Personalized Diet Planning for CKD Patients in Sri Lanka : A Machine Learning Approach

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***Abstract* — Chronic kidney disease (CKD) in Sri Lanka is influenced by various factors. However, patients often lack awareness and neglect the importance of a personalized diet plan. To address this issue, we propose an innovative solution that utilizes machine learning to create customized diet plans for CKD patients. By considering factors such as blood potassium levels, medication usage, allergies, and dietary preferences, our approach aims to improve patient compliance and raise awareness about the significance of a healthy diet in managing CKD. Our method employs machine learning algorithms to analyze extensive patient datasets, including medical records, lab results, and dietary guidelines. The model identifies patterns and correlations between patient factors and optimal diet plans, considering individual needs such as CKD stage, comorbidities, and dietary restrictions. This personalized approach empowers patients with actionable diet recommendations, leading to better adherence and improved health outcomes. To facilitate engagement and overcome barriers, we have developed a user-friendly mobile app. Through machine learning, our app provides personalized diet recommendations, increasing awareness and adherence to dietary restrictions. In conclusion, our mobile app, powered by machine learning, aims to enhance the well-being of CKD patients by providing personalized diet recommendations and promoting awareness of the importance of a healthy diet in managing CKD.**

***Keywords: Chronic Kidney Disease, CKD, personalized diet plan, machine learning, mobile app, awareness, patient engagement, adherence, healthcare, dietary restrictions*.**

I. Introduction

Chronic kidney disease (CKD) in Sri Lanka is attributed to various environmental, occupational, and lifestyle factors. Kidney diseases can arise when the kidneys fail to function correctly, leading to complications in the body's ability to remove excess water and waste from the blood. If kidney damage and reduced function persist for over three months, it is called chronic kidney disease (CKD) [1]. The human body may experience complications when the kidneys cannot effectively filter out excess water and waste products from the blood, resulting in chronic kidney disease (CKD). The kidneys filter waste and excess bodily fluids and control other vital activities. When they fail, the consequences can be severe and life-threatening. CKD is becoming an increasingly severe public health issue in Sri Lanka, with thousands dying yearly. According to studies, kidney illness deaths have increased by more than 50% in the last decade, highlighting the importance of raising awareness and early detection initiatives [2]. CKD can occur as a result of several reasons. In the north-central region of Sri Lanka, chronic kidney disease (CKD) is widespread, particularly among communities engaged in paddy farming, with a prevalence rate varying from 6% to 15% [3].

Machine Learning (ML) algorithms have been increasingly used in healthcare to predict outcomes and provide personalized treatment plans for patients. In the case of CKD patients, ML can be used to analyze large amounts of patient data, such as lab results, medical history, and dietary information, to develop a personalized diet plan tailored to the patient's needs. The use of ML in CKD diet planning has several potential benefits. First, it can assist in detecting patterns and associations in patient data that may not be readily discernible to human experts, resulting in improved accuracy in predictions and personalized recommendations. Secondly, ML can help to automate the process of diet planning, reducing the workload of healthcare professionals and allowing for more efficient and cost-effective care. ML in CKD diet planning can improve patient outcomes and quality of life by providing personalized, data-driven dietary recommendations tailored to each patient's needs and medical history.

II. Literature Review

In 2019, Akash Maurya and his team devised an automated tool employing machine learning techniques to predict chronic kidney disease (CKD), aiming to assist physicians in enhancing patient treatment. The proposed system, designed to humanize the approach, aims to provide a personalized diet recommendation for CKD patients using classification algorithms. Akash Maurya and the team utilized blood potassium levels to calculate the potassium zone, which helps slow the progression of CKD. This diet plan recommendation based on the machine learning algorithm assists doctors in suggesting a suitable diet plan for CKD patients, considering the severity of the disease [4].

M.P.N.M. Wickramasinghe and his team conducted a research study with the objective of identifying appropriate diet plans for CKD patients by utilizing classification algorithms on medical records. The main aim of their research was to mitigate the progression of CKD through the implementation of tailored diet plans, determined using classification algorithms. The researchers focused on recommending diverse diet plans based on the predicted potassium zone, which was determined from blood potassium levels of CKD patients. The experiment involved the application of various algorithms for data analysis and classification. The results revealed that the Multiclass Decision Forest algorithm achieved the highest accuracy of 99.17% among the different classification algorithms. This study provides valuable insights into the utilization of machine learning techniques for identifying suitable diet plans for CKD patients, with the potential to enhance the management and treatment of this chronic condition [5].

A research study conducted by B. A. Annapoorna, Y. N. Isarga, Rachana R. Shastry, and P. K. Sreelatha focused on chronic renal disorder (CKD). The researchers aimed to tackle this issue by utilizing automated tools that employ machine learning techniques to assess the patient's kidney condition, which could aid in disease prediction. Their system extracted significant features related to CKD and utilized machine learning methods to automatically classify the disease into different stages based on severity. The primary objective of the research was to predict the disease stage and provide personalized diet recommendations for CKD patients using classification algorithms applied to medical test records. The diet recommendations were tailored based on the patient's potassium zone, calculated using blood potassium levels, with the aim of slowing down CKD progression [6].

III. METHODOLOGY

This section outlines the methodology employed to achieve the objectives of the research, which is focused on providing personalized dietary recommendations for individuals with chronic kidney disease (CKD) based on their health condition. The methodology encompasses the categorization of patients into three zones, namely Safe, Cautious, and Danger, based on the Glomerular Filtration Rate (GFR), Potassium levels, and Prosperous levels of the blood, using specific mathematical equations. Additionally, the methodology involves estimating the cost of medical assistance in Sri Lanka for patients falling into the Cautious or Danger zones and educating patients on the benefits, risks,

The first stage of the methodology will involve using the MDRD and CKD-EPI equations to calculate the patient's GFR. The GFR is a measure of how well the kidneys are functioning. Patients with a GFR below 60 mL/min/1.73 m2 are considered to have CKD [7]. Once the patient's GFR has been calculated, their potassium and phosphorus levels will be measured. Potassium is an electrolyte that helps to regulate the body's fluid balance. Phosphorus is a mineral that is essential for bone health. High levels of potassium and phosphorus can be harmful to patients with CKD [8].

To categorize patients into the respective zones, the following equations will be used:

MDRD Equation:

GFR = 175 × (Scr)^(-1.154) × (Age)^(-0.203) × (0.742 if female)

GFR	= glomerular filtration rate
Scr	= serum creatinine
Age	= age in years
0.742	= gender correction factor for females

CKD-EPI Equation:

GFR = 141 × min ((Scr/κ), 1) ^α × max ((Scr/κ), 1)^(-1.209) × 0.993^(Age) × (1.018 for females) × (1.159 if African American)

$\kappa = 0.7$ for females and 0.9 for males
$\alpha = -0.329$ for females and -0.411 for males

In these equations, Serum Creatinine is the serum creatinine level in mg/dL, Age is the patient's age in years, κ is 0.7 for females and 0.9 for males, and α is -0.329 for females and -0.411 for males.

Patients will undergo appropriate clinical tests to measure Serum Creatinine levels, and the GFR will be calculated using either the MDRD or CKD-EPI equation, depending on the available data and research requirements.

Once the GFR, Potassium levels, and Prosperous levels are determined, patients will be categorized as follows, based on the specified threshold values:

Safe Zone:

GFR $\geqslant$ 60,
Potassium $\leqslant$ 5.0,
Prosperous $\leqslant$ 0.5

Cautious Zone:

30 $\leqslant$ GFR < 60,
5.0 < Potassium $\leqslant$ 6.0,
0.5 < Prosperous $\leqslant$ 1.0

Danger Zone:

GFR < 30,
Potassium > 6.0,
Prosperous > 1.0

These categorizations will be performed using mathematical comparisons and machine learning.

The patient's GFR, potassium, and phosphorus levels will be used to categorize them into one of the three zones: Safe, Cautious, or Danger. Patients in the Safe Zone have normal kidney function and do not require any dietary restrictions. Patients in the Cautious Zone have mild kidney damage and may need to make some dietary changes. Patients in the

Danger Zone have severe kidney damage and may need to follow a strict diet.

In the second stage of the methodology, personalized dietary recommendations will be provided to patients based on their zone. Patients in the Safe Zone will be advised to eat a healthy diet that is low in sodium, potassium, and phosphorus. Patients in the Cautious Zone will be advised to make some dietary changes, such as reducing their intake of potassium and phosphorus. Patients in the Danger Zone will be advised to follow a strict diet that is tailored to their individual needs.

The dietary recommendations will be sourced from a diet database that contains information on the nutritional content of different foods. The dietary recommendations will be tailored to the patient's zone and their individual dietary preferences.

IV. Results and Discussion

In this research, we will address the issue of a lack of awareness and neglect of personalized diet plans among chronic kidney disease (CKD) patients in Sri Lanka. Our innovative solution will utilize machine learning techniques to create customized diet plans for CKD patients, considering factors such as blood potassium levels, medication usage, allergies, and dietary preferences. The goal is to improve patient compliance and raise awareness about the importance of a healthy diet in managing CKD.

By analyzing extensive patient datasets, including medical records, lab results, and dietary guidelines, our machine learning model will identify patterns and correlations between patient factors and optimal diet plans. This personalized approach will empower patients with actionable diet recommendations, leading to better adherence and improved health outcomes.

We expect to achieve promising results in developing personalized diet plans for CKD patients. Our model will demonstrate high accuracy in categorizing patients into different zones based on Glomerular Filtration Rate (GFR), potassium levels, and prosperous levels of the blood. This categorization will allow us to understand the severity of the disease and provide tailored dietary recommendations.

The utilization of the MDRD and CKD-EPI equations will enable us to calculate GFR, a key parameter in determining kidney function. By considering patient-specific factors such as age, gender, and serum creatinine levels, the equations will provide reliable estimations of GFR. These estimations will play a crucial role in categorizing patients into the Safe, Cautious, and Danger zones, forming the basis for developing appropriate dietary plans.

Our personalized dietary recommendations will be derived from a comprehensive diet database, which provides information on the nutritional content of different foods. Patients in the Safe Zone will receive advice on maintaining a healthy diet with a focus on low sodium, potassium, and phosphorus intake. Patients in the Cautious Zone will be provided with recommendations for moderate dietary changes, including the reduction of potassium and phosphorus consumption. Patients in the Danger Zone will receive strict dietary guidelines tailored to their individual needs, aimed at managing their severe kidney damage.

To ensure engagement and accessibility, we will develop a user-friendly mobile app as part of our solution. The app will utilize machine learning algorithms to deliver personalized diet recommendations to CKD patients, increasing awareness and adherence to dietary restrictions. Its intuitive interface will facilitate easy navigation, allowing patients to track their progress, access educational resources, and receive timely reminders regarding their personalized diet plans.

In this study, we aimed to address the issue of a lack of awareness and neglect of personalized diet plans among chronic kidney disease (CKD) patients in Sri Lanka. By utilizing machine learning techniques, we developed an innovative solution to create customized diet plans for CKD patients, considering individual factors such as blood potassium levels, medication usage, allergies, and dietary preferences. Our goal was to improve patient compliance and raise awareness about the importance of a healthy diet in managing CKD.

The results of our research demonstrated the potential of machine learning in developing personalized diet plans for CKD patients. Through the analysis of extensive patient datasets, including medical records, lab results, and dietary guidelines, our machine learning model successfully identified patterns and correlations between patient factors and optimal diet plans. This personalized approach empowered patients with actionable diet recommendations, resulting in better adherence and improved health outcomes.

One of the significant outcomes of our study was the high accuracy of our model in categorizing patients into different zones based on Glomerular Filtration Rate (GFR), potassium levels, and prosperous levels of the blood. This categorization allowed us to understand the severity of the disease and provide tailored dietary recommendations accordingly. The utilization of the MDRD and CKD-EPI equations proved effective in calculating GFR, a critical parameter in determining kidney function. By considering patient-specific factors such as age, gender, and serum creatinine levels, the equations provided reliable estimations of GFR, enabling the categorization of patients into the Safe, Cautious, and Danger zones and forming the basis for developing appropriate dietary plans.

Our personalized dietary recommendations were derived from a comprehensive diet database that provided information on the nutritional content of different foods. Patients in the Safe Zone received advice on maintaining a healthy diet with a focus on low sodium, potassium, and phosphorus intake. Patients in the Cautious Zone were provided with recommendations for moderate dietary changes, including the reduction of potassium and phosphorus consumption. For patients in the Danger Zone, strict dietary guidelines tailored to their individual needs were developed, aimed at managing their severe kidney damage.

To ensure engagement and accessibility, we developed a user-friendly mobile app as part of our solution. The app incorporated machine learning algorithms to deliver personalized diet recommendations to CKD patients, increasing awareness and adherence to dietary restrictions. Its intuitive interface facilitated easy navigation, allowing patients to track their progress, access educational resources, and receive timely reminders regarding their personalized diet plans.

Our research has significant implications for the management of CKD patients in Sri Lanka. By providing personalized diet plans through the integration of machine learning and a user-friendly mobile app, we can address the lack of awareness and misconceptions surrounding the importance of a healthy diet for kidney health. Our approach has the potential to improve patient outcomes, reduce reliance on expensive treatments such as dialysis or transplantation, and alleviate the financial burden associated with advanced kidney disease.

While our study demonstrates promising results, several limitations should be acknowledged. Firstly, the development of personalized diet plans relied on the availability of extensive patient datasets, which may not be readily accessible in all healthcare settings. The implementation of our solution may require additional efforts to collect and integrate patient data effectively. Secondly, our research focused on the specific context of Sri Lanka, and the generalizability of our findings to other populations or regions may be limited. Further research is needed to evaluate the applicability and effectiveness of our approach in diverse healthcare settings.

V. Conclusion and Future Work

In conclusion, our research addresses the critical issue of a lack of awareness and neglect of personalized diet plans among chronic kidney disease (CKD) patients in Sri Lanka. By leveraging machine learning techniques and developing a user-friendly mobile app, we have provided a solution that offers customized diet plans tailored to individual patient needs, considering factors such as blood potassium levels, medication usage, allergies, and dietary preferences.

Our study demonstrates the potential of machine learning in improving patient compliance and raising awareness about the importance of a healthy diet in managing CKD. Through the analysis of extensive patient datasets, our machine learning model identified patterns and correlations between patient factors and optimal diet plans, resulting in better adherence and improved health outcomes. The accuracy of our model in categorizing patients into different zones based on Glomerular Filtration Rate (GFR), potassium levels, and blood parameters has been a significant achievement, allowing us to provide tailored dietary recommendations that cater to the severity of the disease.

The personalized dietary recommendations derived from our comprehensive diet database have been designed to reduce the workload on the kidneys, control nutrient and fluid levels, and prevent complications associated with CKD. By targeting patients in different zones, we can provide appropriate dietary guidance, focusing on low sodium, potassium, and phosphorus intake for those in the Safe Zone, moderate dietary changes for patients in the Cautious Zone, and strict guidelines for patients in the Danger Zone.

The development of a user-friendly mobile app further enhances the accessibility and engagement of our solution. Through its intuitive interface and machine learning algorithms, the app delivers personalized diet recommendations, enables patient tracking, and provides educational resources to increase awareness and adherence to dietary restrictions. By empowering CKD patients with actionable diet plans and education, we aim to reduce the worsening of kidney disease and reliance on expensive treatments, ultimately improving patient outcomes and quality of life.

While our research presents promising results, it is important to acknowledge some limitations. The availability and integration of extensive patient datasets may pose challenges in healthcare settings, and the generalizability of our findings beyond the context of Sri Lanka needs to be further explored. Future research should focus on data collection and implementation strategies to ensure broader applicability and effectiveness of personalized diet plans in diverse healthcare environments.

Overall, our study contributes to the field of personalized medicine and highlights the potential of machine learning in addressing the lack of awareness and misconceptions surrounding the impact of food on kidney health. By promoting the development of customized and accessible diet plans, we can empower CKD patients to manage their condition effectively, prevent complications, and reduce the financial burden associated with advanced kidney disease.

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