Optimizing Fluid Intake Management in Adult Hemodialysis Patients: The Impact of the H2Overload Mobile Health App on Interdialytic Weight Gain

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ABSTRACT

Fluid intake management is crucial for adult patients undergoing hemodialysis (HD) to prevent adverse health outcomes, including excessive interdialytic weight gain (IDWG). This study evaluated the impact of the H2Overload mobile health app on fluid intake management and IDWG among adult HD patients. Utilizing a pre-post mixed-method single-group design, 18 participants were recruited from Ocean Renal Associates in Toms River, New Jersey. The study assessed changes in adherence to fluid restrictions, perceptions of fluid management importance, and IDWG before and after a four-week intervention using the app. Quantitative results showed significant improvements in adherence ($p < .001$), perception of importance ($p = .004$), and understanding of fluid restrictions ($p = .005$). However, the intervention did not yield a statistically significant reduction in IDWG ($p = .517$). Qualitative feedback identified the app's user-friendly interface and helpful features but also highlighted challenges, such as the inability to track fluid-rich foods and editing entries. These findings suggest that while the H2Overload app enhances patient knowledge and attitudes toward fluid management, additional strategies are needed to translate these improvements into better clinical outcomes. Further research is warranted to explore the app's long-term efficacy and to enhance its functionality for better fluid intake tracking in adult HD patients. This study contributes to understanding the role of mobile health interventions in chronic disease management, emphasizing the need for tailored solutions to support fluid management in this vulnerable population.

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Chapter 1: Introduction

Fluid intake management is crucial for end-stage renal disease (ESRD) patients to maintain health and prevent complications. Adhering to prescribed fluid restrictions and dietary intake is a fundamental aspect of care for ESRD patients on maintenance HD. However, adhering to fluid management guidelines can be challenging for ESRD patients due to factors like thirst, lack of healthcare support, and lifestyle changes (Canaud et al., 2019; Yang et al., 2020). Psychological barriers, particularly a lack of motivation, are common reasons for non-adherence to fluid restrictions (Smith et al., 2010), leading to high interdialytic weight gain (IDWG) (Bossola et al., 2018). IDWG is a marker of survival in hemodialysis (HD) patients, and exceeding 4.0-4.5% of dry weight is associated with adverse outcomes (Bossola et al., 2022; Jalalzadeh et al., 2021; National Kidney Foundation, 2006).

Non-adherence to prescribed diets and fluid restrictions among adult HD patients can result in electrolyte imbalances, fluid overload, decreased quality of life, frequent hospitalizations, increased healthcare costs, and higher mortality rates (Vijay & Kang, 2022). Gallagher et al. (2022) noted higher hospital readmission rates among HD patients, with the inability to reach target weight predicting readmission. Notably, readmission rates for dialysis patients are significantly higher compared to those without CKD (USRDS, 2021), leading to substantial healthcare costs.

In contrast to other patient populations, Gallagher et al. (2022) highlighted in their study that HD patients usually encounter higher rates of hospital readmissions within 30 days. They also noted that the inability to attain the target weight is considered one of the predictors of hospital readmission. Based on the U.S. Renal Data System's 2020 annual data report, the 30-day readmission rates were 16.6% for Medicare beneficiaries aged 66 years and older without

CKD, 23.2% for those with CKD, and notably higher at 31.1% for patients receiving dialysis (USRDS, 2021). The high readmission rate in HD patients not only impacts their quality of life but also has a significant impact on the healthcare costs associated with their care. Fluid overload-related hospitalizations in a U.S. dialysis population cost approximately $266 million over two years, with an average cost estimate of $6,372 per episode (Kooman et al., 2023). Therefore, adequate fluid management becomes even more crucial in reducing the risk of readmission for dialysis patients and reducing health care costs.

Mobile health apps, particularly renal diet-related apps, promise to improve fluid intake management for HD patients (Lambert et al., 2017). Studies suggest that mHealth apps and face-to-face training can enhance dietary and fluid intake adherence, with mobile apps showing greater efficacy (Torabikhah et al., 2023). While some studies indicated the limited impact of specific apps on fluid intake monitoring (Rocco et al., 2023), the overall potential of mobile apps in promoting adherence and improving patient outcomes is widely recognized (Fakih El Khoury et al., 2020; Welch et al., 2013). Recognizing the potential benefits of mobile health apps, particularly the H2Overload app, should inspire optimism about the future of patient care in adult HD patients.

Limiting IDWG in HD patients presents a formidable challenge. Bossola et al. (2018) concluded that while behavioral interventions have shown promise in temporarily enhancing adherence to fluid restriction, the lack of innovative treatments underscores the necessity for further research and development. Encouraging patients to utilize technology to track their daily fluid intake could improve adherence. However, the rapid growth of mobile health applications has created a significant hurdle in identifying the most suitable app for users. In a comprehensive systematic review by Siddique et al. (2019), 12 apps tailored for managing chronic kidney

disease (CKD) and end-stage renal disease (ESRD) patients were assessed. The review highlighted the H2Overload app for its superior functionality and user engagement. It features appointment and medication tracking, a notepad for communicating with physicians, and the ability to send progress updates to healthcare providers, including graphical representations of key parameters like blood pressure, weight, and fluid intake.

Utilizing mobile health apps such as the H2Overload app can foster hope by aiding patients in adhering to specific nutritional guidelines, particularly restricting IDWG. The National Kidney Foundation (NKF) in the U.S. designed the H2Overload app to support CKD patients in managing their fluid intake. The app empowers patients by fostering heightened awareness and accountability in fluid intake management, instilling optimism for improved patient outcomes. It does this by providing tools for tracking fluid intake, scheduling appointments, and communicating with healthcare providers, potentially reducing hospital readmissions and healthcare costs.

Moreover, Bossola et al. (2022) emphasized that patient-level interventions involving educational, cognitive, counseling, behavioral, or psychological strategies can be arduous due to their cost, time demands, and patient cooperation. These interventions entail multiple sessions and complex educational content to enhance patient knowledge about renal disease, fluid intake management, and behavioral modifications. Although mobile health apps offer a convenient method for tracking fluid intake, their significant impact on fluid management and reducing IDWG remains uncertain. Bossola et al. (2022) underscored the urgent and critical need for further research to enhance the efficacy of these interventions in addressing IDWG, highlighting the importance and urgency of this topic

Statement of the Problem

Adherence to fluid intake management among ESRD patients, mainly those undergoing HD, is a critical challenge that can lead to adverse health outcomes, increased hospital readmissions, higher healthcare costs, and reduced quality of life. Despite the potential benefits of utilizing mobile health apps to enhance fluid management, H2Overload app in particular, the effectiveness and impact of such technologies in improving adherence to dietary and fluid intake recommendations remain variable and require further research. The lack of experimental and innovative treatments in this area underscores the need to identify and implement optimal strategies to support ESRD patients in achieving better fluid management outcomes.

Theoretical Framework

This DNP project aligns with individual and family self-management theory (IFSMT) principles, as self-management is central to achieving better fluid management outcomes in HD patients. Self-management interventions such as mobile applications for patients with ESRD on HD can initiate and maintain improvements in clinical markers, self-management skills, self-efficacy, and self-reported adherence (Grieve et al., 2018; Park et al., 2019). IDWG is the specific clinical marker being measured in this study.

The IFSMT, a comprehensive approach to chronic illness, emphasizes the importance of self-management as a multidimensional phenomenon. This includes context, process, and proximal and distal outcomes dimensions (Bauer et al., 2023). In this research, we leveraged the power of mobile health apps, a key component of the IFSMT, to provide a convenient and accessible platform for individuals to monitor and track their health-related behaviors, outcomes, and progress towards self-management goals. The real-time feedback, reminders, and educational resources that mobile apps offer can significantly enhance individuals' self-efficacy,

improve adherence to treatment plans, and ultimately lead to better health outcomes. The use of a mobile health app is a crucial tool in supporting participants to effectively self-manage their fluid intake, thereby reducing their IDWG. This aligns with the core tenets of IFSMT. The convenience and accessibility of these apps can reassure individuals that they can manage their health at their own pace and in their own space.

Purpose

Mobile health apps can potentially improve fluid intake management to reduce IDWG for HD patients. Studies needed to be undertaken to fully understand the significance of mobile health apps in HD patients and address the challenges of adherence to fluid restrictions in this population. This study aimed to evaluate the impact of a mobile health app, H2Overload, on fluid intake management and IDWG among adult HD patients.

Research Questions

The following were the questions that guided the project:

1. How did the H2Overload mobile health app impact IDWG and fluid intake management in adult HD patients?
2. What were the perceptions and experiences of adult HD patients regarding the ease of use and effectiveness of the mobile app in controlling IDWG and fluid intake?

Concepts and Operational Definitions

To ensure clarity in this study, the following numbered entries provide the concepts and operational definitions related to fluid intake management, IDWG, mobile health apps, adherence to fluid intake, and the effectiveness of mobile apps.

1. Fluid intake management involves tracking and managing fluid intake to maintain a healthy balance and prevent dehydration or overhydration (Castera & Borhade, 2023).
2. IDWG refers to the increase in weight experienced by HD patients between dialysis sessions. Specifically, it denotes the disparity between the weight recorded post-dialysis and the weight measured before the next HD session. IDWG is high if it is more than 4.0 to 4.5% of dry weight, which is the patient's weight when not retaining excess fluid (NKF, 2006).
3. A mobile health app is a software program installed on mobile devices that collects and processes health-related data, serving to preserve, enhance, or manage the well-being of its users (Maaß et al., 2022).
4. Adherence to fluid intake entails the degree to which individuals comply with medical advice, particularly regarding prescribed restrictions on fluid intake, within the context of HD treatment.
5. A mobile app's effectiveness can be evaluated by assessing its ability to augment patient adherence to recommended fluid intake restrictions. This assessment can include comparisons between actual fluid and prescribed intake, patient-reported outcomes, and clinical indicators such as IDWG.

DNP Project Essentials

This project is significant within the Doctor of Nursing Practice program. It aligns with various key essentials that provide a framework for advanced-practice nurses to tackle complex healthcare challenges, such as effectively managing fluid intake and IDWG in HD patients using innovative approaches like mobile health apps.

Firstly, this project contributes to the "Scientific Underpinnings for Practice" essential (AACN, 2021). By investigating how a mobile app can assist with fluid intake management in HD care, this research adds to the scientific knowledge required for implementing mHealth interventions for HD patients. This knowledge is crucial for making informed decisions and providing evidence-based care (AACN, 2021).

Moreover, the project's alignment with the "Organizational and Systems Leadership for Quality Improvement" essential (AACN, 2021) underscores its potential to impact the entire healthcare system significantly. By enhancing fluid intake management among HD patients, the project can lead to improved patient outcomes and more efficient resource utilization. This underscores the potential for a positive change within the healthcare system with organized efforts and strong leadership to implement this project.

The “Interprofessional Collaboration for Improving Patient and Population Health Outcomes” essential (AACN, 2021) also aligns with this project. Interprofessional collaboration is vital for addressing HD patients' complex healthcare needs. In the mobile health app context, this necessitates collaborating with other healthcare professionals, such as nephrologists and dietitians, to ensure a comprehensive approach to fluid management in HD patients, highlighting its necessity and effectiveness.

This project also addresses “Advanced Nursing Practice” essential (AACN, 2021). It emphasizes using advanced nursing knowledge and skills to promote high-quality patient care. In the mobile health app context, advanced nursing practice utilizes technology to enhance patient education, monitor fluid intake, and promote adherence to treatment regimens.

The “Clinical Prevention and Population Health for Improving the Nation's Health” highlights nurses' roles in promoting health and preventing disease at the individual and

population levels (AACN, 2021). In the mobile health app context, nurses can utilize it to educate patients about the significance of fluid management and its impact on overall health and well-being.

This research also addresses the "Clinical Scholarship and Analytical Methods for Evidence-Based Practice" essential (AACN, 2021). Through surveys and data analysis, the project adheres to rigorous methods to generate reliable evidence. It involves critically appraising and utilizing research findings to enhance patient outcomes. The commitment to evidence-based practice and clinical scholarship strengthens the study's findings and recommendations (AACN, 2021).

Lastly, the project aligns with the "Information Systems and Health Care Technology" essential (AACN, 2021). Using a mobile app highlights the significance of embracing innovative technology to enhance patient care and improve health outcomes. Moreover, exploring the potential benefits of app-based interventions contributes to the ongoing transformation of healthcare practices (AACN, 2021).

Chapter 2: Literature Review

The following literature review consists of sections relevant to examining the impact of a mobile app on improving fluid intake management and reducing IDWG among adult HD patients. The chapter begins with a description of the theoretical framework. Secondly, an overview of ESRD and HD is provided. The third section covers an overview of fluid intake management, followed by the fourth section on IDWG. The fifth section discusses mobile health apps, while the sixth section explores the impact of mobile health apps. Then, finally, the seventh section focuses on the H2Overload app.

Theoretical Framework

The DNP project was guided by the individual and family self-management theory (IFSMT) that Ryan and Sawin (2009) developed. The theory suggests self-management is a multifaceted phenomenon with three dimensions: context, process, and outcomes. The context dimension includes risk and protective factors, including condition-specific factors, physical and social environments, and individual and family characteristics. The process dimension of self-management includes the components of knowledge and beliefs, self-regulation skills and abilities, and social facilitation. For instance, self-regulation skills and abilities refer to patients' ability to monitor and adjust their fluid intake based on their condition. The process dimension includes factors such as self-efficacy, decision-making, and collaboration.

Proximal outcomes include self-management behaviors and specific actions to manage the condition or improve and maintain a healthy state. Distal outcomes are health status, quality of life, and the cost of health. They emphasize that factors within the context dimension impact individual and family engagement in self-management and influence outcomes directly when

improved. The theory is applicable across all developmental stages and can be used to manage chronic conditions and promote health (Ryan & Sawin, 2009).

The IFSMT has been widely applied as a guiding framework in quantitative and qualitative research, especially in chronic conditions across different age groups and caregiver roles, highlighting its versatility (Bauer et al., 2023). For instance, a study conducted by Sorat (2019) conducted a cross-sectional analysis on 622 Thai adults with CKD stages I-III in four hospitals in southern Thailand. The research utilized IFSMT to investigate the factors influencing the quality of life in Thai adults with early-stage CKD. The study tested a comprehensive model that considered individual and family factors, knowledge, depression, and self-efficacy about self-management behavior and quality of life. The findings revealed that self-management knowledge, self-efficacy, and behavior significantly impacted quality of life, supporting the core principles of the IFSMT.

Park and Kim (2022) utilized the IFSMT theory to examine the effectiveness of a self-management intervention focusing on health literacy for patients and family caregivers undergoing HD. Through a quasi-experimental design, 20 individuals in the intervention group were compared to 23 in the control group who received standard informational text messages. The results showed improvements in HD knowledge, self-efficacy, family support, self-management skills, and IDWG ratio following the eight-week intervention.

Maneesri et al. (2023) conducted a randomized controlled trial involving individuals diagnosed with stage III CKD and their family members. Participants were randomly assigned to the experimental or control group and received the Individual and Family Self-Management Combined mHealth Program for People with CKD. The results indicated that the program effectively improved self-management behaviors. By incorporating the IFSMT, the researchers

provided a structured framework for understanding and enhancing self-management behaviors among individuals and families affected by CKD. This approach focused on promoting knowledge, improving self-regulation skills, and fostering social support, ultimately leading to favorable outcomes for participants with stage III CKD.

This DNP project aligns with the theory's three dimensions: Within the contextual dimension, the research will focus on patients with complex conditions, such as HD patients struggling with fluid intake management. Inclusion criteria will be applied to identify suitable participants for the project, ensuring that individuals can utilize a mobile health app and voluntarily report difficulties in managing their fluid intake effectively. In the process dimension, using the mobile health app will empower participants to establish achievable goals, self-monitor their progress, and reflect on their adherence to guidelines between dialysis sessions.

In this study, healthcare professionals like dieticians, nurses, and nephrologists support this process, as the mobile health app enables participants to communicate with their doctors via email if they exceed their weight goals. Regarding the outcome dimension, proximal outcomes will involve enhanced self-management skills demonstrated by improved fluid intake management and reduced IDWG, leading to fewer adverse symptoms and subsequent healthcare expenses. Distal outcomes will manifest as an enhanced quality of life.

This project aims to empower patients and improve their health outcomes. By using the app and engaging in self-management behaviors, patients can make well-informed decisions about their fluid intake, resulting in improved health outcomes and an enhanced quality of life. Guided by the IFSMT, the present project addresses the implementation of a mobile health app and supports fostering self-management behaviors among HD patients.

ESRD and HD

According to the U.S. Renal Data System's 2020 annual data report, nearly 808,000 people in the U.S. were living with ESRD, with 69% on dialysis (NIDDK, 2023). ESRD has a GFR of less than 15 mL/min (KDIGO, 2024). One of the ESRD treatments involves correcting volume overload or pulmonary edema. For uremic manifestations, long-term renal replacement therapy (e.g., HD, peritoneal dialysis, and kidney transplantation) is needed (Hashmi et al., 2024). Many individuals with ESRD require dialysis as a form of treatment. The worsening of CKD continues to pose a significant challenge, leading to a decline in quality of life and increased risk of premature death. In patients receiving HD, adjusted mortality increased by nearly 17% from 2019 to 2020. Medicare-related spending for beneficiaries with ESKD totaled $50.8 billion in 2020, with the ESRD population accounting for 6.1% of total Medicare expenditures (USRDS, 2022).

Fluid Intake Management

Adhering to prescribed fluid restrictions and dietary intake is a fundamental aspect of care for ESRD patients on maintenance HD. It involves tracking and managing fluid intake to maintain a healthy balance and prevent dehydration or overhydration (Castera & Borhade, 2023). During the 2013 symposium of dialysis providers, it was emphasized that efforts should be concentrated on managing fluid intake effectively, as the high prevalence of fluid overload has been identified as a significant factor contributing to higher mortality rates (Weiner et al., 2014). Fluid overload significantly contributes to all-cause and cardiovascular mortality in the hemodialysis (HD) population, resulting in conditions like hypertension, left ventricular hypertrophy, dysfunction, and pulmonary circulation overload, ultimately impacting the prognosis of end-stage renal disease (Loutradis et al., 2021). It is crucial to involve the entire dialysis team, patients, and families in volume control strategies, emphasizing the monitoring of

extracellular fluid volume, managing target weight, integrating innovative technologies to enhance patient care, and supporting research and effective implementation strategies (Weiner et al., 2014).

Chronic exposure to fluid overload is associated with excessive use of antihypertensive medications (Morais et al., 2020). Hence, effective fluid intake management could prevent fluid overload, enhance blood pressure regulation, and reduce the need for multiple antihypertensive drugs. The risk of death linked to chronic fluid overload is comparable to that of coronary artery disease or congestive heart failure (Zoccali et al., 2017).

Al Maimani et al. (2021) highlighted the strong association between the frequency of hospital admissions due to fluid volume overload and the necessity for additional dialysis sessions with IDWG surpassing 4% of dry weight in HD patients. The study also emphasized that patients with elevated IDWG are more prone to experiencing intradialytic hypotension episodes, indicating the importance of effectively managing IDWG in this population. Furthermore, the research concluded that uncontrolled IDWG can contribute to cardiovascular complications and increased mortality risks, underscoring the significance of addressing this factor in the care of HD patients. They recommended that healthcare providers prioritize providing dietary guidance, adjusting dry weights, and tailoring dialysis prescriptions to prevent excessive IDWG and its associated complications while ensuring the patients receive adequate nutrition. Therefore, maintaining a balance between fluid management and nutritional status is vital for delivering optimal care to HD individuals.

The meta-synthesis findings of Özkan and Taylan (2022) are of significant importance as they underscored the complex and challenging nature of diet and fluid restriction for patients. This understanding is crucial as it forms the basis for the study on the H2Overload mobile app.

The app is a practical example of how technology can support patients in adhering to their treatment regimens, thereby improving health outcomes for HD patients. IDWG refers to the weight gained by an HD patient between two dialysis sessions. It is a crucial indicator of fluid management in these patients.

IDWG is an essential fluid marker and an intuitive tool for managing volume in HD patients. A study by Hecking et al. (2018) involving 38,614 new HD patients explored the correlation between fluid overload pre- and post-dialysis and IDWG with patient outcomes. High fluid overload both before and after dialysis was identified as a mortality risk factor, while low IDWG was linked to short-term mortality, potentially indicating nutritional issues.

IDWG is a marker of survival in HD patients, and exceeding 4.0-4.5% of dry weight is associated with adverse outcomes (Bossola et al., 2022; Jalalzadeh et al., 2021; NKF, 2006). Non-adherence to prescribed diets and fluid restrictions among adult HD patients can result in electrolyte imbalances, fluid overload, decreased quality of life, frequent hospitalizations, increased healthcare costs, and higher mortality rates (Vijay & Kang, 2022). Meticulous management of IDWG within a 3% to 5% range of body weight is vital for supporting optimal mortality and nutrition outcomes (Kahraman et al., 2015). Factors such as self-care levels and treatment adherence can significantly impact IDWG, which varies among patients. Relying on weight gain as a percentage of body weight rather than an absolute value aligns more closely with individual body measurements. For instance, a three-kilogram weight gain may be excessive for a 50-kilogram patient (6%) but typical for a 70-kilogram patient (4.3%). Controlled IDWG enhances the quality of life for HD patients with end-stage renal failure, while uncontrolled weight gain poses mortality risks (Wijayanti et al., 2021).

Striking a balance in dietary management and taking a personalized approach are crucial to preventing unintended protein and calorie intake reductions and promoting overall well-being (Kalantar-Zadeh et al., 2015). As key dialysis team members, dietitians are encouraged to shift focus from phosphorus intake to interdialytic sodium and water intake as indicated by IDWG. A weight gain exceeding three kilograms or 3.5% of body weight should prompt the dialysis dietitian and the entire dialysis team. Therefore, maintaining meticulous control of IDWG within the recommended range is not just important but crucial as it supports optimal mortality and nutrition outcomes.

Mobile Health App

Mobile health applications, a key component of the mHealth ecosystem, are designed to provide health-related services and information on mobile devices such as mobile phones, monitoring devices, personal digital assistants, and other wireless devices (Fortuna et al., 2023; Istepanian, 2022). These software programs, installed on mobile devices, collect and process health-related data, preserving, enhancing, or managing their users' well-being (Maaß et al., 2022). By leveraging mobile technologies like smartphones and tablets, these apps can facilitate data collection and encourage health care consumers to adopt healthy lifestyles or self-manage chronic conditions, thereby improving patient outcomes and the overall quality of care (Free et al., 2013).

Krebs and Duncan (2015) conducted a cross-sectional survey of 1604 mobile phone users in the U.S. They discovered that slightly more than half of the users had downloaded health apps, mainly focusing on fitness and nutrition. Cost was identified as a common reason for not downloading apps. The study found that despite users being reluctant to pay for apps, they found them accurate and secure.

While the initial cost of developing healthcare apps can be significant, their potential cost-effectiveness, particularly when compared to traditional healthcare services, can reassure providers and patients about their financial implications. For instance, the H2Overload app, which is sponsored by reputable organizations like the NKF in the U.S., is offered for free, enhancing its credibility and legitimacy. This reassurance about the financial implications of mHealth apps can help in their wider adoption and use.

Due to their popularity, mobility, and technological capabilities, mobile devices are ideal for providing personalized support to health care consumers. The adoption of mHealth apps not only empowers patients to manage their health actively but also holds the potential to improve patient outcomes significantly. This empowerment is a significant benefit of mobile health apps, as it allows patients to take control of their health through digital care pathways, benefiting healthcare systems by expanding access to services, creating cost-effective treatment options, supporting behavior change, and improving communication with healthcare providers to enhance the overall quality of care provided.

Impact of Mobile Health App

While mobile health apps offer promising solutions, they also come with challenges and limitations. A pilot study by Welch et al. (2013) examined the acceptability and feasibility of using a mobile dietary intake monitoring application (DIMA) with adult ESRD patients based on social cognitive theory. The study involved adult participants randomly assigned to either an intervention group using the DIMA or a control group using the daily activity monitor application, with randomization stratified by dialysis unit. Data were collected at baseline, at the end of a six-week self-monitoring period, and eight weeks post-self-monitoring, where IDWG was assessed, and self-efficacy, perceived benefits, and perceived control were assessed. The

results showed that while using DIMA was feasible and acceptable among adult ESRD patients, it did not significantly impact some dietary and fluid intake aspects. The researchers acknowledged the challenges of adherence to fluid restriction in this population because some participants have difficulty adhering to the recommended dietary and fluid plans. However, the study underscored the need for further investigation, as its findings were based solely on a limited number of patients and might not fully capture how mobile apps impact fluid intake management and dialytic weight gain.

In another pilot study, Rocco et al. (2023) developed mobile phone software that allowed dialysis patients to self-monitor their fluid consumption at home. The objective was to assess the app's safety in HD patients receiving maintenance treatment. The study involved patients receiving maintenance HD in North Carolina, aged 18 and older, with specific criteria. They used a fluid intake monitoring app, FiApp, on their smartphones over four weeks. App training was provided, and participants recorded daily fluid intake data. Study visits at weeks one and four assessed app usage and participant feedback. The primary outcome was the relationship between fluid intake and weight gain, with secondary outcomes focusing on app safety and usage evaluation. The study used descriptive statistics and mixed models for analysis. App safety was assessed by comparing weight changes during the study period. The study concluded that the app effectively decreases most patients' IDWG.

However, the study's limitations were observed, including recruiting patients with a relatively lower IDWG percentage, which may not fully represent the dialysis patient population. Furthermore, the safety assessment was based on patients with an IDWG of less than 4%, restricting the generalizability of the findings to patients with higher IDWG. Despite these limitations, the study supported the app's effectiveness. It provided valuable insights for

improvement, such as using larger fonts and bolder colors, including additional tips to limit fluid intake and implement a zoom feature.

Torabikhah et al. (2023) compared the effectiveness of a mobile health (mHealth) app and face-to-face training in promoting adherence to dietary and fluid intake among HD patients. The study in Iran in 2021-22 used a single-blind, two-stage/two-group randomized clinical trial to compare the effects of an mHealth app called the Di Care app on dietary and fluid intake adherence in 70 HD patients. The patients were divided into two groups: one receiving educational materials via the Di Care app and the other through face-to-face training. The study used the end-stage renal disease adherence questionnaire (ESRD-AQ) to assess adherence levels.

After a one-month intervention, the results indicated that both interventions led to improvements in adherence, with the mHealth app group showing more significant reductions in specific laboratory parameters, such as better serum potassium control, reduced IDWG, and enhanced compliance with dietary restrictions, compared to the face-to-face training group. The study signifies the potential of mHealth applications as a convenient and accessible tool for HD patients to manage dietary and fluid intake, suggesting broader possibilities for improving self-care behaviors in this patient population.

Fakih El Khoury et al. (2020) investigated using the dietary smartphone app KELA.AE is responsible for self-monitoring and educating HD patients in Dubai. The app offers educational materials and self-monitoring features for kidney patients. Twenty-six participants utilized the app for two weeks, meeting with a dietitian weekly. Data on dietary intakes and serum parameters (e.g., phosphorus, potassium, and iron) were collected pre- and post-app usage. Results indicated the KELA.AE app improved short-term energy and protein intake in HD patients, while mineral intakes remained consistent and serum parameters showed no significant

changes. Suggestions for future improvements, such as enhanced analytics and dietary education, were provided. Though fluid intake management was not directly studied, the app could impact fluid management by aiding dietary guideline adherence and appropriate food choices. The study highlights how interventions like dietary apps could help enhance fluid management and nutrition for dialysis patients.

The study by West et al. (2017) used a cross-sectional survey to assess the use of diet and nutrition apps among 217 participants. The participants were asked questions based on three health behavior theories, and their responses indicated positive changes in motivation, self-efficacy, goal setting, and dietary habits. The survey included questions on demographics, use of diet/nutrition apps, engagement and likability of the apps, and changes in dietary behaviors. The findings indicated a connection between behavior change and the engagement, utilization, and education provided through the app. The study concludes that diet and nutrition apps can impact dietary behaviors. It suggests that apps focusing on motivation, desire, self-efficacy, knowledge, and goal setting can effectively promote healthy behaviors.

A review conducted by Yang et al. (2020) provided an overview of existing apps and interventions of mHealth technologies in adult patients undergoing chronic HD. The papers retrieved through the search strategy conducted from January 2008 to October 2018 predominantly originated from the U.S. Among the 22 studies identified, cohort studies were the most common, with 12 prospective and four retrospective studies, followed by randomized controlled trials with four studies. Additionally, one mixed-method study and one case study were included in the findings. Studies have shown that mHealth technologies demonstrated neutral to positive results in patient satisfaction and acceptance, clinical effectiveness, economic assessment, health-related quality of life, and impact on lifestyle or behavioral change. However,

incorporating mHealth technology into the standard care of patients with CKD still faces many challenges. These include the lack of evidence on safety aspects such as reliability, privacy, and data security and organizational considerations like fitting mHealth solutions into existing care settings. The study also highlighted the need to evaluate sociocultural, ethical, and legal implications and a comprehensive economic assessment regarding the cost-effectiveness of mHealth technologies in this population.

Russell et al.'s recent systematic review and qualitative analysis of existing dietary mobile applications for CKD patients (2022) revealed that the ideal mobile app should combine accurate and evidence-based nutritional information specific to CKD patients with a user-friendly design and features that support tracking, monitoring, and personalizing dietary recommendations. Furthermore, they found that adherence to dietary goals through a well-designed CKD dietary app could help prevent or improve complications like volume overload, positively impacting fluid intake management in dialysis patients.

H2Overload App

This project utilized the H2Overload app, a mobile health application developed by the NKF. It is designed for individuals who need to restrict their fluid intake, particularly those with hyponatremia, kidney failure, or heart disease (NKF, n.d.). This tool was used to monitor the daily fluid intake and weight of adult patients with ESRD undergoing HD in this study.

Siddique et al.. (2019) conducted a comprehensive systematic review of mobile apps for medication compliance and nutrition tracking for potential use by CKD and ESRD patients. They utilized the MARS (mobile application rating scale) tool, which demonstrated excellent internal consistency (Cronbach alpha = 0.90) and a moderate level of interrater reliability (2-way mixed ICC 0.65). The apps receiving the highest combined scores were My Kidneys, My Health

Handbook (MARS=4.68); My Food Coach (MARS=4.48); National Kidney Foundation Malaysia (MARS=4.20); and H2Overload, which ranked fourth best (MARS=4.18). H2Overload was selected for this project due to its high ranking, endorsement by the NKF USA, availability, and cost-free nature as an application.

The H2Overload app has advanced features and high user engagement (Siddique et al., 2019). It features tracking appointments and medications, providing a notepad for communication with physicians, and allowing users to share progress updates with healthcare providers, including graphical representations of critical parameters like blood pressure, weight, and fluid intake. While the app offers free access and additional resources such as educational materials, nutrition tips, and an appointment calendar to aid self-management in ESRD patients on HD, its effectiveness in managing fluid intake, particularly in reducing IDWG, remains unproven due to the lack of supporting research. This project sought to address this gap and evaluated the impact of the H2Overload app on fluid intake management in this patient population.

Summary

This literature review highlights the potential impact of mobile health app utilization on fluid intake management in adult HD patients. The examined research studies exemplify encouraging outcomes that suggest mobile health apps have the potential to improve fluid intake management and reduce IDWG. However, additional investigation is imperative to understand mobile health apps' specific impact on fluid intake management within this population. While feasibility and acceptability have been established for employing mobile health apps to self-monitor fluid intake, patient adherence and app enhancement challenges have surfaced.

Nonetheless, integrating mobile health applications can potentially augment patients' quality of life during their HD journey. By using carefully designed mobile applications such as the H2Overload app, which is tailored specifically towards fluid intake management, it becomes possible to enhance the practices related to regulating fluids and positively impact the overall well-being experienced by adult individuals undergoing HD treatment. This study has addressed the knowledge gaps identified in the literature review by evaluating the impact of a mobile health app, H2Overload, on improving fluid intake management and reducing IDWG among adult HD patients.

Chapter 3: Methodology

Chapter 3 describes the research design and methods. This chapter comprises five sections: (a) research design, (b) sample and setting, (c) procedure for data collection, (d) instruments, (e) protection of human subjects, and (e) data analytic methods.

Research Design

This study utilized a pre-post mixed method single group design to investigate the impact of a mobile health app on fluid intake management among adult HD patients. The mixed method approach aimed to provide a comprehensive understanding by assessing health outcomes like IDWG and patients' subjective experiences, perspectives, and behaviors related to fluid intake. Given ethical considerations, randomization was deemed unfeasible for HD patients due to potential risks of restricting fluid intake, which could harm their health and well-being. The research design for this study aligned with Protocol #2024-347, approved on July 10th, 2024, by the research team and the William Paterson University IRB.

Sample & Setting

The study targeted patients with ESRD diagnosed by a nephrologist, with an estimated glomerular filtration rate below 15 mL/min/1.73 m^2, undergoing HD for at least three months, and receiving home HD and in-center HD under the care of Ocean Renal Associates in Toms River, New Jersey. The sample size was determined using G*Power software, with calculations indicating a need for 27 participants.

Participants

The study included adults over 18 years old diagnosed with ESRD and on HD for more than three months. Inclusion criteria required participants to be alert, oriented, English-speaking, report difficulties managing fluid intake during HD, attend at least thrice-weekly outpatient HD

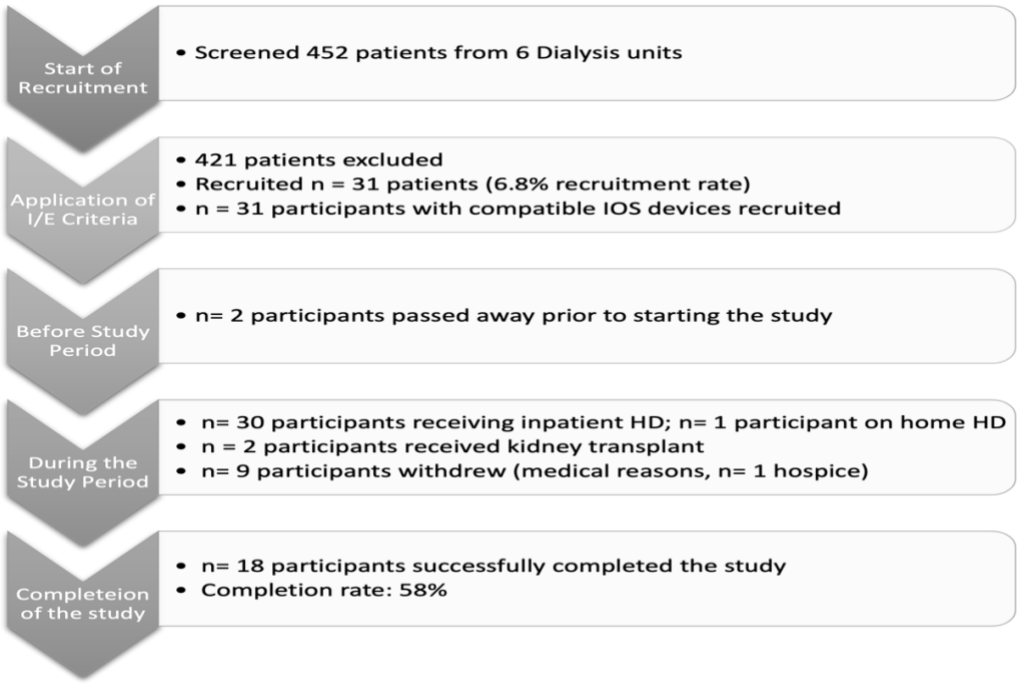
sessions, own an iPhone or iPad for app use (as the app is only compatible with these devices), and commit to the study protocol. Exclusion criteria were established to exclude individuals with cognitive impairments hindering app utilization or study comprehension, those on temporary HD, and those unable to provide informed consent or engage in the study due to language barriers or communication difficulties.

Procedure for Data Collection

In October 2024, 452 patients from six outpatient dialysis units under the care of Ocean Renal Associates in Toms River, New Jersey, were screened based on specified inclusion and exclusion criteria. Out of this initial group, 31 patients met the criteria and were recruited for participation in the study, resulting in a recruitment rate of 6.8%, as shown in Figure 1. All 31 participants had IOS devices compatible with downloading the H2Overload mobile app. During the study, it was noted that two participants received kidney transplants and, therefore, did not complete the study. Additionally, two participants passed away from medical causes prior to the start of the intervention period. Nine participants withdrew from the study before the intervention due to medical reasons, including hospital admissions and undisclosed illnesses, with one transitioning to hospice care. Among the remaining participants, 30 received inpatient HD, and one was on home HD. In the end, 18 participants completed the study, yielding a completion rate of 58%.

Figure 1

Recruitment Process



The list of potential participants provided by Ocean Renal Associates was used to contact potential participants via phone for eligibility screening—those deemed eligible received detailed information about the study. Interested individuals who met the inclusion criteria were invited to participate. Study materials were sent to participants' home addresses, including instructions for using the mobile app, consent forms, an adherence questionnaire, and another questionnaire focused on their subjective experiences with the app. Participants completed these materials at home and returned them by mail using prepaid return stamps.

Advanced nurse practitioners assisted in distributing the study materials to participants who opted to receive them at their outpatient dialysis facility. Data were collected from all recruited participants at the beginning of the study to establish baseline demographic information, including age, gender, race, education, employment, living arrangements, and relevant medical history related to HD (e.g., cause of initiation, duration, and access type).

Before the intervention, participants were given access to the mobile app and received training on tracking and managing their fluid intake. They were educated about the app's features and functionality to ensure consistent usage. A run-in period was provided to familiarize participants with the app before formal data collection began, and troubleshooting contacts were available for technical issues. Pre-intervention data, including IDWG measurements from the electronic health record and the fluid adherence scale, were compared with post-intervention data after the study.

Instruments

Digital weighing scales accurately measured IDWG before and after each dialysis session. To ensure reliability, the weighing scales in every HD unit were calibrated with the same brand, and nurses were the ones who measured each participant's weight before and after HD sessions. The tool used to assess adherence to fluid restriction is the ESRD-AQ. The ESRD-AQ is a 46-item self-report tool designed to assess adherence to treatment regimens among patients with ESRD (Kim et al., 2010). It covers various aspects of adherence behaviors related to HD treatment, medication, fluid restriction, and dietary restriction, with higher scores indicating better adherence. Although participants completed all 46 items of the ESRD-AQ, this study analyzed adherence specifically to fluid restriction scores, as the focus was on adherence to fluid restriction. The analysis of the specific questions concentrated on self-monitoring frequency, the perceived importance of fluid restriction, and the level of understanding regarding the importance of fluid restriction. The ESRD-AQ questionnaire was distributed to participants before and after the intervention period.

The ESRD-AQ demonstrated strong content and face validity, along with robust test-retest reliability based on a previous study conducted by Kim et al. (2010). The questionnaire

showed excellent content validity, confirmed by patients from the target population, with item-level content validities ranging from 0.86 to 1.00. Construct validity was established, indicating the ESRD-AQ's ability to effectively differentiate between adherent and non-adherent patients.

Furthermore, the principal investigator developed a semi-structured interview questionnaire to collect subjective experiences with the mobile app. The questionnaire gathered participants' feedback on managing IDWG and fluid intake using the mobile app. Key questions included describing their experiences with the app and highlighting any challenges encountered during app utilization.

Protection of Human Subjects

This study prioritized the protection of human subjects through various ethical considerations. Before informed consent was obtained, participants were provided with information about the research study, either verbally or through individually provided information sheets. This information outlined research objectives, benefits, potential risks, types of questionnaires, time commitments, and tasks to be completed. In addition to obtaining informed consent from participants, the study implemented measures to safeguard privacy and confidentiality. All information collected from participants was kept confidential and securely stored. Data were coded and anonymized to protect participant identities, with restricted access granted only to the research team, and any identifying information was removed before analysis. Publications resulting from the study will not contain personally identifiable information to uphold participant confidentiality.

Participants had access to support resources during data collection to manage potential risks effectively. The research team prioritized enhancing participant comfort by maintaining open communication, addressing concerns promptly, and creating a safe environment for data

collection activities. Regular monitoring and oversight by the study investigators and the WPU Institutional Review Board (IRB) ensured compliance with ethical guidelines, with any protocol modifications transparently communicated to the IRB and participants. These comprehensive measures aimed to uphold the ethical principles of the study by safeguarding the rights, welfare, and confidentiality of all human subjects involved.

Data Analysis

The data were meticulously coded and analyzed using the latest SPSS version, specifically IBM SPSS 30. To ensure the validity of the study findings, a triangulation approach was employed, integrating both quantitative and qualitative data analysis methods. Descriptive statistics such as mean, median, and standard deviation were used for demographic analysis to provide a comprehensive summary. Paired t-tests were employed to compare means of IDWG within the same group pre- and post-intervention. Additionally, one-way ANOVA was utilized to determine if demographic data such as age, gender, race, or living arrangements could influence the IDWG of HD patients.

Qualitative data were obtained through semi-structured interviews focused on participants' perspectives regarding mobile app usage. The participants' feedback on the app's ease of use and any challenges or barriers they faced were explored. The qualitative data, collected through a semi-structured questionnaire, underwent thematic analysis to complement the quantitative results effectively. Subsequently, data coding categorized segments into themes that captured participants' experiences related to fluid intake management and mobile app usage. The qualitative themes were then integrated with the quantitative findings, providing a comprehensive understanding of the mobile health app's impact on fluid intake management among HD patients.

Chapter 4: Results

This chapter presents the integrated quantitative and qualitative findings on a mobile app intervention's impact on fluid intake management and IDWG in adult HD patients. The chapter begins by outlining the demographic characteristics of the participants, followed by the presentation of quantitative results derived from paired samples t-tests, including the impact of demographic variables such as race and living arrangement on IDWG outcomes using ANOVA. Lastly, it concludes with the qualitative findings obtained from semi-structured interviews.

Demographic Characteristics of Participants

As shown in Table 1, the study included 18 participants with a mean age of 67, ranging from 37 to 87 years. There were three females and 15 males. Regarding race and ethnicity, there were two individuals of Asian descent, one Black participant, and 15 White participants. Regarding educational background, nine participants had completed college education, another nine had some college education, and 13 had a secondary level of education. Regarding employment status, 11 participants were retired, five were unemployed, one was employed, and one was self-employed. The marital status distribution was as follows: 11 participants were married, four were single, and three were widowed.

Concerning living arrangements, five participants resided alone, while 13 participants lived with their family members. The leading causes of HD initiation among the participants included diabetes mellitus II for nine individuals and hypertension for five, and other causes such as multiple myeloma (MM), polycystic kidney disease (PKD), and congestive heart failure (CHF).

The duration of HD treatment varied among the participants, with 17 receiving treatment for less than five years and one for over five years. Most participants (16) had an AV fistula as

their dialysis access, while one had an AV graft and another had a Permacath dialysis catheter access.

Table 1

Demographic Characteristics of Participants (n=18)

Characteristics	Participants			
	n	*%*	*Mean*	*SD*
Age Group in Years			66.83	13.43
18-40 years	1	5.6		
41-50 years	1	5.6		
51-60 years	3	16.7		
>60 years	13	72.2		
Gender				
Male	15	83.3		
Female	3	16.7		
Race				
White	15	83.3		
Asian	2	11.1		
Black	1	5.6		
Hispanic	0	0		
Education				
Secondary	7	38.9		
Some College	6	33.3		
College	5	27.8		
Employment				
Retired	11	61.1		
Employed	1	5.6		
Self-Employed	1	5.6		
Unemployed	5	27.8		
Marital Status				
Single	4	22.2		
Married	11	61.1		
Widowed	3	16.7		
Living Arrangement				
Living Alone	5	27.8		
Living with family members	13	72.2		
Cause of HD Initiation				
Diabetes	9	50		
Hypertension	5	27.8		
Other (CHF, MM, PKD)	4	22.2		
Duration of HD Treatment in Years				
Less than 5	17	94.4		
More than 5	1	5.6		
Dialysis Access				
AV fistula	16	88.9		
AV graft	1	5.6		
Permacath	1	5.6		

Quantitative Results

In this research study, a pre-post mixed-method single-group design was employed. The data were coded and analyzed using the latest SPSS, specifically IBM SPSS 30. Paired t-tests and one-way ANOVA were utilized to analyze the variables, while semi-structured interviews were conducted to gather qualitative data. A significance level of .05 was used for the analyses. Table 2 presents the results of a paired samples t-test, assessing the mean differences between various pairs of variables before and after an intervention.

Table 2

Results of Paired Samples Test

		Paired Differences						Significance	
				95% Confidence Interval of the Difference					
		Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Frequency of following fluid restriction recommendations before intervention - Frequency of following fluid restriction recommendations after intervention	.594	.140	.371	.962	4.761	17	<.001	<.001
Pair 2	Perception of importance of fluid restriction before intervention - Perception of importance of fluid restriction after intervention	.502	.118	.139	.638	3.289	17	.002	.004
Pair 3	Understanding the level of importance of fluid restriction before intervention - Understanding the level of importance of fluid restriction after intervention	.958	.226	.246	1.199	3.198	17	.003	.005
Pair 4	Pre-Intervention IDWG - Post-Intervention IDWG	.53102	.12516	-.18129	.34685	.661	17	.259	.517

The paired samples test indicated significant improvements in participants' adherence to fluid restriction recommendations, their perception of its importance, and their understanding of fluid management after the intervention. Specifically, participants showed a marked increase in their frequency of following fluid restriction guidelines, with this change being highly significant ($p < .001$). Additionally, perceptions of the importance of fluid restrictions improved significantly ($p = .004$), as did participants' understanding of the critical nature of fluid management ($p = .005$).

However, despite these positive behavioral and cognitive changes, the intervention did not significantly impact IDWG ($p = .517$). This suggests that while awareness and adherence to fluid restrictions improved, these changes did not significantly reduce IDWG. Therefore, although the intervention successfully enhanced knowledge and behaviors, additional strategies may be needed to improve interdialytic weight outcomes.

The study also investigated the impact of various demographic variables on IDWG following the intervention. Among these variables, race emerged as a factor that approached statistical significance with a p-value of 0.112, as illustrated in Table 4. While this value does not meet the conventional threshold for significance ($p < 0.05$) (Table 3), it suggests a potential relationship between race and IDWG, indicating that further exploration of race as a contributing factor in future research could be valuable and promising.

Table 3

Pre and Post-Intervention Differences by Race

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
White	15	-.0307	.50192	.12959	-.3086	.2473	-1.08	.68
Asian	2	.5550	.23335	.16500	-1.5415	2.6515	.39	.72

Black	1	.8400	.	.	.	.	.84	.84
Total	18	.0828	.53102	.12516	-.1813	.3468	-1.08	.84

Table 4

ANOVA Results of Pre and Post-Intervention Differences by Race

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.212	2	.606	2.539	.112
Within Groups	3.581	15	.239		
Total	4.794	17			

Table 5

Pre and Post-Intervention Differences by Living Arrangement

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Living Alone	5	-.0220	.59281	.26511	-.7581	.7141	-.64	.84
Living with Family members	13	.1231	.52536	.14571	-.1944	.4406	-1.08	.72
Total	18	.0828	.53102	.12516	-.1813	.3468	-1.08	.84

Table 6

ANOVA Results of Pre and Post-Intervention Differences by Living Arrangement

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.076	1	.076	.258	.619
Within Groups	4.718	16	.295		
Total	4.794	17			

Another demographic variable in the study that needs to be emphasized is the living arrangement, which refers to people living alone versus those living with family members. The data indicate that the living arrangement had no significant impact after the intervention, with a p-value of .619, as shown in Table 6. This does not meet the conventional threshold for significance ($p < 0.05$) (Table 5). While slight positive changes are observed in those living with family members, the wide confidence intervals and the ANOVA results indicate that these findings are not statistically reliable. Therefore, further research with larger sample sizes is necessary to draw more definitive conclusions about the impact of living arrangements on fluid management.

Qualitative Results

Qualitative interviews with 18 participants were conducted to explore their experiences with the mobile app designed to track fluid intake. Two major themes emerged from the analysis: Ease of Use of the Mobile App and Challenges and Barriers.

Theme 1: Ease of Use of the Mobile App

User-Friendly Interface

Many participants found the app easy to navigate. One participant stated, "The mobile app was very user-friendly, and I enjoyed using it each day as it allowed me to track my fluid intake." Another noted, "It is easy to use and a helpful tool in my daily routine."

Convenience

Participants highlighted the app's convenience in helping them monitor their fluid intake regularly. Several noted that having a tool to track their hydration was a key feature, with comments such as, "It is convenient for me to record my fluid consumption to stay on top of my fluid consumption," and, "It is a straightforward tool."

Helpful Features

The app's features were highly beneficial, with comments like 'Helpful tips in managing thirst.' Participants believed that these features added educational value, helping them better understand their fluid intake and improve their adherence to dietary guidelines.

Theme 2: Challenges and Barriers

Limitations in Tracking Fluid Sources

Some participants expressed significant frustration with the app’s inability to track liquid-rich foods such as Jello, ice cream, puddings, and yogurt, significantly contributing to overall fluid intake. This limitation led to concerns that the app was not accurately reflecting their fluid consumption. One participant stated, "The daily fluid intake only accounts for liquid consumed, but there is no way to identify food that changes to liquid after being absorbed in the body, like Jello, puddings, yogurts, and ice cream." Their frustration was palpable, highlighting the need for further app development.

Editing and Customization Issues

Participants expressed frustration with the inability to edit the time of fluid entries. Comments included, "The app does not allow changing the time fluids were consumed if entered immediately after intake," and, "Inability to edit the time of input for fluid consumption entries; timing is inaccurate."

Desire for Enhanced Features

Some participants strongly desired improvements, such as customization options and visual aids. For example, one said, "Needs more customization options such as reminders," and another suggested, "Add more visuals like graphs or charts to improve user experience." Their desire for these enhancements was clear, underscoring the potential for further app development.

In conclusion, the qualitative findings from the interviews suggest that participants responded positively to the mobile app overall, highlighting its user-friendly interface and helpful features that supported effective tracking of fluid intake. This positive response from the participants is encouraging and underscores the potential of the app to be a valuable tool in managing fluid intake. Participants valued the convenience of tracking their hydration and appreciated the educational aspects of the app, including tips for managing thirst. However, some challenges were identified, including limitations in tracking liquid-rich foods (e.g., Jello, ice cream, pudding, and yogurt), difficulties in editing fluid intake entries, and a need for more customization options. These findings indicate that, although the app offers value, there are areas for improvement to address the specific needs of the patients better.

Chapter Five: Conclusion

This chapter discusses the study's findings on the impact of the H2Overload mobile app on fluid intake management and IDWG among adult HD patients. The results of previous research were analyzed, leading to conclusions regarding the effectiveness of the intervention and insights into its implications for practice. These conclusions provide valuable insights into the potential of mobile health applications in nephrology care. However, they also underscore the need for further research to realize these technologies' benefits fully. Additionally, limitations and strengths of the study were presented, and recommendations for future research and practice were outlined.

Discussion of Findings

The primary objective of this study was to evaluate the impact of the H2Overload mobile app on fluid intake management and IDWG among adult HD patients. The quantitative findings revealed significant improvements in several critical areas: the frequency of adherence to fluid restriction recommendations, perceptions regarding the importance of fluid restrictions, and overall understanding of their significance. These results, along with the identified areas for improvement, highlight the potential of the H2Overload app to be a valuable tool in managing fluid intake, instilling a sense of hope for its future development.

The observed increase in patients' knowledge and attitudes toward fluid intake management suggests that mobile applications can effectively engage patients in their self-care practices, consistent with the principles outlined in IFSMT. This theory emphasizes that self-management is a multidimensional process that can improve health outcomes when patients are actively involved in their care (Ryan & Sawin, 2009).

In contrast to the positive outcomes reported by Griva et al. (2018) and Park et al. (2019), this study did not replicate the benefits of self-management interventions. Griva et al. (2018) and Park et al. (2019) highlighted that self-management interventions, such as mobile applications for patients with ESRD on HD, can improve clinical markers, self-management skills, self-efficacy, and self-reported adherence. Similarly, the present study on the impact of the H2Overload mobile app aligns with these findings regarding enhanced self-reported adherence.

However, unlike previous research, this study did not significantly impact clinical markers such as IDWG. This discrepancy underscores the challenge of translating self-management education into tangible clinical outcomes, as noted in prior literature by Bossola et al. (2018). Their study suggests a disconnect between improved knowledge and actual behavioral change. In their subsequent study, Bossola et al. (2022) emphasized that acquiring knowledge does not always result in sustained behavioral modifications, as patients may initially adhere to recommendations but later relapse into non-adherence. This highlights the complexity of long-term self-management and the need for additional strategies to reinforce behavioral change.

The gap noted in this study may stem from limitations associated with the app's functionality and the duration of the intervention. While the app assisted, participants expressed frustration over its inability to track fluid intake from foods like Jello, yogurt, pudding, or ice cream. If users find the mobile app unreliable, it could hinder their ability to achieve better health outcomes, especially considering the diet's crucial role in managing health among HD patients (Kowal et al., 2023). Additionally, the study by Griva et al. (2018) suggested that more extended intervention periods with follow-ups may result in better long-term health outcomes. They used blended assessments at the first week, three and nine-month intervals, which improved clinical markers and even enhanced self-reported adherence. In contrast, the present study’s use of the

H2Overload mobile app for only four weeks may have improved self-reported adherence but was not long enough to produce significant changes in clinical markers such as the IDWG.

It is crucial to recognize that lower IDWG does not necessarily reflect an optimal nutritional status among HD patients. For instance, the study of Jalalzadeh et al. (2021) showed a potential positive correlation between higher IDWG and improved nutritional health, as elevated albumin levels are often associated with increased weight gain during the interdialytic period. This finding aligns with the study of Hecking et al. (2018), which indicated that low IDWG could be linked to short-term mortality, potentially reflecting underlying nutritional deficiencies.

In the context of this study, while the H2Overload app showed significant improvements in participants' adherence to fluid restriction recommendations and understanding of fluid intake management, the lack of a corresponding decrease in IDWG raises important questions. It suggests that simply increasing patients' knowledge and awareness may not be sufficient to translate into improved clinical outcomes, such as the reduction of IDWG. This gap highlights the complexity of fluid management in HD patients, where nutritional status and weight gain patterns must be carefully studied to fully understand their impact on patients' health.

Although all of the participants in the study had been diagnosed with end-stage kidney disease, some of the individuals still may have had residual renal function that could influence the regulation of fluid and the management of weight. This is because even a minimal amount of kidney function can allow for the excretion of excess fluid in between HD treatments. Therefore, there is a crucial need for individualized assessment and interventions to appropriately account for these physiological differences in addressing fluid intake in adult HD patients. The emphasis on personalized care not only acknowledges the unique needs of each patient but also highlights its potential to significantly improve patient outcomes. This finding aligns with Maimani et al.

(2021), who emphasized the importance of healthcare providers adjusting dry weights and tailoring dialysis prescriptions to prevent excessive IDWG and its associated complications.

The study's analysis of demographic variables about IDWG revealed an intriguing trend regarding race. Specifically, being white appears to correlate with a slight decrease in IDWG when utilizing the mobile app intervention, with a p-value of 0.112 approaching statistical significance. While not conventional ($p < 0.05$), this p-value suggests a potential relationship between race and IDWG that merits further exploration. The potential link between race and IDWG underscores the need for ongoing research to carefully consider how race can significantly affect fluid-restriction adherence or the effectiveness of an intervention, such as a mobile health app. This call for further investigation should spark interest, as it may lead to the development of mobile health apps more tailored to the specific needs of diverse racial groups. The need for further research on the potential link between race and IDWG is an important consideration in healthcare research, highlighting the importance of diversity in understanding and addressing health disparities.

Another demographic characteristic examined in this study that is important to highlight is living arrangement, which was categorized as either living alone or living with family. The findings indicated that living arrangements did not significantly impact the reduction of IDWG. Özkan and Taylan (2022) noted in their study that many patients feel unsupported in managing their dietary restrictions, complicating their ability to adhere to these guidelines. In contrast, this study on H2Overload app mobile use revealed that approximately 75% of participants live with their families, yet this did not correlate with an improvement in their IDWG. This suggests that living with family does not necessarily equate to strong support in managing health needs. Evaluating the quality of support systems, not just their presence, is crucial to ensure a more

holistic approach to healthcare. Ideally, family members should assist their loved ones in tracking fluid intake using the mobile app. However, the mobile app's reliability issues and the quality of family or caregiver support likely hindered its effectiveness, preventing a positive impact on managing IDWG. Therefore, future studies should emphasize the importance of evaluating the quality of support systems to ensure a more comprehensive approach to healthcare.

Participant feedback has underscored critical concerns with the H2Overload mobile app's inability to track liquid-rich foods such as Jello, pudding, and ice cream, constituting significant portions of daily fluid consumption. Despite participants becoming more aware of their fluid intake restrictions, the app's limitations hinder its effectiveness in managing fluid intake. This gap not only affects individual patient outcomes but also has broader implications for the healthcare system, as it may lead to increased healthcare costs and resource utilization. It highlights the pressing need for comprehensive tracking features in mobile health applications, increasing awareness of the current technological gaps and the need for further development.

While AI presents a promising solution for enhancing mobile app adherence among patients struggling with fluid intake management, its implementation in healthcare is not without challenges. These may include data privacy concerns, the need for specialized training for healthcare professionals, and potential resistance to change. By leveraging AI's personalization capabilities, adaptive app reminders can be developed that adjust based on usage patterns and recommendations over time (Sandys et al., 2022). This technological advancement offers a hopeful vision for the future of mobile health technology, instilling optimism about AI's potential in improving patient care, while also acknowledging the need for careful consideration of associated challenges.

In light of these research findings, future iterations of the H2Overload app and similar health applications must enhance tracking features that account for various sources of fluid intake, thereby preserving, enhancing, or managing users' well-being (Maaß et al., 2022). It is important to note that the H2Overload mobile app was not primarily designed for the HD population, indicating a need for better updates to serve these patients. To optimize user engagement and satisfaction, healthcare apps should incorporate personalized features that support dietary recommendations (Russell et al., 2022).

The resolution of usability issues identified in the study is essential to create mobile applications that improve adherence while promoting tangible behavioral changes. Personalized fluid restriction and weight gain targets must be implemented for better clinical outcomes when managing fluid intake complexities for HD patients. Moreover, the involvement of the dialysis team, alongside patients and their families, is essential for implementing effective volume control strategies and integrating innovative technologies to enhance patient care, as Weiner et al. (2014) emphasized.

Limitations of the Study

The study presents areas for improvement that offer opportunities for future research directions. The first significant issue is the low recruitment rate of 6.8%, with only 31 out of 452 screened patients participating in the study and only 18 completing it. This limited number of participants constrains the data's robustness and generalizability. It underscores the challenges posed by their morbidity in terms of retention for study participation. Furthermore, the study focused on participants with iOS devices compatible with the H2Overload app, excluding many potential participants who use other mobile devices like Android. This limitation narrows the applicability of the results to a broader demographic. Additionally, despite the assistance made

available by the research team during the four-week mobile app usage, older or less tech-savvy participants may have encountered challenges in using the app, potentially impacting usage rates and data accuracy. The app could introduce bias as participants may underestimate or overestimate their compliance. The brief four-week intervention period may be insufficient to observe notable effects on IDWG. It may not allow enough time to foster long-term behavioral changes in managing fluid intake.

Variability in fluid regulation among participants, especially those with residual renal function, could have confounded IDWG results. The presence of residual renal function might impact fluid regulation and weight management. Additionally, some participants reported usability challenges that could impact engagement and potentially the overall effectiveness of the app. These challenges included difficulty tracking liquid-rich foods, editing fluid intake entries, and understanding the range of foods classified as liquid. A more user-friendly design with more straightforward navigation is recommended for future iterations. Addressing these limitations in subsequent research could enhance the understanding of mobile health apps' effectiveness and improve fluid intake management for adult HD patients.

Strengths of the Study

Despite the above limitations, the study reveals several strengths that underscore its significance and potential effectiveness in improving patient outcomes. First, the study addresses a critical health issue adult HD patients face: effectively managing fluid intake. This is critically important because of the proven serious risks that stem from poor fluid intake management, which can lead to hypertension, heart failure, and other conditions leading to increased morbidity (Loutradis et al., 2021; Morais et al., 2020; Zoccali et al., 2017). By focusing specifically on adult patients with ESRD undergoing HD, the study adds valuable insights that can inform

tailored interventions, ultimately aiming to improve patient care and outcomes for a population that faces unique challenges related to fluid management.

Second, the study aligns with contemporary trends in healthcare that emphasize the importance of using AI to enhance patient autonomy and self-management. It does not only highlight the potential of the H2Overload mobile app in managing fluid intake among adult HD patients but also underscores the broader implications of the integration of AI and mobile applications in healthcare, which can transform patient-centered care by enhancing engagement and empowerment (Oyeniyi, 2024). The H2Overload mobile app can be upgraded with AI-driven features, such as personalized care recommendations and virtual health assistants, enabling patients to manage their health more effectively.

The mixed-methods design employed in the study is another strength, allowing for a comprehensive understanding of the impact of the H2Overload mobile app. The research combined quantitative data from IDWG results and adherence questionnaires with qualitative insights from participant interviews to provide a richer context of the findings. This multifaceted approach will help future researchers and scholars fully understand mobile apps' impact on this vulnerable population. This will pave the way for future research into mobile health applications for fluid management in adult HD patients. Additionally, by generating data on the effectiveness of the H2Overload app, the study will contribute to the growing body of evidence supporting the use of mobile health technologies in chronic disease management. This evidence can inform clinical practice guidelines, promoting the integration of such tools into routine care for adult HD patients, thereby enhancing overall treatment efficacy. Finally, the affordable app, free and sponsored by the National Kidney Foundation, addresses economic barriers that may prevent patients from accessing essential health management tools. This aspect significantly enhances the

app's accessibility and potential for widespread adoption among patients facing financial constraints, ultimately contributing to improved health outcomes and quality of life.

Implications for Practice

This study has several important implications for nursing practice and the healthcare industry. Mobile health apps can potentially increase patient engagement and improve health outcomes. Healthcare professionals must consider incorporating mobile health apps to manage adult HD patients. They also need to ensure that continuing education and adequate support are offered so that these applications may result in greater adherence to fluid restrictions and better health outcomes.

The study found limitations in the app for tracking fluid-rich foods and providing customization options, with a noted need for future iterations to incorporate user feedback to make the app more reliable. Healthcare providers or professional organizations, such as the National Kidney Foundation, who initially developed the H2Overload app, should take the initiative to inform the app developers to make these changes, emphasizing the tracking of all sources of liquid intake, including liquid-rich foods, and install more customizable app features to help patients achieve their fluid management goals. AI holds much promise for making health-related applications more customizable. AI can observe and learn from user behavior and can make recommendations that are much more personalized and adaptive (Sandys et al., 2022). For instance, using biofeedback systems in HD is a promising strategy for assessing and managing volume overload and IDWG in patients undergoing this treatment (Bossola et al., 2025). The researchers noted that wearable bioimpedance devices can efficiently track fluid overload and offer patient feedback, facilitating timely interventions.

Fluid management involves a collaborative approach with a multidisciplinary team that includes nephrologists, dietitians, nurses, and social workers. The insights gathered from this study should encourage healthcare professionals to work together more closely to create comprehensive treatment strategies bolstered by relevant innovative technology that considers the unique needs of adult HD patients. Nephrology teams must identify adherence barriers and encourage patients to utilize mHealth tools like the H2Overload app to enhance self-management and improve health outcomes. This aligns with the IFSMT that was used in this study. Moreover, the study suggests the importance of considering social determinants of health when implementing mobile health interventions. It encourages healthcare providers to assess patients' access to innovative technology, race, literacy levels, and social support systems to tailor interventions that meet their needs.

Recommendations for Future Research and Practice

The study results regarding the H2Overload mobile app's effect on managing fluid intake and IDWG in adult HD patients provide helpful information about the potential impacts of mobile health applications on chronic disease management. Nevertheless, despite these findings, there are still some apparent limitations and a few questions that require exploration to truly understand the work that mHealth applications can, or cannot, do in this patient population.

The study findings indicate that race and living arrangements may influence adult HD patients' fluid intake management. Future research should explore these two variables and include a more diverse participant pool to understand how other social determinants affect adherence to fluid restrictions and impact health outcomes such as inter-dialytic weight gain. A broader understanding of these factors will enable the development of more targeted interventions that address the unique challenges faced by this vulnerable population.

Future research should consider extending the intervention beyond the four weeks utilized in this study. Longer interventions could help patients understand and adhere to fluid restriction guidelines, which might significantly affect some clinical markers, like IDWG. Research suggests that sustained engagement can reinforce behavioral changes (Griva et al., 2018), emphasizing the importance of prolonged intervention periods to achieve meaningful health outcomes.

While the H2Overload mobile app was not constructed with the exclusive purpose of monitoring fluid intake for adult HD patients, it is still important to note the limitations, especially in tracking liquid-rich foods and the customization that would make it an ideal option. Future research should concentrate on creating mobile health apps that can track all sources of fluid intake with accuracy and that can do so with an adult HD population as the targeted user. The app must address these concerns in the next version(s). AI may significantly improve patient adherence to fluid management when integrated into mobile health applications. This could be achieved by customizing mobile health apps for every patient. Future research should explore this strategy to enhance user engagement and improve health outcomes.

The present research study aimed to improve our understanding of the impact of mobile health applications on managing fluid intake and IDWG. Future studies of this nature need to include more direct clinical outcome measures, like clinical markers and rehospitalization rates, that were not measured in this study. In addition, the use of a mixed-method approach, which was used in this study, should be considered, as it will yield more significant findings about the real impact of mobile health app interventions on this population.

The study found that while patient knowledge and attitudes had improved, it did not translate into significant reductions in IDWG. Özkan & Taylan (2022) emphasized that diet and

fluid restriction is a complex and challenging process involving a constant struggle, citing lack of support as a barrier. Thus, effective fluid management in adult HD patients requires teamwork involving nephrologists, dietitians, nurses, social workers, and family or caregiver support. Also, in conjunction with mobile health interventions, continuous patient education is recommended to empower patients to take ownership of their health. With this, healthcare providers can ensure that comprehensive support is provided, crucial for improving adherence and clinical outcomes.

Moreover, it is vital for professional organizations beyond the National Kidney Foundation to step up and serve as catalysts in sponsoring and developing mobile health apps that engage patients. Future mobile health applications need to take additional steps to address social determinants of health, particularly for this vulnerable population. Collaboration among professional organizations, technology developers, academic institutions, and healthcare providers can significantly improve health outcomes while reducing healthcare costs. By working together, these stakeholders can create more effective and accessible digital health solutions tailored to the needs of adult HD patients.

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APPENDICES

APPENDIX A: End-Stage Renal Disease Adherence Questionnaire (ESRD-AQ)

End-Stage Renal Disease Adherence Questionnaire (ESRD-AQ)

This survey asks for your opinion about how well you follow your dialysis treatment schedule and about medical recommendations related to medication, diet, and fluid intake. This information will help us to understand if you have difficulty following your dialysis treatment, medication regimen, fluid restriction, and recommended diet. Please answer every question by marking the appropriate box. If you are unsure about how to answer, please choose one best answer that applies to you.

Note: Numbers in parentheses are the response codes.

I. General Information

1. When did you begin or restart your hemodialysis treatment?
   a. Beginning Date:
   b. Restarting date if you restarted hemodialysis:
2. Have you ever had chronic peritoneal dialysis treatment?
   a. No(1)
   b. Yes(2) (Please answer below)
   I had peritoneal dialysis from

_____/_____ to _____/_____
Month/Year Month/Year

3. Have you had a kidney transplant?
   a. No(1)
   b. Yes(2) (Please answer below)

I had a kidney transplant once from _____/_____ to _____/_____
Month/Year Month/Year

Or

I had kidney transplant twice from _____/_____ to _____/_____
Month/Year Month/Year

And from _____/_____ to _____/_____
Month/Year Month/Year

If you have had transplants more than twice, please write the dates in the spaces above for the last two transplants.

4. What type of transportation do you use to go to the dialysis center?
    a. Personal transportation(1)
    b. Bus(2)
    c. Taxi(3)
    d. Medical transportation van(4)
    e. Other (Specify)(5
5. Who accompanies you to the dialysis center?
    a. Myself(1)
    b. Parent(2)
    c. Spouse (Husband or wife)(3)
    d. Child(4)
    e. Friend(5)
    f. Other (Specify the person)(6)

II. Hemodialysis Treatment

6. How many days a week do you receive hemodialysis treatment?
    a. 2 days or less(1)
    b. 3 days(2)
    c. 4 days(3)
    d. More than 4 days(4)
    e. More than 5 days(5)
7. How many hours are you treated for each hemodialysis?
    a. Less than 3 hours(1)
    b. 3 hours(2)
    c. 3 hours and 15 minutes(3)
    d. 3 hours and 30 minutes(4)
    e. 3 hours and 45 minutes(5)
    f. 4 hours(6)
    g. More than 4 hours(7)
    h. Other (Specify the hours)(8)
8. Is your dialysis schedule convenient for you? (Please choose one best answer that applies to you.)
    a. Yes(1)
    b. No, because I have to come to the dialysis center too early(2)
    c. No, because I have to come to the dialysis center too late(3)
    d. No, because of my work schedule(4)
    e. No, because it is my meal time and I get hungry during dialysis treatment(5)
    f. No, because it is my medication time and I have to take medicines/insulin(6)
    g. No, because of (Other)(7): _____
9. When was the last time a medical professional (your doctor, nurse, dietician, or other medical staff) talked to you about the importance of not missing your dialysis treatment?

a. This week(1)
b. Last week(2)
c. One month ago(3)
d. More than a month ago(4)
e. When I first began dialysis treatment(5)
f. Never(6)
g. Other (Specify)(7): _____

10. How often does a medical professional (your doctor, nurse, dietician, or other medical staff) talk to you about the importance of staying for the entire dialysis time during your dialysis treatment?
    a. Every dialysis treatment(1)
    b. Every week(2)
    c. Every month(3)
    d. Every 2 to 3 months(4)
    e. Every 4 to 6 months(5)
    f. When I have abnormal blood or other test results(6)
    g. Rarely(7)
    h. Irregularly(8)
    i. Never(9)
    j. Other (Specify)(10): _____
11. How important do you think it is to follow your dialysis schedule?
    a. Highly important(1)
    b. Very important(2)
    c. Moderately important(3)
    d. A little important(4)
    e. Not important(5)
12. Why do you think it is important to follow your dialysis schedule? (Please choose one best answer that applies to you.)
    a. Because I fully understand that my kidney condition requires dialysis as scheduled(1)
    b. Because following the dialysis schedule is important to keep my body healthy(2)
    c. Because medical professional (my doctor, nurse, or dietitian) told me to do so(3)
    d. Because I had an experience that I was sick after I missed dialysis(4)
    e. Because I had an experience that I was hospitalized after I missed dialysis(5)
    f. I don't think following the dialysis schedule is very important to me(6)
    g. Other (Specify)(7): _____
13. How much difficulty have you had staying for your entire dialysis treatment as ordered by your doctor?
    a. No difficulty(1)
    b. A little difficulty(2)
    c. Moderate difficulty(3)
    d. A lot of difficulty(4)
    e. Extreme difficulty(5)
14. During the *last month,* how many dialysis treatments did you miss completely?
    a. None (I did not miss any treatments)(1)
    b. Missed one dialysis treatment(2)
    c. Missed two dialysis treatments(3)
    d. Missed three dialysis treatments(4)
    e. Missed four or more dialysis treatments(5)
15. What was the main reason you missed your dialysis treatment *last month*?
    a. Not applicable: I did not miss any treatment(1)
    b. Transportation problems(2)

c. I had other things to do (Please explain)(3):
d. Hemodialysis access (graft, fistula, or catheter) clotted(4)
e. Physician (medical or surgical) appointment(5)
f. I had to go to the emergency room(6)
g. I was hospitalized(7)
h. Forgot(8)
i. "Didn't want to go" or "Couldn't go" *(Go to the next question: Question #16)*(9)
j. Other (Please specify)(10): _____

16. (Answer this question when you marked the above question as *"Didn't want to go Couldn't go."*)
Why didn't you want to go to the dialysis center? (Please choose one best answer that applies to you)
    a. Because dialysis treatment makes me anxious(1)
    b. Because I had vomiting/diarrhea(2)
    c. Because I had cramping(3)
    d. Because I often get hungry during dialysis treatment(4)
    e. Because I was physically uncomfortable (Specify the condition)(5)
    f. Because I was sick due to other conditions (Specify the conditions)(6)
    g. Because I was emotionally depressed(7)
    h. Other(8): _____
17. During the *last month*, ***how many times*** have you ***shortened*** your dialysis time?
    a. Not applicable: I have not shortened my dialysis time(1)
    b. Once(2)
    c. Twice(3)
    d. Three times(4)
    e. Four to five times(5)
    f. Other (Specify frequency)(6): _____
18. During the *last month*, when your dialysis treatment was shortened, what was the ***average number of minutes?***
    a. Not applicable: I have not shortened my dialysis time(1)
    b. Less than 10 minutes or 10 minutes(2)
    c. 11 to 20 minutes(3)
    d. 21 to 30 minutes(4)
    e. More than 31 minutes(5)
    f. Other (Specify)(6)
    (If you need to write two or more different time because you shortened dialysis more than once, please use this space): _____
19. What was the main reason you have shortened your dialysis treatment?
    a. Not applicable: I have not shortened my dialysis time(1)
    b. Cramping(2)
    c. Bathroom use(3)
    d. Restlessness(4)
    e. Low blood pressure(5)
    f. Access (graft, fistula, or catheter) clotted(6)
    g. Physician (medical or surgical) appointment(7)
    h. Personal business or emergency(8)
    i. Work schedule(9)
    j. Transportation problems(10)
    k. Staff decision (**Why? Please explain:** For example, poor blood flow, clotting dialyzer, machine malfunction, etc.)(11): _____
    l. Did not feel like staying(12)

m. Other (Please specify)(13): _____

III. Medication

20. When was the last time a medical professional (your doctor, nurse, dietician or other medical staff) spoke to you about your medicines?
    a. This week(1)
    b. Last week(2)
    c. One month ago(3)
    d. More than a month ago(4)
    e. When I first began dialysis treatment(5)
    f. Never(6)
    g. Other (Specify)(7): _____
21. How often does a medical professional (your doctor, nurse, dietician or other medical staff) talk to you about the importance of taking medicines as ordered?
    a. Every dialysis treatment(1)
    b. Every week(2)
    c. Every month(3)
    d. Every 2 to 3 months(4)
    e. Every 4 to 6 months(5)
    f. When I have abnormal blood or other (for example, blood pressure) test results(6)
    g. Rarely(7)
    h. Irregularly(8)
    i. Never(9)
    j. Other (Specify)(10): _____
22. How important do you think it is to take your medicines as scheduled?
    a. Highly important(1)
    b. Very important(2)
    c. Moderately important(3)
    d. A little important(4)
    e. Not important(5)
23. Why do you think it is important to take your medicines as scheduled? (Please choose one best answer that applies to you.)
    a. Because I fully understand that my kidney condition requires to take medicines as scheduled(1)
    b. Because taking medicines is important to keep my body healthy(2)
    c. Because a medical professional (my doctor, nurse, dietician, or other medical staff) told me to do so(3)
    d. Because I had an experience that I was sick after I missed medicines(4)
    e. Because I had an experience that I was hospitalized after I missed medicines(5)
    f. I don't think taking medicines is very important to me(6)
    g. Other (Specify)(7): _____
24. Have you had any difficulty with taking your medicines?
    a. No(1)
    b. Yes(2)
25. How much difficulty have you had with taking your prescribed medicines?
    a. No difficulty(1)
    b. A little difficulty(2)
    c. Moderate difficulty(3)
    d. A lot of difficulty(4)
    e. Extreme difficulty(5)
26. During the *past week*, ***how often*** have you missed your prescribed medicines?

a. None of the time: I did not miss my medicines(1)
b. Very seldom(2)
c. About half of the time(3)
d. Most of the time(4)
e. All of the time(5)

27. What was the main reason for not taking your prescribed medicines this *past week*?
    a. Not applicable: I did not miss medicines(1)
    b. Forgot to take medicines(2)
    c. Forgot to order medicines(3)
    d. Medicine cost(4)
    e. Inconvenience(5)
    f. I was hospitalized(6)
    g. Side effects(7) *(Go to question #28)*
    h. Other(8): _____
28. (Answer this question when you have marked the above question as *"Side effects."*)
    What kind of side effect(s) to the medication(s) did you have? (Please choose one best answer that applies to you.)
    a. Loss of appetite(1)
    b. Nausea/vomiting/diarrhea/constipation(2)
    c. Stomach pain(3)
    d. Dizziness(4)
    e. Headache(5)
    f. Itching/skin problems(6)
    g. Other (Specify symptoms)(7): _____

IV. Fluid

29. When was the last time a medical professional (your doctor, nurse or dietician or other medical staff) spoke to you about your fluid restrictions?
    a. This week(1)
    b. Last week(2)
    c. One month ago(3)
    d. More than a month ago(4)
    e. When I began dialysis treatment(5)
    f. Never(6)
    g. Other (Specify)(7): _____
30. How often does a medical professional (your doctor, nurse, dietician or other medical staff) talk to you about the importance of fluid restriction?
    a. Every dialysis treatment(1)
    b. Every week(2)
    c. Every month(3)
    d. Every 2 to 3 months(4)
    e. Every 4 to 6 months(5)
    f. When I have abnormal blood or other (for example, blood pressure) test results(6)
    g. Rarely(7)
    h. Irregularly(8)
    i. Never(9)
    j. Other (Specify)(10): _____
31. During the *past week*, how often have you followed the ***fluid restriction*** recommendations?

a. All of the time(1)
b. Most of the time(2)
c. About half of the time(3)
d. Very seldom(4)
e. None of the time(5)

32. How important do you think it is to limit your fluid intake?
    a. Highly important(1)
    b. Very important(2)
    c. Moderately important(3)
    d. A little important(4)
    e. Not important(5)
33. Why do you think it is important for you to limit your fluid intake? (Please choose one best answer that applies to you.)
    a. Because I fully understand that my kidney condition requires limiting fluid intake(1)
    b. Because limiting fluid intake is important to keep my body healthy(2)
    c. Because a medical professional (my doctor, nurse, dietician, or other medical staff) told me to do so(3)
    d. Because I got sick after I drank lots of fluid(4)
    e. Because I was hospitalized after I drank lots of fluid(5)
    f. I don't think limiting fluid is very important to me(6)
    g. Other (Specify)(7): _____
34. Have you had any difficulty with limiting your fluid intake?
    a. No(1)
    b. Yes(2)
35. How much difficulty have you had following your fluid restriction recommendations?
    a. No difficulty(1)
    b. A little difficulty(2)
    c. Moderate difficulty(3)
    d. A lot of difficulty(4)
    e. I was unable to follow any recommendations at all(5)
36. If you had difficulty following your fluid restriction recommendations, ***what type of difficulty*** have you had?
    a. No difficulty(1)
    b. Not interested(2)
    c. I was unable to control fluid intake(3)
    d. I don't understand how to follow the fluid restriction(4)
    e. Other(5): _____
37. During the past week, how many times have you weighed yourself ***at home*** (outside dialysis center)?
    a. More than 3 times(1)
    b. 3 times(2)
    c. Twice(3)
    d. Once(4)
    e. None of the time(5)
    f. Other(6): _____
38. How important do you think it is to weigh yourself daily?
    a. Highly important(1)
    b. Very important(2)
    c. Moderately important(3)
    d. A little important(4)
    e. Not important(5)

V. Diet

39. When was last time a medical professional (your doctor, nurse, dietician, or other medical staff) talked to you about your diet?
    a. This week(1)
    b. Last week(2)
    c. One month ago(3)
    d. More than a month ago(4)
    e. When I first began dialysis treatment(5)
    f. Never(6)
    g. Other (Specify)(7): _____
40. How often does a medical professional (your doctor, nurse, dietician or other medical staff) talk to you about the importance of following a proper diet?
    a. Every dialysis treatment(1)
    b. Every week(2)
    c. Every month(3)
    d. Every 2 to 3 months(4)
    e. Every 4 to 6 months(5)
    f. When I have abnormal blood or other (for example, blood pressure) test results(6)
    g. Rarely(7)
    h. Irregularly(8)
    i. Never(9)
    j. Other (Specify)(10): _____
41. How important do you think it is to watch the types of food you eat each day?
    a. Highly important(1)
    b. Very important(2)
    c. Moderately important(3)
    d. A little important(4)
    e. Not important(5)
42. Why do you think it is important for you to watch your diet daily? (Please choose one best answer that applies to you.)
    a. Because I fully understand that my kidney condition requires to watch my diet(1)
    b. Because watching my diet is important to keep my body healthy(2)
    c. Because a medical professional (my doctor, nurse, or dietician) told me to do so(3)
    d. Because I got sick after eating certain food that I was not supposed to eat(4)
    e. Because I was hospitalized after eating certain food that I was not supposed to eat(5)
    f. I don't think watching my diet is important to me(6)
    g. Other (Specify)(7): _____
43. Have you had any difficulty following your dietary recommendations?
    a. No(1)
    b. Yes(2)
44. How much difficulty have you had following your dietary recommendations?
    a. No difficulty(1)
    b. A little difficulty(2)
    c. Moderate difficulty(3)
    d. A lot of difficulty(4)
    e. I was unable to follow any recommendations at all(5)
45. What type of difficulty have you had keeping your dietary recommendations?
    a. Not applicable: No difficulty(1)
    b. I was not willing to control what I want to eat(2)

c. I was unable to avoid certain unrecommended food(3)
d. I don't understand what type of diet to follow(4)
e. Other (Specify)(5): _____

46. During the *past week*, how many times have you followed the diet recommendations?
    a. All of the time(1)
    b. Most of the time(2)
    c. About half of the time(3)
    d. Very seldom(4)
    e. None of the time(5)

APPENDIX B: William Paterson University IRB Approval

THE WILLIAM PATERSON UNIVERSITY OF NEW JERSEY

INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECT RESEARCH

c/o Office of Sponsored Programs
1800 Valley Road, Room 222
973-720-2852 (Phone)
973-720-3573 (Fax)
http://www.wpunj.edu/osp/

Chair: Professor Michelle Gonzalez (GonzalezM77@wpunj.edu)
College of Education
Contact: Kate Boschert (irbadministrator@wpunj.edu)
Office of Sponsored Programs

To: Dirksen Taguiam
Doctoral Candidate of Nursing

From: Michelle Gonzalez

Subject: IRB Approval: Expedited Review

Study: Protocol # 2024-347: Optimizing Fluid Intake Management in Adult Hemodialysis Patients: The Impact of the H2Overload Mobile Health App on Interdialytic Weight Gain.

Date: October 1, 2024

The IRB has Approved the modification to the above study involving humans as research subjects. This study was approved as Category: Expedited Category 1(b) and Category 7; special class of subjects: Participants are over the age of 18 who have been diagnosed with end-stage renal disease (ESRD).

IRB Number: 2024-347 This number is WPU's IRB identification that must be used on all consent forms and correspondence.

Approval Date: 07/10/2024
Modification Date: 09/19/2024
Modification Date: 10/01/2024
Expiration Date: 07/09/2025

This approval is for one year. It is your responsibility to ensure that an application for annual continuing review has been submitted before the expiration date noted above. If you do not receive approval before the expiration date, all study activities must stop until you receive a new approval letter. There will be no exceptions. In addition, you are required to submit a Final Report at the conclusion of the project. The IRB Continuing Review, Annual Update, and Final Report Request are to be submitted through InfoReady at https://wpunj.infoready4.com/.

Revisions/Modifications: You are required to carry out this research as described in the protocol. All amendments/modifications of protocols involving human subjects, must have prior IRB approval, except those involving the prevention of immediate harm to a subject. Revisions/Modifications are to be submitted through InfoReady at https://wpunj.infoready4.com/.

Adverse Effects/Unanticipated Problems: The principal investigator must report immediately any serious problem, adverse effect, or outcomes that are encountered while using human subjects or any complaints

APPENDIX C: Letter of Approval from a Nephrology Practice Group

OCEAN RENAL ASSOCIATES, P.A.

Jin Park, M.D., Jose Iglesias, D.O., F.A.C.P, Winicjusz Palecki, M.D., Nadeem Haider, M.D.,
Daniel Brouder, M.D., Angelo Markatos, D.O., Joseph Schirripa, M.D., Ariel Meyer, D.O.,
Ankit Shah, M.D., Mrugesh Panchani, M.D., Neethu Gopisetti, M.D., Amar Bhagat, D.O.
Mary Jane Castillo, APN, Dirksen Taguiam, APN, Matt Holt, APN, Olusola Akintola, APN, Theresa Nguyen, APN

September 3rd, 2024

The William Paterson University of New Jersey
c/o Office of Sponsored Programs
1800 Valley Road, Room 222
IRB Number: 2024-347

Re: Dirksen Taguiam
Doctoral Candidate of Nursing

Dear Professor Michelle Gonzalez,

My name is Dr. Jose Iglesias, and I am the President & Managing Partner of Ocean Renal Associates, P.A.. I am pleased to have reviewed the research protocol submitted by Dirksen Taguiam, APN, and I gladly accept the responsibility for overseeing the Human Subject Research involving the patients currently under our practice's care.

This research will focus on optimizing fluid intake management in adult hemodialysis patients, examining the impact of water overload, and assessing the use of a mobile health app on managing interdialytic weight gain. Should you have any questions, please do not hesitate to contact me at 732-458-5854.

Sincerely,

Dr. Jose Iglesias
President, Ocean Renal Associates, PA

APPENDIX D: Permission to use the End-Stage Renal Disease Adherence Questionnaire (ESRD-AQ)

On Fri, Mar 22, 2024 at 4:28 AM Taguiam, Dirksen <taguiamd@wpunj.edu> wrote:
Dear Dr. Kim,
I hope this message finds you well. I am currently enrolled in a Doctor of Nursing Practice program (DNP) at William Paterson University in New Jersey, USA, with a focus on the use of mobile health apps and their impact on treatment adherence among hemodialysis patients. During my research, I came across your study on ESRD-AQ published on PMC in 2011, which I found to have good validity and reliability based on your research.
I would like to ask for permission to utilize the ESRD-AQ as part of my study. I assure you that I will appropriately cite your work in my research. Additionally, I would appreciate it if I could obtain an official copy of the scale for reference.
Thank you for considering my request. I look forward to hearing from you soon.

Warm regards,
Dirksen Taguiam, MSN, APN
DNP Student
William Paterson University
taguiamd@wpunj.edu

From: Youngmee Kim <youngkim234@gmail.com>
Sent: Sunday, March 24, 2024 5:52 AM
To: Taguiam, Dirksen <taguiamd@wpunj.edu>
Subject: Re: ESRD-AQ
Dear Dirksen,
Thank you for your interest in the ESRD-AQ. Please contact the Nephrology Nursing Journal (NNJ) and get permission to use the ESRD-AQ. If you do not receive any response from the NNJ in a week, please go ahead and use the tool.
Best regards,
Young

Youngmee Kim, PhD, RN, FNP
Professor, Red Cross College of Nursing, Chung-Ang University
Bldg 102 Rm #523
84, Heuksuk-ro, Dongjak-gu, Seoul 06974, Korea
Office: +82-2-820-5984. Fax: +82-2-824-7961
E-mail: ykim@cau.ac.kr or youngkim234@gmail.com

From: Taguiam, Dirksen <taguiamd@wpunj.edu>
Sent: Sunday, March 24, 2024 9:34 PM
To: BethTUlrich@gmail.com
Subject: Request for Permission to Use ESRD-AQ Tool

Dear Nephrology Nursing Journal (NNJ) Editorial Team,
I am currently enrolled in a Doctor of Nursing Practice program at William Paterson University in New Jersey, USA, with a research focus on exploring the impact of mobile health apps on treatment adherence among hemodialysis patients. I came across your research article on the ESRD-AQ, titled "The End-Stage Renal Disease Adherence Questionnaire (ESRD-AQ): Testing The Psychometric Properties in Patients Receiving In-Center Hemodialysis," published on April 14, 2011 in PMC.
I reached out to Dr. Kim Youngmee, a co-author on the study, for permission to use the ESRD-AQ, but she advised me to seek approval from you. Therefore, I am contacting you to request authorization to incorporate the ESRD-AQ tool into my DNP project.

I firmly believe that utilizing the ESRD-AQ in my research will be instrumental in enhancing our understanding of patient outcomes in end-stage renal disease.
I appreciate your consideration of my request and look forward to your timely response.
Thank you.
Respectfully,
Dirksen Taguiam, MSN, APN
DNP Student
William Paterson University
taguiamd@wpunj.edu

RE: Request for Permission to Use ESRD-AQ Tool
From bethtulrich@gmail.com <bethtulrich@gmail.com>
Date Fri 3/29/2024 11:56 PM
To Taguiam, Dirksen taguiamd@wpunj.edu

You will need to contact the author for permission to use this tool. It does not “belong” to the Nephrology Nursing Journal.

Beth
Beth Ulrich, EdD, RN, FACHE, FAONL, FAAN
Editor-in-Chief, ***Nephrology Nursing Journal***
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