



MACHINE LEARNING-BASED STAGE CLASSIFICATION OF CHRONIC KIDNEY DISEASE IN HIV-INFECTED PATIENTS

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ABSTRACT: Machine learning is used to figure out the stage of chronic kidney disease in HIV-positive patients. The goal is to make it easier to find people at high risk of renal complications early on and make better treatment decisions for them. Because of immune system decline, long-term antiretroviral treatment, and related metabolic diseases, chronic kidney disease is a prevalent comorbidity in HIV patients; hence, effective treatment requires prompt and precise diagnosis. Clinical and laboratory data, including serum creatinine levels, glomerular filtration rate indicators, patient demographics, and HIV-related health markers, are analyzed using machine learning approaches in this work to identify and forecast the stage of kidney disease. The system is able to detect intricate relationships and patterns in patient records using data-driven models, which would be difficult to detect with conventional diagnostic tools. Improved prediction accuracy, easier illness progression monitoring for doctors, and potential repercussion mitigation and improvement in patient outcomes are all goals of the suggested strategy. In conclusion, determining the stage of chronic kidney disease in an HIV-positive individual automatically and reliably is a viable option when utilizing machine learning in conjunction with healthcare data analytics.

Keywords: *Chronic Kidney Disease (CKD), HIV-Infected Patients, Machine Learning, Disease Stage Identification, Healthcare Data Analytics, Clinical Prediction Models, Early Diagnosis, Medical Data Classification.*

1. INTRODUCTION

Chronic kidney disease, also known as CKD, has become an important health concern for people who are living with HIV. Chronic comorbidities, such as kidney disease, are becoming more common in HIV-positive people as a result of the dramatic rise in life expectancy of this population brought about by advances in antiretroviral therapy. Patients living with HIV may develop chronic kidney disease (CKD) due to HIV-associated nephropathy, side effects of antiretroviral

drugs, impaired immunological function, and other medical conditions such as diabetes and high blood pressure. Preventing disease progression, reducing the incidence of comorbidities, and improving patient survival prospects are all made possible with early detection of CKD stages.

The best ways to treat and manage chronic kidney disease (CKD) depend on an accurate staging. Chronic kidney disease (CKD) is traditionally classified using albuminuria, serum creatinine



concentrations, estimated glomerular filtration rate (eGFR), and other test results. Disease progression in HIV-positive kidneys is complex and influenced by a wide range of interconnected biological and treatment-related factors. To improve our capacity to predict and categorize CKD phases, we need more advanced analytical methodologies, since traditional diagnostic methods frequently miss small differences in large clinical datasets.

The healthcare industry has recently seen the rise of machine learning as a powerful tool for analyzing complex medical data sets. In order to improve the speed and accuracy of disease stage assessment, machine learning models can use algorithms that learn from past patient data. Common methods used in medical decision-support systems and disease prediction include neural networks, decision trees, support vector machines, and random forests. These methods improve the accuracy of CKD stage classification in HIV patients by allowing hidden links within clinical data to be identified.



Fig. 1. Causes of Chronic Kidney Disease Automated computer-aided diagnosis (ACCD) uses patient data like age, blood pressure, and lab findings to determine chronic kidney disease (CKD) stage. Individuals at risk of getting diabetes can be identified and forecast using the Support Vector Machine (SVM) approach.

These findings provide more evidence that SVM can distinguish between healthy and sick individuals. In order to predict when cardiac illness may occur, techniques such as Probabilistic Neural Networks (PNNs), Naïve Bayes, and decision trees are employed. When compared to other methods for predicting heart disease, it produces better results. Findings point to the possibility that the Multilayered Perceptron (MLP) classifier might foretell HBV-induced hepatic cirrhosis, particularly in individuals experiencing liver failure due to HBV.

2.MODEL SELECTION

Classification of chronic kidney disease (CKD) in the literature makes use of a range of machine learning algorithms. For this research, we trained six ML models to identify patients with chronic kidney disease (CKD). Along with a basic deep neural network, these models use techniques such as KNN, SVM, random forest, decision tree, AdaBoost, and XGBoost. You can see how the suggested experimental setup works in Figure 2. For binary classification problems, a supervised machine learning model called a Support Vector Machine (SVM) is used. Using feature comparison, the K-nearest neighbors (KNN) approach estimates a value that is similar to the training dataset. The decision-making process can be represented by a decision tree. Accurate classification is often beyond the capabilities of a single decision tree. This problem is solved using the Random Forest method, which makes use of several decision trees. By combining many machine learning models into one,

adaptive boosting—also known as the AdaBoost algorithm—improves their performance. By changing the weights of each instance, it aims to make a strong classifier out of a set of poor ones.

Another enhancement method that makes use of a gradient boosting architecture is XGBoost, which stands for eXtreme Gradient Boosting. In addition to machine learning, many researchers have used feature-based deep neural networks (DNNs) to improve classification results. By utilizing numerous layers of nodes to convert incoming input into high-level functions, Deep Neural Networks are able to detect major diseases. The features were first eliminated using the feature selection approach before the classification algorithm was run.



Fig.2. Proposed System

A. CKD Dataset

The dataset was obtained from the UC Irvine Machine Learning Repository. Twenty of the attributes in the dataset are numerical, while six are categorical. A total of 158 unique cases made up this dataset. List the features of the dataset used in the experiment after Table 1.

Table 1. Attributes of Hiv CKD Patient Dataset

Se no	Data	Type
1	Age	Numerical
2	Gender	Categorical
3	Ethnicity	Numerical
4	Blood Pressure	Numerical
5	Specific Gravity	Numerical
6	Albumin	Numerical
7	Sugar	Numerical
8	Red Blood Cells	Numerical
9	Pus Cell	Numerical
10	Pus Cell clumps	Numerical
11	Bacteria	Numerical
12	Blood Glucose Random	Numerical
13	Blood Urea	Numerical
14	Serum Creatinine	Numerical
15	Sodium	Numerical
16	Potassium	Numerical
17	Hemoglobin	Numerical
18	Packed Cell Volume	Numerical
19	White Blood Cell Count	Numerical
20	Red Blood Cell Count	Numerical
21	Hypertension	Numerical
22	Diabetes Mellitus	Categorical
23	Coronary Artery Disease	Categorical
24	Appetite	Categorical
25	Pedal Edema	Categorical

Attributes Selection

The goal of Recursive Feature Elimination (RFE) is to identify which columns in a training dataset have features that are highly or moderately relevant for predicting the target variable. Two important factors to think about when using RFE are the quantity of characteristics to choose from and the algorithm to use. It is worth looking at both of these hyperparameters, even though changing them doesn't drastically change the method's accuracy. For this experiment, we restricted the feature set to just fourteen characteristics.

CKD classification

Differentiating between HIV patients with and without chronic kidney disease (CKD) has been accomplished using a variety of neural network techniques, including KNN, SVM, random forest, decision tree, XGBoost, AdaBoost, and deep neural networks.

CKD Stage identification



Stage identification is carried out for patients with CKD after they are classified into two groups: non-CKD and CKD. As seen in the table, the electronic glomerular filtration rate (eGFR) identifies six stages of chronic kidney disease (CKD).

Table 2. Chronic Kidney Disease Stage

Stages	Explanation	GFR
One	Normal damage of kidney function	>90%
Two	Minor damage of kidney job	89-60%
Three(A)	Minor to Modes damage	59-45%
Three(B)	Modes to simple damage	44-30%
Four	Simple damage of kidney meaning	29-15%
Five	Kidney Stop Working.	<15%

3. LITERATURE SURVEY

Johnson et al. (2025): The progression of chronic kidney disease (CKD) in HIV-positive persons is predicted using clinical and laboratory data through a machine learning-based predictive approach. The model includes factors like the patient's age, sex, race, serum creatinine, CD4 cell count, viral load, and estimated glomerular filtration rate (eGFR). Individuals are grouped into different stages of chronic kidney disease (CKD) using advanced classification algorithms like Gradient Boosting and Random Forest. Finding early signs of renal impairment in HIV-positive persons is more achievable, according to empirical research.

Martinez & Choudhury (2024): A data-driven approach for healthcare analytics is presented in this research with the objective of determining the progression of chronic kidney disease in people who are infected with HIV. Analyzing comorbidity features, medication history, and laboratory test outcomes is done by means of supervised machine learning algorithms. The most important factors impacting renal health are identified using feature

selection techniques. Machine learning algorithms can help doctors detect kidney disease early and monitor its progression, according to the results.

Natarajan & Bose (2023): The use of advanced classification approaches to predict CKD stages in HIV-positive persons is explored in this work. With the use of decision tree and support vector machine methods, clinical datasets containing information about treatments and biochemical testing are examined. Using markers of renal function, the prediction algorithms determine the disease's severity with high accuracy. In order to improve clinical decision support for the management of renal disease, the research highlights the significance of computational approaches.

Hernandez et al. (2022): A The goal of developing a predictive healthcare system is to monitor the progression of renal disease in HIV patients by analyzing their medical records. Machine learning models are trained using clinical parameters such as immune system indicators, blood urea nitrogen, and creatinine concentrations. This method classifies people into different phases of chronic kidney disease by looking at risk factors linked to kidney problems. Intelligent models can aid in early diagnosis and preventive healthcare, according to test results.

Osei & Mensah (2021): The purpose of this research is to examine the feasibility of using various machine learning algorithms to detect the progression of chronic kidney disease in HIV patients automatically. This approach predicts how a disease will develop by analyzing test findings, physiological traits, and



demographic data. To improve the precision of diagnoses, classification methods like logistic regression and k-nearest neighbors are employed. Machine learning has the potential to greatly enhance the current methods for the early diagnosis and treatment of chronic kidney disease in people living with HIV, according to the results.

4.RESULTS



Fig4.1 User login



Fig4.2 View all remote users



Fig4.3 Register your details here



Fig4.4 View all remote users



Fig4.5 Kidney disease trained and tested results



Fig4.6 Bar Graph



Fig4.7 Line chart

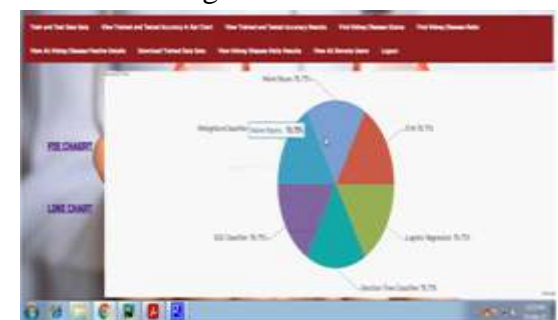


Fig4.8 Pie chart

5. CONCLUSION

An effective option for early diagnosis and clinical decision-making support is the identification of Chronic Kidney Disease (CKD) phases in HIV-positive patients



using machine learning methods. Through the evaluation of thorough patient data, including test results, demographics, and clinical symptoms, machine learning algorithms can accurately diagnose stages of chronic kidney disease (CKD) and assist healthcare providers in expedited interventions. Improved predictive accuracy, customized patient care, and reduced risk of problems in later stages are all outcomes of this method. Improved surveillance, stronger prevention efforts, and better treatment for HIV-positive individuals at risk of renal illness are all possible outcomes of healthcare systems that use machine learning.

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