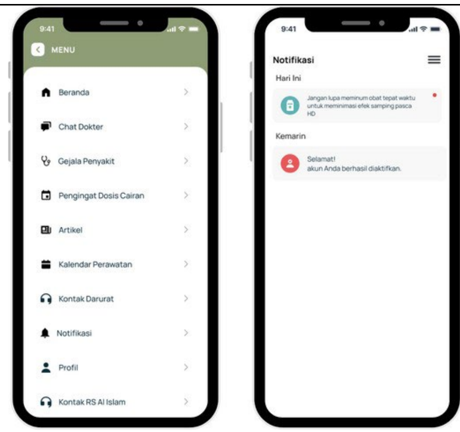
<table>
<tr>
<td>Availability of checklist menu (diet control)</td>
<td>


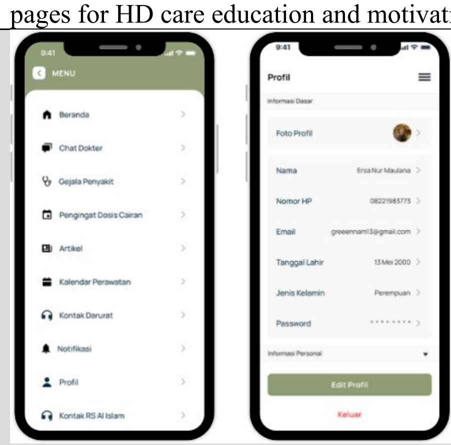
After users click symptoms, diet control helps medical staff monitor HD patients' dietary compliance. Users fill questions and await remote intervention regarding conditions and treatment.
</td>
</tr>
<tr>
<td>Fluid dosage reminder</td>
<td>


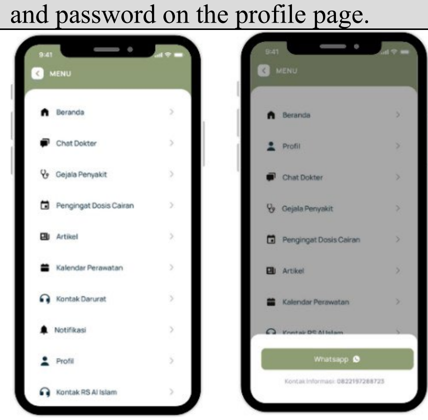
This feature explains reminders of salt intake, fluids, and dosages that patients must follow to increase discipline in treatment and prevent complications.
</td>
</tr>
<tr>
<td>Weekly treatment management calendar system & reminder for treatment</td>
<td>


A calendar feature displays patients' weekly HD procedure schedules. At the bottom, a reminder shows their routine HD check-up schedule.
</td>
</tr>
</table>

Hemodialysis treatment articles	 This feature aims to provide users with more understanding regarding HD care by displaying various kinds of HD information.
Availability of search engine menu	 The search engine menu in article and doctor search features enables users to quickly search keywords when reporting complaints.
Emergency support system	 The menu includes an emergency contact feature to help users reach emergency contacts or ER when patients have acute conditions requiring outside care.

<table>
<tr><td>Hd article notifications</td><td>

The notification feature displays educational headlines which direct users to article pages for HD care education and motivation.</td></tr>
<tr><td>Availability of profile page</td><td>

Users can view and edit patient data including name, phone, email, birth date, gender and password on the profile page.</td></tr>
<tr><td>Availability of contact helpdesk</td><td>

Contact helpdesk where users can contact Hospital for problems when using the smart monitoring system.</td></tr>
</table>

The design pages are then linked by creating a clickable mockup. This is done so that the smart monitoring system prototype can be used and operated in the same way as a genuine program or system would, with the features and functions of the prospective users' desires. The interactive mockup aids in monitoring and testing the design outcomes through UI usability testing.

A usability test was conducted to evaluate the user interface of the intelligent monitoring system with five families, five medical staff members, and one hemodialysis unit head. Testing involved a 10-item questionnaire in which users indicated their agreement with statements about the prototype using a 1-5 Likert scale. The system achieved a usability score of 72.045, receiving grade C ("good"), indicating acceptable user reception. The system was validated by the chief supervisor of the HD unit. By focusing on user requirements and applying design thinking theory and quality function deployment methods, this study contributes to smart monitoring system design in healthcare. This emphasizes the importance of user involvement in creating designs that effectively address user challenges. The system design requires that hospitals monitor patients' physical symptoms more closely to improve their quality of life. Additionally, HD treatment education requires improvements through diet control information and regular reminders for treatment efficacy.

5. Conclusion

Chronic kidney disease (CKD) is among the most prevalent non-communicable diseases worldwide. Dialysis therapy is a treatment option for this condition. HD patients must adapt to treatment protocols to prevent complications, such as blood pressure fluctuations caused by hypertension, salt intake, and fluid overload. Hospitals must monitor patients' conditions during treatment. A design thinking approach developed a smart monitoring system to meet user requirements through the following stages: empathize (user persona), define (empathy mapping), ideate (QFD), prototype (design), and usability testing. The design includes the following technical attributes: HD information, social media login, patient data compliance, error notifications, medical chat features, symptom delivery, diet checklist, fluid reminders, treatment calendar, HD articles, search function, emergency support, notifications, profile page, and helpdesk. The usability testing evaluation achieved a "C" grade ("Good"). This research contributes to smart monitoring system design and healthcare by implementing design-thinking theory and prioritizing consumer requirements.

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References

Alwashmi, M. F., Hawboldt, J., Davis, E., & Fetters, M. D., The iterative convergent design for mobile health usability testing: Mixed-methods approach, *JMIR MHealth and UHealth*, vol. 7, no. 4, 2019, https://doi.org/10.2196/11656.

Apuke, O. D., Quantitative Research Methods : A Synopsis Approach, *Kuwait Chapter of Arabian Journal of Business and Management Review*, vol. 6, no. 11, 2017, https://doi.org/10.12816/0040336.

Ardani, F., Caesaron, D., & Kusnayat, A., Design of Flood Barrier with Developed IoT-Based Flood Detection and Monitoring Systems, *Jurnal Teknik Industri*, vol. 25, no. 2. pp.111-120, 2023, https://doi.org/10.9744/jti.25.2.111-120.

Gao, M., Kortum, P., & Oswald, F. L., Multi-Language Toolkit for the System Usability Scale. *International Journal of Human-Computer Interaction*, vol. 36, no. 20, 2020, https://doi.org/10.1080/10447318.2020.1801173.

Jebraeily, M., Safdari, R., Rahimi, B., Makhdoomi, K., & Ghazisaeedi, M., Development of a web-based information system for monitoring of hemodialysis adequacy. *Journal of Nephropharmacology*, vol. 8, no. 2, 2019, https://doi.org/10.15171/npj.2019.19.

Kim, T., Lim, H., & Cho, K., Conceptual robot design for the automated layout of building structures by integrating QFD and TRIZ. *International Journal of Advanced Manufacturing Technology*, vol. 120, no. 3–4, 2022 https://doi.org/10.1007/s00170-022-08803-2.

Li, J., Tigwell, G. W., & Shinohara, K., Accessibility of high-fidelity prototyping tools. *Conference on Human Factors in Computing Systems*, 2021, https://doi.org/10.1145/3411764.3445520.

Malhotra, G., Strategies in Research. *International Journal for Advance Research and Development*, vol. 2, no. 5, pp. 172–180, 2017, https://doi.org/xx.xxx/ijariit-v2i5-1220.

Mohajan, H., & Mohajan, H. K., Munich Personal RePEc Archive Qualitative Research Methodology in Social Sciences and Related Subjects Qualitative Research Methodology in Social Sciences and Related Subjects, *Journal of Economic Development*, *Environment and People*, vol. 7, no. 1, 2018.

Mueller-Roterberg, C., *Handbook of design thinking*, Hochschule Ruhr West, Mülheim, 2018.

Nassaji, H., Qualitative and descriptive research: Data type versus data analysis, *Language Teaching Research*, vol. 19, no. 2, 2015, https://doi.org/10.1177/1362168815572747.

Ni, Z., Jin, H., Jiang, G., Wang, N., Peng, A., Guo, Z., Bai, S., Zhou, R., Lu, J., Wang, Y., Li, Y., Zhuang, S., Yu, C., Deng, Y., Jin, H., Xu, X., Zhang, J., Zhao, J., and Yu, X., A telemedicine-based registration system for the

management of renal anemia in patients on maintenance hemodialysis: Multicenter study. *Journal of Medical Internet Research*, vol. 21, no. 5, 2019, https://doi.org/10.2196/13168.
Pileggi, S. F., Knowledge interoperability and re-use in Empathy Mapping: an ontological approach, *Expert Systems with Applications*, vol. 180, 115065, 2021, https://doi.org/10.1016/J.ESWA.2021.115065.
Pressman, A., *Design Thinking: A Guide to Creative Problem Solving for Everyone*, 2018, https://doi.org/10.4324/9781315561936.
Reeves, S., How UX practitioners produce findings in usability testing, *ACM Transactions on Computer-Human Interaction*, vol. 26, no.1, 2019, https://doi.org/10.1145/3299096.
Santos, P. R., and Arcanjo, F. P. N., Distance between residence and the dialysis unit does not impact self-perceived outcomes in hemodialysis patients, *BMC Research Notes*, vol. 5, 2012, https://doi.org/10.1186/1756-0500-5-458.
Sasmito, G. W., Zulfiqar, L. O. M., & Nishom, M., Usability Testing based on System Usability Scale and Net Promoter Score, *Proceedings of the 2nd International Seminar on Research of Information Technology and Intelligent Systems, ISRITI 2019*, 2019, https://doi.org/10.1109/ISRITI48646.2019.9034666.
Wang, X., & Cheng, Z., Cross-Sectional Studies: Strengths, Weaknesses, and Recommendations. *Chest*, vol. 158, no. 1, 2020, https://doi.org/10.1016/j.chest.2020.03.012.
Weijie, J., Research and Application of Mechanical Product Design Process Based on QFD and TRIZ Integration. *Journal of Physics: Conference Series*, vol. 1544, no. 1, 2020, https://doi.org/10.1088/1742-6596/1544/1/012088.
Zohrabi, M., Mixed method research: Instruments, validity, reliability and reporting findings, *Theory and Practice in Language Studies*, vol. 3, no. 2, pp. 254-262, 2013, https://doi.org/10.4304/tpls.3.2.254-262.

Biographies

Herfaida Nadia Ningrum is a graduate of the Master's program in Industrial Engineering at Telkom University, Bandung. Her expertise lies in applying human-centered methodologies, particularly design thinking, to the development of effective monitoring and information systems. She has previous publication experience in the field of product design, and her primary research interests include human-centered design, product development, and user experience (UX) strategy.

Dino Caesaron is an Associate Professor in the Department of Industrial Engineering at Telkom University, Bandung, Indonesia. He acquired his Ph.D. in Industrial Management from the National Taiwan University of Science and Technology (NTUST), Taiwan. He has a strong background in motion analysis, virtual and augmented reality, and conducting laboratory-based research experiments. His current research focuses on investigating human performance within 3D stereoscopic displays.

Nadia Daliana is a recent graduate with a Bachelor of Engineering degree in Industrial Engineering from Telkom University, Bandung. Her latest research was conducted in the field of Human-Computer Interaction. Her primary research interests include Ergonomics, Occupational Health and Safety, new product development, and Human-Computer Interaction.

Ilma Mufidah is an Assistant Professor in the Department of Industrial Engineering at Telkom University, Bandung, Indonesia. She received her Bachelor’s and Master’s degrees in Industrial Engineering from the Sepuluh Nopember Institute of Technology (ITS), Indonesia. She later earned both an MBA and a Ph.D. from the National Taiwan University of Science and Technology (NTUST), Taiwan. Her research interests include industrial ergonomics, safety culture, occupational health, sustainable product development, and consumer behavior toward green innovation