

# Chapter 13

## An Intelligent Framework for Early Chronic Kidney Disease Prognosis: Hybrid Ensemble and Statistical Feature Selection Approach and Comparative Study


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### **ABSTRACT**

*We propose a hybrid wrapper approach, “Statistical-Recursive Feature Elimination” (S-RFE), to obtain an optimal and highly predictive subset of features. Max Voting Ensemble (MVE) optimization is applied to effectively predict diseases with optimal features, where the problem of finding the best classifier is formulated by represent-*

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*ing multiple objective functions as a single objective function. Significant disease predictors were validated using statistical significance values and AUC-ROC. The proposed model has been experimentally validated for real data, and a comparison of models with different benchmark classifiers is also presented. We have achieved maximum accuracy (99.25%) and F1-score (99.2), with accuracy (0.99), having the ideal count of predictive features. Our prototype generates alerts for patients at risk, as well as for any new patients who may be at risk.*

## 1. INTRODUCTION

Chronic Kidney Disease (CKD), a painful clinical condition with high morbidity plus mortality (Said and Hernandez 2014, Chen, Zhang et al. 2016, Cheng, Xu et al. 2021, Control and Prevention 2021), also predisposes the patient to other diseases. In our nation, more than 10 million cases are being diagnosed every year (Jankowski, Floege et al. 2021), and more than 15% of American adult citizens are likely to have this disease (Control and Prevention 2021). Since this disease, CKD, is often not apparent until kidney function is severely impaired, symptoms develop gradually, albeit steadily, and are mostly nonspecific to this particular illness. Some people never exhibit any symptoms and are thus only diagnosed through laboratory testing. In fact, 40% of persons who have significantly impaired kidney function are unaware that they have CKD. The progression of this disease is linked to several clinical indications, including diabetes mellitus, hypertension, and anemia (Chen, Zhang et al. 2016). Diabetes, heart disease, and kidney disease are an intertwined trio of serious health problems, one of which often causes the other two diseases. The incidence percentage of end-stage renal disease (ESRD) patients due to diabetes mellitus increased (Banerjee, Crews et al. 2014) from approximately 22.1% to nearly 31.3% between 2000 and 2015 (Cheng, Xu et al. 2021). The authors (Agarwal and Srivastava 2009, Said and Hernandez 2014, Jankowski, Floege et al. 2021) summarize the clinical consequences of cardiovascular disease (CVD) in CKD. Other consequences include an increased incidence of infections, high levels of phosphorus and potassium, low calcium levels, loss of appetite, and depression. Further, CKD can progress to ESRD, which requires repeated dialysis and kidney transplantation (Plantinga, Tuot et al. 2010). Patients with Chronic Kidney Disease (CKD) face painful health conditions or renal impairment due to a delay in diagnosis, and have to rely on various costly laboratory tests for diagnosis. Effective and early prognosis of CKD can reduce treatment costs and the risk of renal failure.

A detailed illustration of the nephron anatomy, including its components and position within the kidney, is shown in Figure 1. Kidney cross-sections show the pathway of impure blood, filtered blood, and urine. Labels are shown on the glomeruli,

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