

MYKIDNEY APPLICATION: OPTIMIZING M-HEALTHCARE FOR ENHANCED CHRONIC KIDNEY DISEASE SELF-CARE MANAGEMENT - A RESEARCH STUDY

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ABSTRACT: Chronic Kidney Disease (CKD) poses a significant global health challenge due to deficiencies in patient engagement, leading to disease progression and increased strain on healthcare systems. In chronic kidney disease, insufficient patient engagement in self-management behaviors, such as adhering to dietary restrictions and medications, increases the risk of complications and burdens the healthcare system, underscoring the need for effective strategies to encourage active participation. This project aims to address these challenges by developing the "My-Kidney" mobile health application, designed to empower CKD patients through comprehensive self-management tools and crucial health information. Utilizing an Agile methodology, the development process focuses on iterative feedback and rapid prototyping to ensure user-centric design and functionality. Qualitative research methods are employed to explore patient health management strategies and preferences, informing the application features and usability. By promoting active patient participation in self-care practices and providing tailored support, the "My-Kidney" app aims to improve health outcomes and reduce healthcare burdens. Through technological innovation and patient-centered care, this initiative seeks to catalyze a paradigm shift in CKD management, offering personalized and empowered healthcare delivery for patients worldwide.

KEY WORDS: *Chronic Kidney Disease (CKD), Mobile Health Application, Remote Monitoring, Patient Engagement, Disease Management*

1. INTRODUCTION

Chronic kidney disease (CKD) represents a significant global health challenge, characterized by a spectrum of renal impairments leading to a gradual decline in kidney function (Webster et al., 2017). With its prevalence rapidly escalating, CKD affects millions worldwide, exerting substantial burdens on healthcare systems and individual well-being (Deng et al., 2021). Despite advancements in medical understanding and treatment modalities, CKD remains a leading cause of morbidity and mortality, necessitating comprehensive strategies for prevention, management, and patient engagement (P. K. T. Li et al., 2020). Human Kidney or known also as renal care is a crucial aspect of maintaining a healthy lifestyle. Fig. 1 demonstrates a healthy renal and poorly maintained renal.

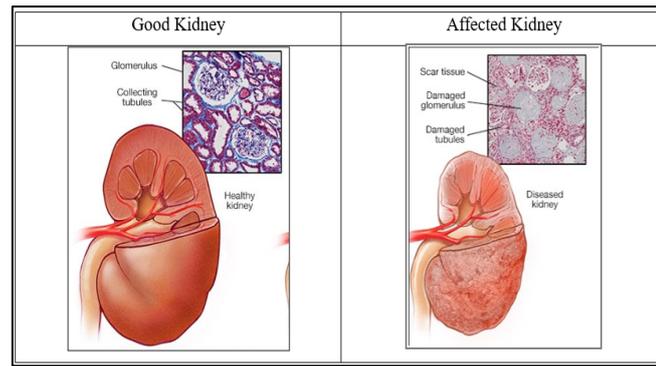


Fig. 1. Renal Overview

A brief overview of normal kidney function serves as a strong basis for understanding chronic renal disease. The kidneys' principal function is to eliminate waste and excess water from the circulation, releasing urine as a byproduct. A good passage from the nephron to the urethra is vital. A clean passage from the nephron to the urethra is required, and each kidney has 700,000 to 1 million filtering units or nephrons. CKD is caused by problems that gradually limit the number or function of nephrons. When the kidneys function properly, they maintain the body's fluids and chemicals in balance. Any imbalance might cause signs of kidney disease. Swelling, notably around the feet and ankles, may manifest in some CKD cases before other symptoms emerge. Even in advanced stages of kidney failure, individuals may continue to produce a seemingly normal amount of urine, though it lacks sufficient waste product elimination. While CKD is typically thought to be a slowly progressing illness, the rate of advancement varies between individuals and is determined by factors such as the underlying cause of CKD, overall health, genetics, and the efficacy of medical treatments. Early detection, lifestyle changes, and timely medical intervention are critical to effectively manage the condition and prevent or delay its progression to more severe stages. Regular monitoring and prompt intervention are vital in managing CKD and mitigating its associated symptoms and complications.

CKD's multifaceted nature encompasses various physiological abnormalities, including compromised renal function and declining Glomerular Filtration Rates (GFR) (Deng et al., 2021). Its impact reverberates across demographics and geographies, with South Asia notably bearing a high prevalence. Notably, CKD's insidious progression underscores its status as a silent epidemic, often evading detection until advanced stages. Risk factors such as diabetes, hypertension, and cardiovascular disease contribute significantly to CKD's pathogenesis, amplifying its global health footprint (Chen et al., 2019; Ghelichi-Ghojogh et al., 2022). Furthermore, one of the key challenges in managing CKD is the limited access that patients have to essential educational materials and monitoring tools. A critical issue is the inconsistency in information availability, which often leaves patients struggling to find comprehensive and up-to-date educational resources.

A significant challenge within the CKD patient population is the insufficient awareness and understanding of their condition, which impairs their ability to effectively self-manage it. Many CKD patients lack knowledge about the causes, progression, and potential consequences of their disease, leading to difficulties in making informed decisions regarding self-management. This knowledge gap often

results in non-adherence to prescribed treatment regimens, as patients may not fully grasp the rationale behind dietary restrictions, medications, and lifestyle changes. Moreover, inadequate disease understanding can lead to delayed or missed diagnoses, as patients may underestimate or overlook CKD symptoms.

Addressing the complexities of CKD management necessitates a nuanced understanding of the challenges impeding effective care delivery (Schrauben et al., 2021). Foremost among these challenges is the inadequate engagement of patients in self-management behaviors, including medication adherence and dietary compliance. Such lapses not only exacerbate CKD progression but also strain healthcare resources (Liu et al., 2014). Moreover, insufficient monitoring and management of comorbidities like diabetes and hypertension further compound CKD's trajectory, underscoring the need for integrated care approaches.

2. REVIEW OF LITERATURE

Chronic Kidney Disease (CKD) is a complex health issue characterized by gradual kidney function loss. The severity of CKD is often evaluated using the estimated glomerular filtration rate (eGFR) from serum creatinine concentration. Early identification of CKD stages is crucial, as complications and end-stage renal disease progression are more common in severe cases. CKD poses significant challenges for patients, affecting their daily lives and requiring diligent care management to mitigate risks and improve outcomes. CKD profoundly affects patients' daily lives, with symptoms ranging from fatigue and weakness to complications such as hypertension, anemia, and bone disease. According to a study published in the *Journal of Renal Nutrition*, CKD patients often experience reduced quality of life due to physical symptoms and psychological distress associated with the disease (Russell et al., 2022). Furthermore, CKD imposes dietary restrictions and lifestyle modifications, leading to challenges in meal planning, social interactions, and overall well-being.

Apparently, failure to manage CKD effectively can result in serious complications, including cardiovascular disease, kidney failure, and premature death. Research published in the *American Journal of Kidney Diseases* highlighted the heightened risk of cardiovascular events among CKD patients, emphasizing the need for comprehensive care management to address modifiable risk factors such as hypertension, diabetes, and dyslipidemia (Schrauben et al., 2021). Managing CKD requires a multifaceted approach, including medication adherence, dietary modifications, regular exercise, and close monitoring of kidney function and associated comorbidities. Medical mobile apps offer promising tools for empowering patients to take control of their health. A review in the *Journal of Medical Internet Research* suggested that mobile apps can facilitate self-care management by providing educational resources, medication reminders, symptom tracking, and communication with healthcare providers (W. Y. Li et al., 2020). This review explored the impact of CKD on patients' lives, the risks associated with inadequate care, and strategies for effective management, including the role of medical mobile apps.

The exploration process undertaken in this review delved into previous research focusing on self-care management, particularly for patients with CKD. By analyzing literature and technological advancements related to CKD management, including epidemiology, diagnosis, treatment strategies, and patient engagement,

insights were synthesized from 24 research articles as presented in Table 1. These insights serve to highlight the development of the "My-Kidney app," envisioned as a user-centric healthcare application tailored to the specific needs of CKD patients. The analysis conducted aims to identify existing features, gaps, challenges, and opportunities in CKD management. By examining the literature, this review sets out to determine the critical elements necessary for the proposed app's development. Through this exploration, the review seeks to uncover insights that will shape the creation of a more effective and user-centric healthcare solution for CKD patients. Central to this review is the assessment of features present in existing applications, encompassing areas such as symptom monitoring, dietary guidance, educational resources, self-management tools, medication tracking, fluid balance monitoring, patient information provision, accessibility, ease of navigation, and user-friendliness. By evaluating these features across a spectrum of reviewed applications authored by different researchers, this review sheds light on the diverse dimensions of functionality and usability within the realm of CKD management applications.

Table 1: Review on Published Papers Based on Features of My Kidney-Application Development

Author	Year	Application Feature					Technological Integration		Patient		
		Symptom monitoring	Dietary Guidance	Education Resource	Self-Management	Medication Tracking	Fluid balance	Patient Information	Accessibility	Easy to Navigate	User-Friendly
Siddique et al.	2019	✓	✓		✓	✓		✓			
Markossian et al.,	2021	✓	✓	✓		✓			✓		
Schraube et al.	2021	✓			✓						
Che Johan et al.	2023	✓		✓					✓		
W. Y. Li et al.	2020	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lee et al.	2018	✓			✓	✓					
Lightfoot et al.	2022	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lo et al.	2017	✓	✓			✓	✓				
Kovesdy	2022	✓		✓				✓			
Chen et al.	2019	✓		✓	✓				✓		

The works of Chen et al. (2019) provided a broad environment in the domain of health application research for chronic disease management. The studies inquiry

confirmed the inclusion of features such as symptom monitoring, nutritional assistance, self-management, and medication recording. Besides that, study by Chen et al. (2019) emphasized comparable elements but did not go into detail on education resources, fluid balance monitoring, patient information offering accessibility, ease of navigation, or user-friendliness. A study by Ghelichi-Ghojogh et al. (2022) highlighted symptom monitoring and self-management components but did not address dietary guidance, education resources, medication tracking, fluid balance monitoring, patient information provision, accessibility, ease of navigation, or user-friendliness. A study conducted in 2023 acknowledged symptom monitoring, self-management, and accessibility features but did not mention dietary guidance, education resources, medication tracking, fluid balance monitoring, patient information provision, ease of navigation, or user-friendliness (Che Johan et al., 2023). A comprehensive 2021 study of Markossian et al. (2021) stood out for its inclusive coverage of features such as symptom monitoring, dietary guidance, education resources, self-management, medication tracking, fluid balance monitoring, patient information provision, accessibility, ease of navigation, and user-friendliness.

Besides that, in Siddique et al. (2019), application developments focus on symptom monitoring, self-management, and medication tracking but exclude nutritional assistance, education resources, fluid balance monitoring, patient information availability, accessibility, simplicity of navigation, and user-friendliness. On the other hand, Liu et al. (2014) considered a wide range of features, such as symptom monitoring, dietary guidance, education resources, self-management, medication tracking, fluid balance monitoring, patient information provision, accessibility, ease of navigation, and user-friendliness. However, although most studies focused on monitoring and nutritional guidance, they failed to examine education resources, self-management, medication tracking, fluid balance monitoring, patient information availability, accessibility, simplicity of navigation, or usability. In further support of Liu et al. (2014), a review by Lee et al. (2018) acknowledged symptom monitoring, self-management, and accessibility, but it made no clear mention of nutritional guidance, education resources, medication tracking, fluid balance monitoring, patient information providing, ease of navigation, or user-friendliness. Several challenges emerged from the literature review, notably the inconsistencies in the inclusion of essential features across different CKD management applications. While some studies comprehensively covered a wide range of features, others lacked depth in certain areas, such as educational resources, fluid balance monitoring, and ease of navigation. Additionally, the varying emphasis placed on different aspects of CKD management by different researchers contributed to discrepancies in the findings. Addressing these challenges requires a nuanced approach, including the development of standardized criteria for evaluating CKD management applications and fostering collaboration among researchers to ensure comprehensive coverage of essential features.

The analysis of various applications dedicated to CKD management reveals several key features and technological integrations aimed at supporting patients in self-care management. Symptom monitoring emerges as a prevalent feature across the majority of applications, indicating a strong emphasis on real-time tracking to facilitate timely intervention and management. Similarly, dietary guidance features

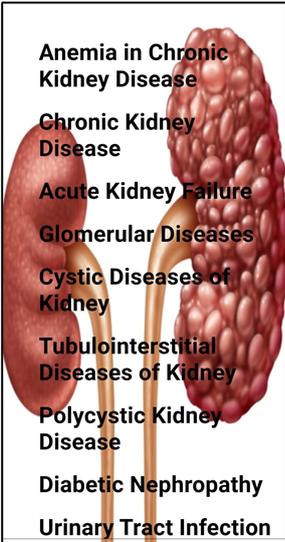
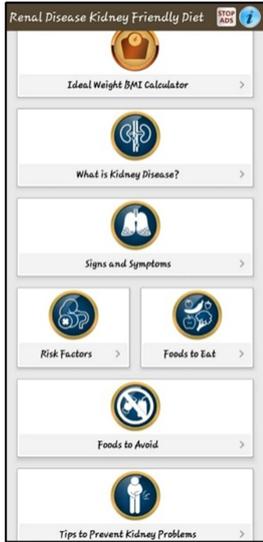
are widely incorporated, highlighting the recognition of nutrition's critical role in disease management and the importance of aiding patients in adhering to dietary restrictions. While about half of the applications offer educational resources, indicating a focus on patient education and empowerment, self-management tools are prevalent, underscoring the significance of empowering patients to take an active role in their care. Medication tracking functionalities are also common, aiding patients in adhering to complex medication regimens critical for optimizing treatment outcomes. However, the presence of fluid balance monitoring features is comparatively limited, suggesting a potential area for improvement in future app developments to address this essential aspect of CKD care. Moreover, the provision of patient information across many applications facilitates access to essential health resources and fosters informed decision-making among patients. While not explicitly listed, considerations such as accessibility, ease of navigation, and user-friendliness are integral to enhancing the overall usability and effectiveness of healthcare applications. Overall, the analysis underscores a positive trend towards leveraging technology to support CKD patients in self-care management, while also highlighting potential areas for further enhancement and innovation to provide comprehensive and patient-centered care solutions. To overcome the challenges identified, several solutions can be proposed. Firstly, establishing clear guidelines or criteria for evaluating CKD management applications can help ensure consistency and comparability across studies. This would enable researchers to systematically assess the presence and effectiveness of key features, facilitating more meaningful comparisons and insights. Secondly, fostering collaboration and knowledge-sharing among researchers in the field can enhance the collective understanding of CKD management applications and facilitate the identification of best practices. Finally, continuous monitoring and evaluation of emerging technologies and trends in CKD management can guide ongoing refinement and improvement of existing applications, ensuring their relevance and effectiveness in addressing the evolving needs of CKD patients. Through these measures, the literature review contributes to the ongoing discourse on CKD management applications, offering insights into current challenges and potential avenues for future research and development efforts.

3. REVIEW OF EXISTING APPLICATION

This study seeks to empower CKD patients to prioritize personal care management and address health and lifestyle concerns affecting themselves and their peers. Through the utilization of a digital application, the study aims to assess patients' knowledge regarding CKD management and potential threats to their well-being. To guide the development of this application, a review of existing systems with similar objectives was conducted to identify essential features that can be incorporated and customized. Three existing applications with comparable purposes were selected for analysis, with each application summarized for reference. Table 2 presents the detailed comparison of similar products related to CKD.

Table 2: Comparison of Similar CKD Mobile Applications

System Name	CKd(Care for Kidney)	All Kidney Disease	Kidney Renal Disease Diet Help
Developer Name	Altus Solution Sdn Bhd	Devo Dream Team	Data Recovery Software
Manufactured Year	2022	2022	2016
Purpose	The "Care for Kidney (CKd)" app promotes kidney health and educates users about chronic kidney disease through user-friendly features, language options, and personalized self-monitoring tools.	The app offers a user-friendly interface and comprehensive information on renal disease, along with expert advice on kidney-friendly foods from qualified nutritionists. This empowers users to take control of their kidney health and maintain optimal well-being	"Renal Health Guide" is an app providing answers to user questions and offering diet tips approved by dietitians for kidney health. It's designed for kidney patients and anyone seeking better kidney health.
Strength	The "Care for Kidney (CKd)" app, funded by the National Kidney Foundation Malaysia, helps promote kidney health and educate users about chronic kidney disease (CKD). It's easy to use, with features like self-monitoring, medication reminders, and health education. Users can share their health data with healthcare providers, and healthcare workers can monitor multiple users through a central web app.	The "All Kidney Diseases Guide" app on Android is a one-stop resource for kidney health information. It covers kidney diseases like CKD, infections, stones, and injuries, offering expert advice on symptoms, treatments, and prevention. It's a handy tool for anyone looking to keep their kidneys healthy.	"Renal Disease Info & Diet Tips" is an easy-to-use app that gives comprehensive details on kidney diseases, causes, symptoms, and recommended foods. Reviewed by dietitians, it's well-organized for simple navigation, empowering kidney patients and those interested in kidney health.
Weakness	The "Care for Kidney (CKd)" app has some strengths, like being available in multiple languages and letting users set personalized goals. But it also has challenges, such as technical issues and keeping users engaged. To make it better, the app could focus on improving data security, adding more educational content,	The "All Kidney Diseases Guide" app has some flaws, including the need for frequent content updates, improving navigation and accessibility in the user interface, and ensuring the accuracy of medical information. Adding interactive features and feedback systems could enhance the app's	To stay current with developments in renal health, the "Renal Disease Info & Diet Tips" app might need regular updates. Enhancing user engagement through interactive features and feedback mechanisms could enhance the app's overall user experience.

	and considering cultural differences. It could also integrate wearable devices, offer better personalization, provide user training, and seek clinical validation to enhance its impact on kidney health promotion and self-management.	effectiveness, reliability, and user satisfaction.	Expanding its audience to include healthy individuals, both men and women, could also broaden its reach and effectiveness.
System Interface			

In summary, each app presents its unique strengths and weaknesses, addressing various aspects of kidney health. Altus Solution Sdn Bhd's "CKD (Care for Kidney)" app, developed in 2022, prioritizes personalized care and multilingual accessibility, supported by the National Kidney Foundation Malaysia. While it offers self-monitoring tools, it faces challenges like technological limitations and user engagement sustainability. Enhancements such as improved data security and cultural adaptations are underway to address these issues. On the other hand, the "All Kidney Diseases Guide" app provides expert advice on kidney health issues but requires frequent content updates and improvements in user interface navigation. Finally, Data Recovery Software's "Renal Disease Info & Diet Tips" software, launched in 2016, offers extensive information on renal disorders and diets, boasting an easy-to-use interface and educational content. However, regular upgrades and increased user involvement through interactive features and feedback mechanisms are recommended to enhance the overall user experience.

Moreover, in order to provide best features for the proposed app, the comparison analysis of the three existing systems in the market focuses on evaluating their features related to fluid balance, educational materials, dietary guidance, blood pressure monitoring, and diabetes monitoring as presented in Table 3. These components are crucial for effective kidney health management. The review aims to provide users with insights into the unique offerings of each product, enabling them to make informed decisions based on their specific needs

and preferences. This comparative analysis is also essential for researchers seeking to propose the best features for the development of the MyKidney app.

Table 3. Comparison of Features for Proposed Model

Features	Products vs. Proposed App			
	CKd(Care for Kidney)	All Kidney Disease	Kidney Renal Disease Diet Help	Propose App
Fluid Intake Balance	No	No	No	Yes
Educational Material	Yes	Yes	Yes	Yes
Dietary Guidance	No	No	Yes	Yes
Blood Pressure Monitor	Yes	No	No	Yes
Diabetes Monitoring	Yes	No	No	Yes

In evaluating the features of existing kidney health applications, including CKd (Care for Kidney), All Kidney Disease, and Kidney Renal Disease Diet Help, each app presents specific strengths and limitations. CKd stands out for its educational material, blood pressure monitoring, and diabetes monitoring features, yet it lacks functionalities such as fluid intake balance management and dietary guidance. On the other hand, All Kidney Disease offers comprehensive educational content, dietary guidance, and blood pressure monitoring. Meanwhile, Kidney Renal Disease Diet Help emphasizes dietary guidance and blood pressure monitoring but falls short in addressing fluid intake balance and diabetes monitoring.

In contrast, the proposed My-Kidney application aims to encompass all features listed in the table. From fluid intake balance management to educational materials, dietary guidance, blood pressure monitoring, and diabetes monitoring, My-Kidney strives to offer a comprehensive and user-friendly solution for individuals managing kidney health. By amalgamating these functions into a single application, My-Kidney seeks to bridge existing gaps in feature availability within current applications, providing users with a robust platform to proactively manage their kidney health with ease and efficacy.

4. METHODOLOGY

In the development of the healthcare application for CKD patients, a qualitative study approach was adopted, incorporating open-ended interview questions to glean insights from a sample size of two CKD patients and two staff members. To ensure patients' comfort and facilitate in-depth discussions, each session was recorded and later transcribed for analysis. Thematic analysis was applied to identify recurring themes, which were then coded to align with the development of the application. Figure 2 illustrates the research design of this study.

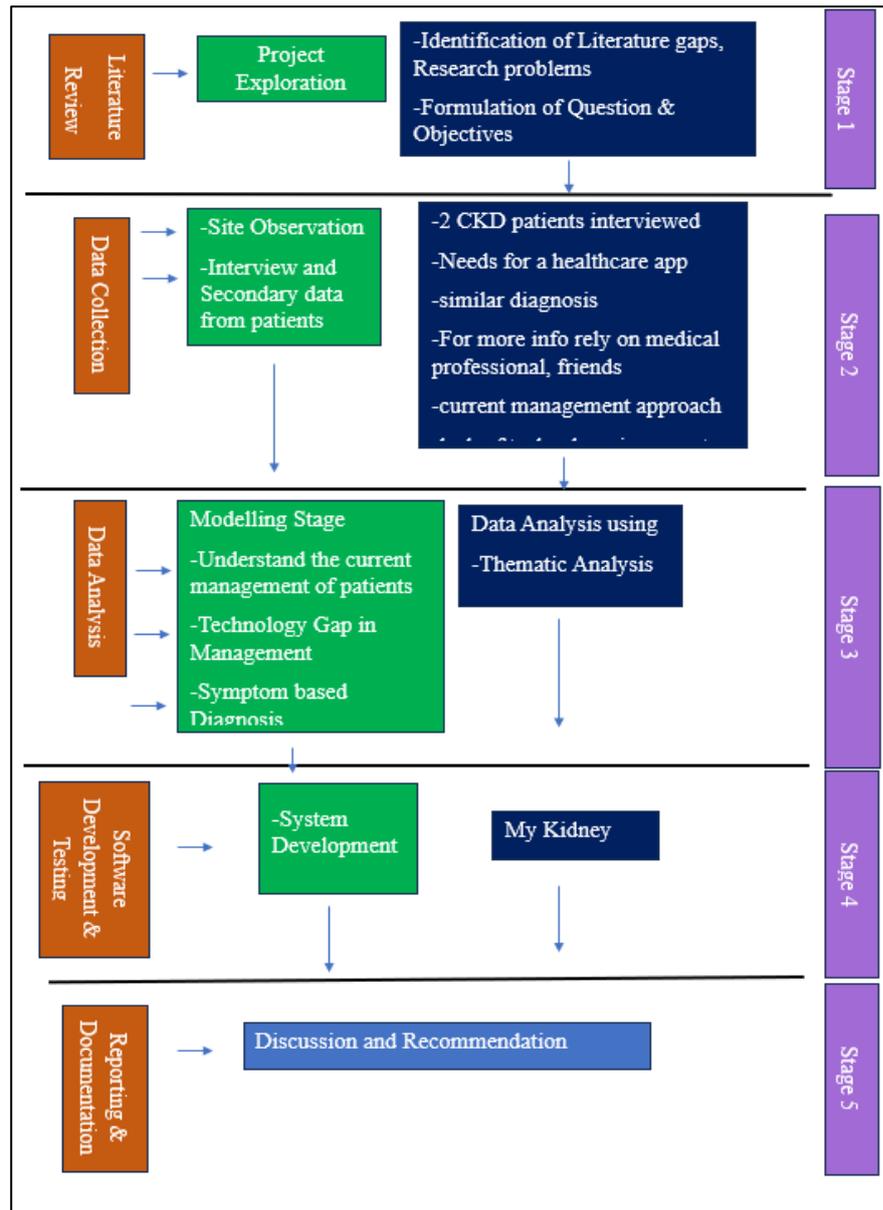


Fig.2. Research Design

The Agile methodology was chosen for the development process due to its fundamental flexibility, adaptability, and patient-centric approach. Agile's iterative development method enables constant feedback and real-time adaptations, which are crucial in the dynamic landscape of healthcare. This approach allows for the incorporation of changing healthcare recommendations, patient needs, and regulatory requirements. Furthermore, Agile's patient-centered approach resonates effectively with the development of a CKD application tailored to meet patients' specific needs and experiences. By emphasizing cooperation among cross-functional teams, Agile ensures that medical expertise is integrated into the development process, which is essential for a healthcare application. The adaptability of Agile to changes, continuous delivery of incremental value, and risk mitigation strategies make it well-suited for the complexities and uncertainties inherent in healthcare projects. Ultimately, this approach contributes to the development of a responsive, patient-centered, and effective CKD application that

addresses the diverse needs of patients and healthcare providers alike. Table 4 presents a summary of the process flow.

Table 4: Agile Process Description

Phases	Input	Process	Output
Planning	-Meet supervisor, discuss on plan, -search for relevant paper according to title -Plan to visit dialysis centre	-Conduct search for case study -Definition of project scope and objectives	Completed project thesis of chapter 1 and 2
Design	-Sketch UML Diagrams - Design Interview Questions	-Creation of UML diagrams (e.g use case diagram, class diagram) - Visited a Dialysis Centre and Interviewed two patients.	-Completion of UML diagrams for application -Successfully conducted at Sai Ananda Free Hemodialysis Centre
Development	-Begin to develop the application	- Iterative coding and development -Regular meet up with supervisor	- Functional healthcare application
Testing	-test the developed application	- Conduct unit testing, user acceptance testing	- Bug-free and fully functional application
Deploy	-The tested phase completed and the application is approved	- Deploy the application on any platform -Monitor for any possible issues	- Successfully deployed healthcare app
Review	-Check for user feedback	- Evaluate feedback and performance of the app -Changes are made based on the feedback given	-Updated version of the healthcare app

4.1. Case Study

The chosen case study focuses on a dialysis center located in Laksamana, 340, Jalan Laksamana 2/2, 68100 Batu Caves, Selangor, which has been operational since 2018 as illustrated in Fig. 3. Over time, the center has witnessed a significant increase in the number of patients it serves, transitioning from an initial number of 4 patients to a current count of 36 individuals. Operating seven days a week, the center offers dialysis services from 7: 00 a.m. to 5:00 p.m. daily except on Sundays and public holidays. Presently, the center is staffed with a team comprising 9 employees, including supervisors and management staff. However, an interview with management personnel revealed a concerning trend wherein most patients lack personal care management records and rely solely on the center's record-keeping system. This reliance poses a considerable risk during emergencies, as there is no provision for shared electronic records via cloud-based platforms for the management of CKD patients, especially concerning individual treatment histories and immediate care requirements. This scenario underscores the critical need for enhanced data management practices and technological solutions within the dialysis center to ensure comprehensive and timely care for CKD patients. By implementing cloud-based electronic health records (EHR) systems, the center can facilitate seamless sharing of patient information among healthcare providers,

enabling swift and informed decision-making during emergencies. Moreover, personalized care management plans can be established and updated regularly, incorporating patient-specific treatment protocols and preferences. Through such initiatives, the dialysis center can mitigate risks associated with inadequate record-keeping practices, thereby improving the quality and efficiency of care delivery for CKD patients.



Fig. 3. Sai Dialysis Centre

5. FINDINGS

The aim of this pilot study was to obtain a deeper understanding of the management of Chronic Kidney Disease (CKD) by conducting semi-structured interviews with CKD patients who are receiving treatment at a hemodialysis center. Table 5 presents the demographic summary applied for this pilot study.

Table 5: Demographic Summary of Semi-Structured Interview Participants

Age	Race	Gender	Occupation	Location	Years of Dialysis
68	Indian	Male	Unemployed	Selayang	5 years
43	Indian	Male	Employed	Batu Caves	2 years
33	Indian	Male	Employed	Sungai Tua	6 years
36	Indian	Male	Employed	Selayang	3 years
33	Indian	Male	Employed	Selayang	3 years
38	Chinese	Female	Unemployed	Sungai Tua	6 years
36	Chinese	Male	Employed	Selayang	4 years
67	Indian	Male	Unemployed	Selayang	4 years
45	Chinese	Male	Employed	Batu Caves	5 years
38	Chinese	Female	Unemployed	Sungai Tua	2 years

The demographic data of the research participants are summarized in the above table. There are five Indian males sampled, with their age ranging from 33-68 years. Their occupational statuses also vary with one out of work, while the rest are employed. In terms of geographical residence, there are three residing at Selayang, one at Batu Caves, and one residing at Sungai Tua. It also indicates the time dependencies of treatment from dialysis, with a range of 2 to 6 years. As such,

this demographic data presents a whole background against which the experiences and perceptions of the interviewees can be understood. The interviews unveiled various significant discoveries. Initially, the participants frequently mentioned symptoms such as edema in the legs, high blood pressure, and diabetes as crucial signs that resulted in their diagnosis of chronic kidney disease (CKD), emphasizing the significance of promptly identifying and dealing with these symptoms. Furthermore, participants highlighted the importance of controlling fluid and sugar intake as a critical aspect of managing CKD, indicating that dietary adjustments have a vital role in this regard. This emphasizes the significance of tailored nutritional advice and assistance for individuals with chronic kidney disease (CKD). Moreover, the process of undergoing dialysis was characterized as physically strenuous and disruptive to everyday activities, highlighting the significant burden that dialysis places on patients and the necessity for comprehensive assistance. Ultimately, the participants indicated a desire for actionable recommendations and direction from their peers, emphasizing the importance of peer support networks in supplementing official healthcare education. In summary, the results indicate that healthcare technology solutions and interventions should be created with a specific emphasis on the viewpoints and requirements of patients. By incorporating patient perspectives and giving priority to user-friendly and tailored solutions, healthcare practitioners and technology developers can optimize results in managing chronic kidney disease (CKD) and enhance the overall quality of life for CKD patients.

The thematic analysis of the semi-structured interviews with CKD patients and staff members revealed several key themes essential for the design and functionality of the My-Kidney application. The thematic analysis method was chosen for its ability to identify and interpret patterns within qualitative data, providing a nuanced understanding of participants' experiences and needs. By examining the themes that emerged from the interviews, this study seeks to align the My-Kidney application with the real-world requirements of CKD patients and healthcare providers. The findings from this analysis are crucial for developing a user-centric application that enhances patient engagement, self-management, and overall health outcomes. These themes, identified through rigorous analysis, highlight the critical areas necessary for improving CKD management through mobile health applications. Table 6 presents the identified themes from the pilot study.

Table 6: Thematic Analysis Findings

Theme	Identified Need	Existing Literature
Symptom Monitoring	Monitoring symptoms like edema, high blood pressure, and blood sugar levels	Consistent with Schrauben et al. (2021)
Dietary Guidance	Adjusting diet, controlling fluid and sugar intake	Supported by Lee et al. (2018) and Markossian et al. (2021)
Educational Resources	Comprehensive materials on CKD management	Corroborated by Chen et al. (2019) and Lightfoot et al. (2022)
Medication Tracking	Adherence to complex medication regimens	Highlighted by Siddique et al. (2019) and W. Y. Li et al. (2020)
Peer Support Networks	Support from peers for education and recommendations	Noted as beneficial by Schrauben et al. (2021)
User-Friendly Interface	Usability and ease of navigation for sustained u	Emphasized by Lo et al. (2017) and Kovesdy (2022)

The My-Kidney healthcare app integrates several critical themes to provide a comprehensive platform for CKD management. Accurate and user-friendly symptom monitoring tools are essential for early detection and management of CKD complications. The challenge lies in ensuring that patients consistently use these features, which require intuitive designs and continuous patient education. Advances in wearable technology and IoT offer promising solutions for real-time tracking of symptoms like edema, blood pressure, and blood sugar levels. However, integrating these technologies into a mobile application must balance affordability and accessibility (Kovesdy, 2022). Additionally, maintaining patient engagement through motivational features like reminders and progress tracking is crucial for the success of symptom monitoring tools. Providing personalized dietary recommendations is another critical theme that presents several challenges. Accurate patient data is necessary to tailor dietary guidelines, which must be continuously updated to reflect current best practices. Additionally, cultural and individual dietary preferences must be considered to ensure adherence. Technological integration of meal logging and instant feedback features can enhance dietary management, but ensuring the accuracy of logged data and providing meaningful insights remains challenging. Educating patients about the significance of dietary management and effective use of these features is crucial for their success (W. Y. Li et al., 2020).

Developing and maintaining up-to-date educational content requires collaboration with healthcare professionals and regular updates. Ensuring that the information is engaging and accessible is also a challenge. Interactive educational tools, like videos, quizzes, and infographics, can significantly enhance patient learning. However, creating high-quality content demands substantial resources. Encouraging patients to utilize these resources requires integrating them with other app features, such as symptom monitoring and dietary guidance, to make learning a seamless part of their daily self-management routine. Medication tracking is vital for ensuring adherence to complex medication regimens. Technological solutions, such as medication reminders, pill identification tools, and interaction warnings, can enhance medication management. However, integrating these features without overwhelming users with notifications requires careful design. Educating patients on the importance of medication adherence and providing clear, easy-to-use interfaces are essential for ensuring compliance. Effective medication tracking can also be supported by educational resources that explain the importance of each medication and its role in managing CKD (Che Johan et al., 2023).

Facilitating meaningful interactions within peer support networks presents challenges, including ensuring the quality and reliability of shared information and addressing privacy concerns. Technological features like forums, chat groups, and peer mentoring programs can foster a supportive community. However, maintaining active participation and a positive environment requires ongoing management. Encouraging patients to engage with peer support networks involves highlighting their benefits and integrating these features seamlessly within the app to make them easily accessible. Peer support can also enhance the effectiveness of educational resources and dietary guidance by providing practical advice and emotional support (Subbiah et al., 2024).

The My-Kidney healthcare app integrates these critical themes to create a comprehensive and effective platform for CKD management. Addressing the

challenges associated with each theme—such as intuitive design, continuous education, accurate data integration, and active patient engagement—will enhance the app's functionality and user experience. By leveraging advances in technology and fostering a supportive community, the My-Kidney app aims to transform CKD management and improve patient outcomes.

6. MY-KIDNEY APPLICATION DEVELOPMENT

Current mobile applications mostly concentrate on monitoring diabetes and blood pressure, but there is a significant deficiency in addressing the specific requirements of those with chronic kidney disease (CKD). Understanding the significance of customized solutions for this specific group, "My-Kidney" seeks to transform healthcare management by placing water intake monitoring as a key focus. Unlike general health applications, "My-Kidney" is specifically tailored to meet the distinct needs of individuals with Chronic Kidney Disease (CKD), providing a comprehensive platform to enhance health results.

The objectives of the project are:

1. To understand how CKD patients plan their health management, including their current strategies, challenges faced, and areas for improvement.
2. To identify and promote health information and self-monitoring practices related to water intake among CKD patients, empowering them to make informed decisions about their hydration levels.
3. To develop a mobile healthcare application, "My-Kidney," tailored to the needs of CKD patients, providing user-friendly tools for tracking water intake, accessing educational resources, and facilitating communication with healthcare providers.

The following images of Fig. 4 illustrates the MyKidney M-Healthcase Application Designs.

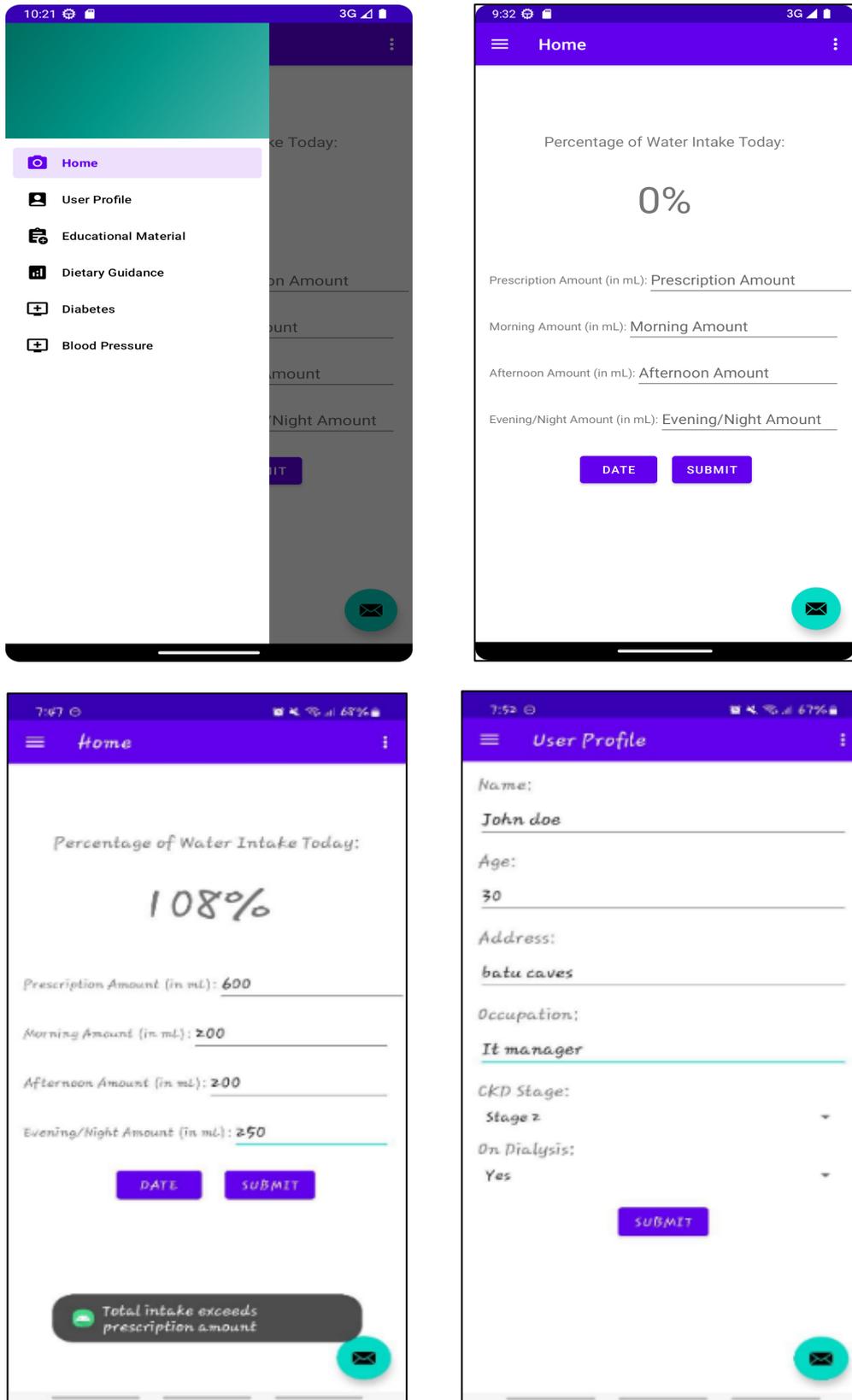


Fig. 4. My-Kidney Application Interface Design

7. CONCLUSION

The My-Kidney healthcare app is an essential tool for treating chronic renal failure. It combines knowledge of CKD pathology, patient needs, and technological improvements to bridge the gap between traditional and modern healthcare solutions. The application's user-centric design and iterative development approach create a solid platform for self-management, teaching, and monitoring. It has functions such as fluid intake tracking, blood pressure monitoring, diabetes management, and instructional materials. The seamless connection between users and administrators ensures that the information is relevant, accurate, and adaptable. The My-Kidney system design is a comprehensive approach to CKD management that aims to transform healthcare delivery and enhance patient outcomes. The My-Kidney healthcare app integrates these critical elements to create a comprehensive and effective platform for CKD management. Addressing the challenges associated with each element—such as intuitive design, continuous education, accurate data integration, and active patient engagement—will enhance the app's functionality and user experience. By leveraging advances in technology and fostering a supportive community, the My-Kidney app aims to transform CKD management and improve patient outcomes. The app's holistic approach ensures that all aspects of CKD management are covered, from monitoring and education to dietary management and emotional support.

Looking forward, the insights gained from the development and implementation of the My-Kidney app will be invaluable for future projects. The emphasis on user-centric design, continuous education, and technological integration provides a blueprint for developing similar applications for other chronic diseases. Future projects can benefit from the lessons learned in balancing technological sophistication with user accessibility and engagement. By continuously refining these strategies based on user feedback and technological advancements, we can create even more effective healthcare solutions that address the specific needs of different patient populations, ultimately improving health outcomes and quality of life on a broader scale.

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