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Clinical Decision Support System for Chronic Obstructive Pulmonary Disease using Big Data Cloud Computing

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Abstract- project aims at the development of a technical solution that will leverage integrated care of COPD and comorbidities via wearable technologies, user applications and cloud computing. This work focuses on the latter part and proposes technological approaches that will enable standardized cloud based data management and analytics in a challenging multimorbid health scenario This paper proposes an Electronic Health Record (EHR) - integrated CDSS System for COPD in out-patient setting. The CDSS will utilize GOLD criteria (Global Initiative for Chronic Obstructive Lung Disease) (updated 2017) procedures for the diagnosis and treatment of COPD. The proposal will include various interventions, clinical workflow improvements, the system architecture, the logic and the user interface. COPD is one of the diseases which are spreading rapidly worldwide. Its occurrence, illness and death rates are growing and COPD is fourth main cause of death globally. COPD is generally under-diagnosed, though the disease is a life-harming, which is not completely mutable. The WHO, in the year 2012 has said that about Two Hundred and Ten Million people around the globe have COPD [1]. By 2030, COPD is projected that it will be third largest cause for mortality globally.

Keywords- Artificial Intelligence, CDSS, Classifier Ensemble, Cloud Computing, COPD, Decision Trees, Machine Learning, Neural Networks, Support Vector Machines.

1. INTRODUCTION

In last two decades, Artificial Intelligence (AI) has become a major tool in every domain in general and medical applications in particular. AI is globally accepted and used for designing medical applications to support medical practitioners in diagnosing and treating patients effectively and efficiently. Chronic Obstructive Pulmonary Disease (COPD) is a kind of obstructive lung disease. Patients suffering from COPD make breathing uneasy. COPD's incidence of sickness and death rates are rising and it is now the fourth leading cause of death globally. In this paper, we are discussing need for Clinical Decision Support System (CDSS) for COPD which helps the physicians to provide better and effective diagnosis and treatment strategies. In addition, we have designed a CDSS for COPD which is discussed in detail in this paper [1].

The CDSS encompasses Machine Learning techniques like Classifier Ensemble methods, Support Vector Machine, Neural Networks, and Decision Trees. The evolution of COPD is slow; therefore it is not diagnosed until the age 40. One of the most significant origins of COPD is by smoking. The active, passive smokers, industrial chemicals and air pollution add great risk for COPD. COPD can be just controlled as there is no permanent cure for it. Through treatment and management strategies we can improve the quality of life and reduce the symptoms of COPD. In today's era, the technology has reached a new level specially the use of Machine Learning (ML) in biomedical field, helping to diagnosis effectively, efficiently and more accurately [2].

The proposed CDSS helps the physicians to diagnosis COPD and the stage with which the patient is suffering from and also provides a suitable treatment and management strategies to the patients. The application of the outcomes generated from this research has a credible potential to contribute to lowering the level of under-diagnosis, reducing the level of misdiagnosis, and improving the quality of lung function assessment performed in non-specialist settings for COPD as well as other chronic respiratory diseases.

Modern medicine is a unique synthesis of a patient, healthcare professionals, and technology. For the past 10-15 years there has been a slow but steady increase in the use and storage of electronic machine readable formats known as electronic health records (EHRs). It is unlikely that there will be major improvements in the quality and cost of care, solely from the use of EHRs without the proper implementation and use of clinical decision support [4–6].

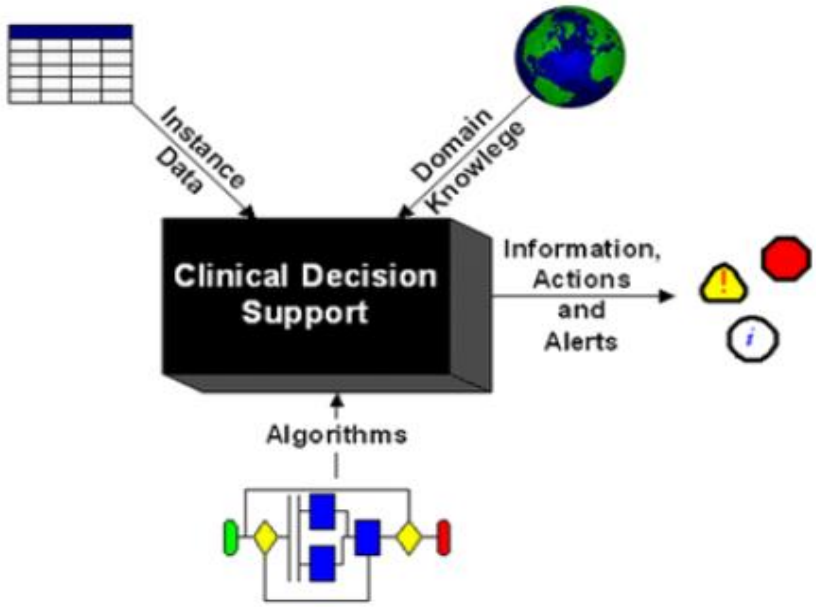

Fig.1: Principle elements of a clinical decision support system (CDSS)

A clinical decision support system (CDSS) can be defined as "software that is designed to be of direct aid to clinical decision-making in which the characteristics of an individual patient are matched to a computerized clinical knowledge base, and patient-specific assessments or recommendations are then presented to the clinician and/or the patient for a decision" [7]. Fig.1 depicts the three principle elements generally required for a CDSS, which are:

- the knowledge base contains in a computer interpretable format the rules, associations, and clinical know-how for the task at hand (e.g. screening, diagnosis, treatment, prognosis);
- the algorithms determine how to combine the knowledge base to an instance of patient specific data, which is supplied to the system in order to generate an actionable recommendation or assessment of the patient;
- The communication mechanism is the manner in which the system inputs the patient specific data and outputs the recommendations or assessments to the clinician.

2. COPD

Chronic obstructive pulmonary disease (COPD) is a poorly reversible disease of the lungs that is one of the major causes of morbidity and mortality worldwide. In the United States, it is the fourth leading cause of death after heart disease, cancer, and cerebrovascular disease.[8, 9] By 2020, it is projected to become the third leading cause of death worldwide.[8] Contrary to the trends for other major chronic diseases in the United States, the prevalence of and mortality from COPD have continued to rise[10]; the death rates doubled between 1970 and 2002,[11] and for the first time in 2000, mortality figures for women surpassed those for men.[8] In the United States, 12 million patients are currently diagnosed with COPD, but there is believed to be at least an equal number of individuals with impaired lung function suggestive of COPD who are undiagnosed [13]. Given that the majority of COPD cases are caused by smoking, it is primarily a preventable disease.

Most patients with COPD are middle-aged or elderly. In 2000, 16 million office visits were attributed to COPD-related conditions,[14] with the caseload expected to increase with the aging of the population. There is no cure for COPD. True breakthroughs in treatment, particularly disease-modifying agents, have been elusive. The only strategy known to reduce the incidence of the disease is smoking cessation. Healthcare costs associated with COPD are approaching $18 billion and $14 billion in direct and indirect costs, respectively [9]. Hospitalizations, which often result from acute exacerbations, account for approximately 40% of direct costs; prescription drugs account for 20%. Emergency department visits for COPD totaled 1.5 million in 2000 [9]. Inpatient mortality from acute exacerbation is 10% by some estimates, [16] and nearly 60% at 1 year for patients older than 65 years of age [17].

Risk Factor

Cigarette smoking is the principal risk factor for COPD. However, approximately 1 of 6 Americans with COPD has never smoked. Occupational and environmental exposures to chemical fumes, dusts, and other lung irritants account for 10% to 20% of cases. Individuals with a history of severe lung infections in childhood are more likely to develop COPD. Alpha-1 antitrypsin deficiency is a rare cause of COPD but should be suspected in persons in whom

emphysema develops before the age of 40 or those who lack the common risk factors.

Key points

- The prevalence of COPD, characterized by an irreversible limitation of expiratory airflow, is growing in the United States and worldwide, and no cure is available.
- Smoking is the major cause for this disease, thus smoking cessation in smokers is crucial. Employers are in a unique position to assist employees to stop smoking.
- Direct and indirect US healthcare costs for COPD are estimated at $18 billion and $14 billion, respectively.
- Regular use of inhaled bronchodilators to prevent and relieve symptoms is the mainstay of management.
- Short-acting inhalers provide immediate symptom relief, but long-acting inhaled bronchodilators are more effective and offer greater convenience; thus combining inhalers is often recommended.

3. PROPOSED SYSTEM

3.1. *Existing System*

COPD diagnosis is mainly dependent on 3 different aspects. We look at the symptoms of the patients, evaluation of lung function and the calculation of the reactions to gulped pharmacological agents. The above mentioned test is informative, they need lot of time to be invested and the important factor is they are dependent on the physician's professional experience.

Under-diagnosed of COPD is a major issue this may be due to several factors like the patient not visiting the doctor or the doctor not conducting required test for the diagnosis. The growth of under-diagnosed is due to the time span between the visits to the doctor. Almost all the symptoms of COPD are generally found in a regular smoker.

And normally smokers hardly pursue medical advice especially for cough and sputum production.

A spirometer is an apparatus for measuring the volume of air inspired and expired by the lungs. A spirometer measures ventilation, the movement of air into and out of the lungs. The spirogram will identify two different types of abnormal ventilation patterns, obstructive and restrictive. Spirometer (Fig.1) is one of the devices used for diagnosing of COPD. But the spirometry test can be conducted effectively and accurately only by trained staff. Spirometer test may not produce accurate results for young or aged patients [3]. The standard for identifying COPD is still under discussion [4]. Therefore a well-constructed CDSS helps the physicians to diagnosis COPD and also provide a right treatment and management strategies for the patients suffering from COPD.

Table1: Normal levels of spirometry test

Pulmonary function test	**Normal value (95 percent confidence interval)**
FEV_1	80% to 120%
FVC	80% to 120%
Absolute FEV_1 /FVC ratio	Within 5% of the predicted ratio
TLC	80% to 120%

In order to better analyse, evaluate and specify CDSSs, it is important to note the differences among these systems along other dimensions as well. There are many ways to categorize CDSSs; we have adopted an approach used by Berlin et al. who identified a comprehensive list of descriptors or features that are grouped into five categories.

Kawamoto et al. performed a systemic review of CDSS publications that reported the performance of their systems and described the particular characteristics of the system. The objective was to determine a correlation between successful CDSS and specific student currently needs. [5]

COPD is a one of the leading chronic respiratory syndrome that is affecting many people globally. COPD has key result due to the extreme illness and death rates [6, 7]. The British Medical Research Council well-defined chronic bronchitis as "day-to-day constructive cough for a minimum

3 successive months for more than 2 consecutive years. Wig et. al. in 1964 conducted a study to know the occurrence of COPD in India in some of the places like rural Delhi. His study outcome says that 3.36% in Men and 2.54% in Women was the occurrence of COPD. Viswanathan et. al. in the year 1966 conducted a study to know the occurrence of COPD and reported that 2.12% in Men and 1.33% in Women, these test were conducted in Patna, India.

Few years down the line, Radha et. al. conducted the study and noticed there was a rise in the growth of occurrence of COPD in Delhi. She reported in 1977 that 8.1% in Males and 4.6% in Females.

COPD has many risk factors, to name few are smoking (active and passive), industrial pollutants, bio-mass gas etc. COPD may also occur due to the deficiency of Alpha1-

Antitryspin and it may be found in young people. A study says that the occurrence of COPD due to the deficiency of Alpha1-Antitryspin is 1 to 2% only [around the globe. Forey BA et. al. has conducted a study in which he made conclusion that smoking is major cause for the occurrence of COPD. He also discussed the other factors which may cause COPD like air pollution, industrial exposure to dust or fumes, inhalation of bi-mass smoke and patients suffering from Tuberculosis (TB) may suffer from COPD. Depression is almost found in every patients suffering from COPD.

Worldwide it is predicted that COPD will be the 3rd largest killing dieses by 2030. The Decision Support

System (DSS) uses information and models from various areas, to upkeep a multipart decision making and solve problems with ease. DSS helps the physicians to construct and discover the inferences of their decisions.

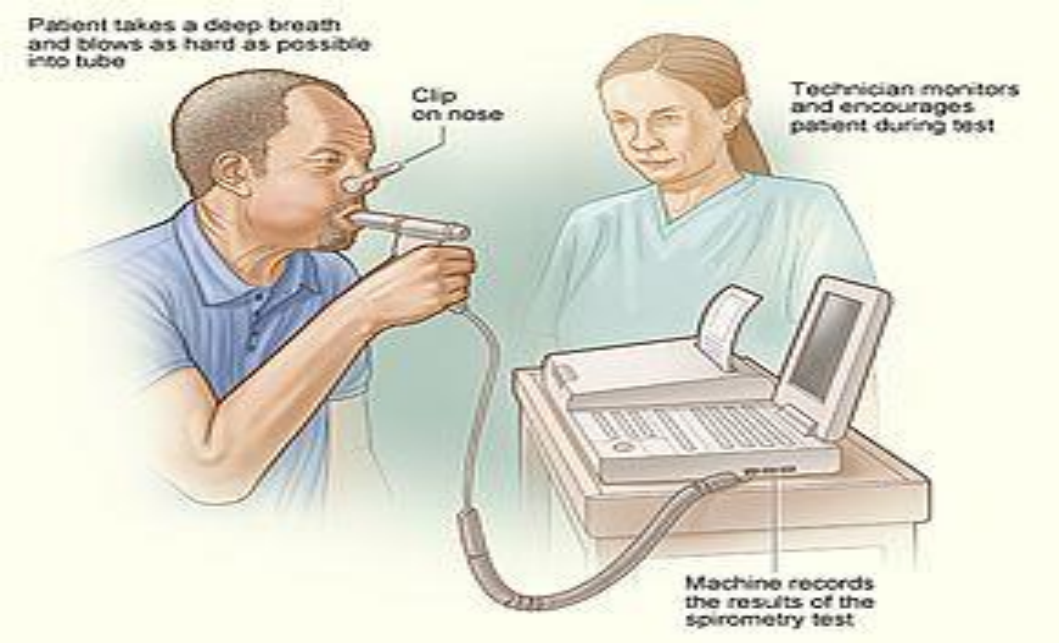

Fig.2 Spirometry device

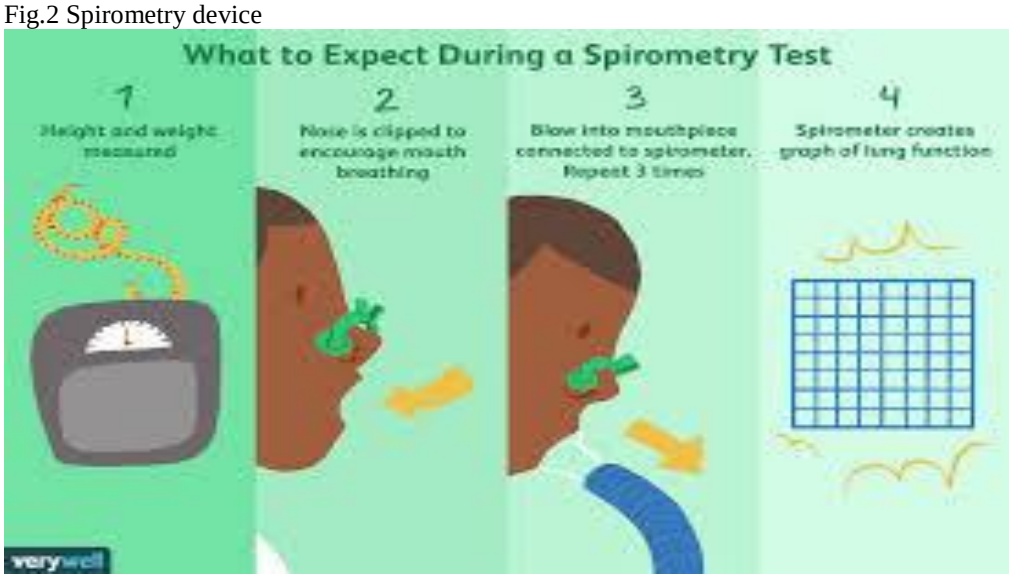

Fig.3 Spirometry: Uses, Procedure.

3.2. *Problem Statement*

Spirometry test can be conducted effectively and accurately only by trained staff. Spirometer test may not produce accurate results for young or aged patients. Therefore CDSS will help timely finding and precise diagnosis will help the patients improve their quality of life with lowering risk factors and harmful to life. Currently the diagnosis of COPD is done by a device Spirometer which is very expensive and needs a trained staff to run the spirometric test accurately. Spirometer may not produce accurate result for young or aged people. Therefore a well-constructed CDSS helps the physicians to diagnosis COPD and also provide a right treatment and management strategies for the patients suffering from COPD.

3.3. *Objective*

The primary objective of this thesis is to facilitate through clinical decision support research and development, the tasks related to early stage COPD detection so that healthcare providers (primary care clinicians, nurses, and/or allied health service providers such as pharmacists) can obtain fast, reliable and directly applicable advice when facing an existing or potential COPD patient. Specifically these clinical tasks are (i) screening / case-finding, (ii) diagnosis, and (iii) patient stratification. Furthermore, the pulmonary function test of spirometry is necessary for all the aforementioned tasks. Hence, in this thesis there is a special emphasis on the goal of ensuring high quality spirometry assessment for non-expert users through novel algorithms and applications of artificial intelligence.

More specifically, the objectives of this work are:

- Objective 1 - investigate, propose and implement the optimal CDSS architecture
- Objective 2 - investigate and develop CDSS algorithms (both knowledge-driven and/or data driven) for the clinical tasks involved in COPD management: (i) case-finding (ii) diagnosis and (iii) patient stratification.
- Objective 3 - investigate and develop CDSS algorithms (both knowledge-driven and/or data driven) for the quality assurance of spirometry (the gold standard for lung function measurement).
- Objective 4 - validate the CDSS algorithms against expert clinical professionals using existing datasets, and extending existing datasets where necessary.

4. SYSTEM ARCHITECTURE

The architecture of Clinical Decision Support System for COPD (Fig.3), we first collect the basic information of the patient followed by medical history like smoking history, alcoholic consumption rate, allergy, TB history, Cardiac problem, Asthma, Wheezing, Breathlessness, Hypertension, and Symptoms of COPD. Once the medical history of the patient is collected we conduct Spirometer test, the results of the Spirometer result values (FEV1/FVC) is used for knowing the stage of COPD the patient is suffering. The different stages of COPD with the FEV1 values are shown in the below table 1.

Table2. Classification of different stages of copd with fev1 values

COPD Severity	FEVI Results
Mild	FEVI>= 80% Predicted
Moderate	50%<=FEVI<80% Predicted
Severe	30%<=FEVI<50% Predicted
Very Severe	FEVI<30% Predicted

With the increase of life expectancy and the consequent increase in the number of patients suffering from Chronic Obstructive Pulmonary Disease (COPD), there is an urgent need for the development of an automated model which can diagnose the COPD disease accurately so that early detection and correct diagnosis can lead to disease-retarding therapies which can slow disease progression and reduce patient and caregiver stress and morbidities. Therefore, pulmonarylogist all over the world are looking for new automated model which can help in the diagnosis and management of chronic obstructive disorders. In this context, the current study aims at developing a new model which can be used by the Pulmonologist, Radiologists or Respiratory Therapist to get the information to classify disease more accurately rather than deciding through experience.

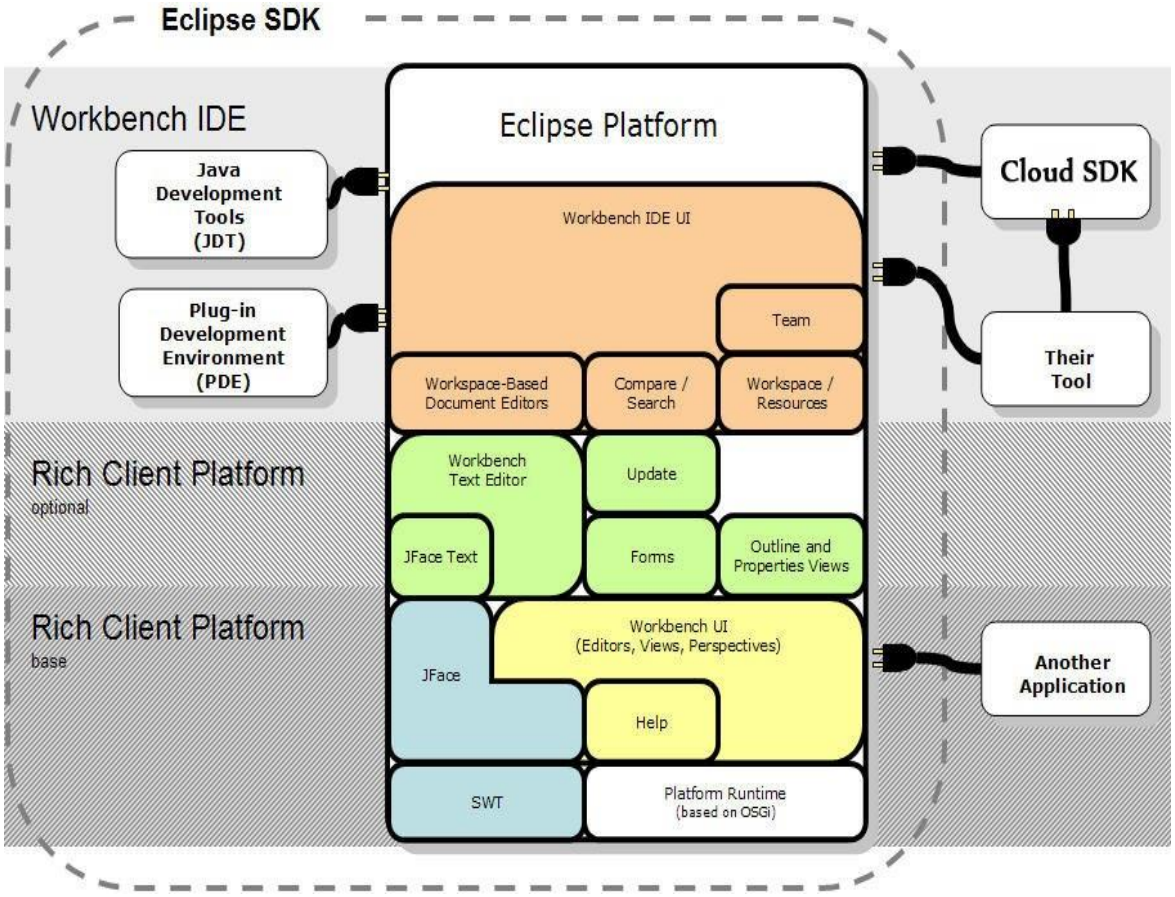

Fig.3 System Architecture

5. COCLUSION

Clinical Decision Support System is need of the hour for physicians which helps in the diagnose COPD accurately and efficiently. The proposed CDSS can classify the different stages of COPD the patient is suffering from. It also has a Drug-Drug interaction checker module to check the interactions between the COPD and its associated comorbidities diseases. The patients suffering from COPD and if their age is above 55 it is necessary to check two important comorbidities associated with COPD that is Depression and Dementia both test are part of the proposed CDSS. It also has a quit smoking test which helps the patients quit smoking if they are diagnosed with COPD. The CDSS has a well-defined Treatment & Management strategy to improve the quality of life of the patients suffering from COPD.

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