ABSTRACT

This paper presents a new clinical decision support system for diagnosing patients with Chronic Renal Failure (CRF) which is not yet thoroughly explored in literature. This paper aims at improving performance of a previously reported CRF diagnosis system which was based on Artificial Neural Network (ANN), Decision Tree (DT) and Naïve Bayes (NB) classifying algorithms. This is achieved by utilizing more efficient data mining classifiers, Support Vector Machine (SVM) and Logistic Regression (LR), in order to: (i) diagnose patients with CRF and (ii) determine the rate at which the disease is progressing. A clinical dataset of more than 100 instances is used in this study. Performance of the developed decision support system is assessed in terms of diagnostic accuracy, sensitivity, specificity and decisions made by consultant specialist physicians. The open source Waikato Environment for Knowledge Analysis library is used in this study to build and evaluate performance of the developed data mining classifiers. The obtained results showed SVM to be the most accurate (93.14%) when compared to LR as well as other classifiers reported in the previous study. A complete system prototype has been developed and tested successfully with the aid of NHS collaborators to support both diagnosis and long-term management of the disease.

Keywords: Artificial Neural Networks, Chronic Renal Failure, Clinical Decision Support, Data Classification, Decision Tree, Logistic Regression, Naïve Bayes, Support Vector Machines

1. INTRODUCTION

Chronic Renal Failure (CRF) is defined as a reduction in function of the kidneys that develops over months to years (Goldman & Schafer, 2014). Under normal circumstances, the kidneys function to remove wastes, maintain acid base balance, and control fluid and electrolytes balance in the body (WebMed, 2014). Therefore, chronic kidney disease can lead to dangerous metabolic derangements, electrolyte abnormalities and accumulation...
of waste products in the body. CRF can result from a number of causes; hypertension and diabetes mellitus account for the majority (>60% of cases) of the causes. Other etiologies include glomerulonephritis (inflammation of the glomerulus; the functional unit of the kidney), polycystic kidney disease, autoimmune diseases, and certain medications (Bope & Kellerman, 2014). In terms of epidemiology, CRF affects 1700 per 1,000,000 population. Moreover, there are about 26 million adults with CRF in the United States. Significantly, 16.8% of the population has CRF (Saydah & Eberhardt, 1999).

The kidney disease outcomes quality initiatives (KDOQI) define CRF as either kidney damage or a decrease in Glomerular Filtration Rate (GFR) of less than 60 mL/min/1.73 m² for three or more months. According to KDOQI, CRF is classified into five stages, based on the GFR (Levin, 2006). Moreover, GFR is considered to be the best overall measure of kidney function. However, measurement of GFR is cumbersome and expensive and is usually performed for research purposes and not in routine clinical practice. Therefore, serum levels of endogenous filtration markers, such as creatinine, have classically been used to estimate GFR. For this purpose, there are two widely-used equations that incorporate the measured plasma creatinine concentration, gender, age and ethnicity to estimate GFR.

Diagnosis of patients suffering from CRF, which is based on various factors or symptoms, is a critical task in the health care process of this disease. It is complex and prone to false pre-assumptions due to some unpredictable effects. The medical decision is yet mostly based upon the physicians’ knowledge and experience rather than on intensive knowledge of the patient’s medical history. Such practice is prone to human errors which may delay diagnosis of the diseases or affect quality of the service provided to patients. Thus, automating (or semi automating) the diagnostic process by combining both knowledge and experience is expected to be of interest to the health carers working in this field. However, unlike other chronic diseases, the CRF is not yet thoroughly explored in literature.

Goals of treatment in CRF include reversal of symptoms; return the patients to their prior lifestyle and activities of daily living, maintenance of an adequate energy intake, and improving quality of life (Thomas, Kanso, & Sedor, 2008). The management plan should include dietary modifications in addition to management of high blood pressure, electrolyte abnormalities (especially potassium and phosphate), bone disease, and anemia (Goldman & Schafer, 2014). End stage renal disease (stage 5) requires the initiation of renal replacement therapy (RRT) which consists of either dialysis or renal transplantation from a donor (Bope & Kellerman, 2014).

In this paper, performance of a CRF diagnosis system which was previously reported by the authors (Al-Hyari & Al-Taee2, 2013) is improved through utilization of more efficient data mining classifiers, SVM and LR. A complete system prototype is developed and its performance is assessed and compared with the performance of the original system in terms of diagnosis accuracy, sensitivity, specificity and decisions made by consultant specialist physicians. Development of system under study was supported by availability of electronic medical dataset for CRF at Prince Hamza Hospital in Jordan. This system is expected to assist health carers in providing second opinion and thus, minimising medical errors, reducing medications’ side effects, and predicting disease progression using evidence data collected from patients’ medical history.

The remainder of this paper is organised as follows. Section 2 reviews previously reported research relevant to clinical decision support applications. Section 3 provides an overview for the proposed system along with medical attributes relevant to the disease diagnosis. Section 4 describes the study dataset and development methodology of the proposed system. The study findings and performance evaluation methods are discussed in Section 5. Finally, the closing remarks are provided in Section 6.
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