Abstract

Home treatment of Chronic Obstructive Pulmonary Disease (COPD) by a remote monitoring system can prevent progression of patient's illness and hospital admission due exacerbations. This paper presents the development of a COPD management system module to be integrated into the already existing product - OneCare Sensing, a platform able to monitor remotely biomedical parameters and/or vital signs, promoting an Ambient Assisted Living (AAL) ecosystem for patients in the comfort of their homes. Its aims is to provide a reliable and an effective system, helping patients and healthcare providers to control the COPD progress and prevent potential risk situations through alert and event settings.

1. Introduction and Objectives

Average life expectancy has been growing worldwide the last decades. In Europe the average age will move from 38 in 2004 to 49 years in 2050 [1]. We also observe an increasing of chronic diseases on population; according to WHO1, chronic diseases are the leading cause of mortality around the world, representing 60% of all deaths [2]. In this way, we can attribute at least part of the healthcare’s systems overload to the increasing demand by an older and more chronically sick population. Chronic diseases are among the most common and costly health problems, but they are also among the most preventable and can be effectively controlled. For this reason, health-care authorities are encouraging the promotion of the self-management, delivering the responsibility of controlling and managing the disease to the patient or to the healthcare provider. Monitoring and remote care solutions to manage patient’s chronic diseases using telecommunication technology are being widely implemented with special attention to computer-aided assistance.

Monitoring of COPD’s patients with new technology is part of the solution to diminish its symptoms and focus on empowering people with age related dependencies or disabilities to live independently, delay or avoid

1 World Health Organization.
institutionalisation and staying active as much and as long as possible. In four New England hospitals, in-home management of congestive heart failure has reduced rehospitalizations for heart failure by 72% and all cardiac-related hospitalizations by 63% [3]. Thus, personal health home management of acute exacerbations of COPD may relieve pressure on acute care facilities and improve patient’s well-being. As an example, there is AERIAL’s mobile application [4] that is enable to collect respiratory values and predict exacerbations, based on a Bayesean network; or the system developed by VitalMobile Health [5] to monitoring COPD patients through pulse-oximetry values and assisted ventilation. None of these systems provides all capabilities of our solution, since the former does not implement GOLD guidelines and its sensors are not totally portable and the second do not include spirometry data.

The purpose of this study is to develop and integrate a new module into OneCare Sensing platform to monitor patients with COPD: OneCareTablet Spiro. The medical team of the Pneumologist service of Idealmed Private Hospital² and ISA Intellicare³ team have participated on definition of requirements and specifications of this COPD monitoring system. A Proof of Concept will be also performed to validate the needs of patients and healthcare professionals to manage and control the disease. It will take place on Idealmed Private Hospital and in an early stage there will be given one kit (include a Tablet, a spirometer and an oximeter) for each 3 COPD’s patients that accepted to participated in this pilot study. An important feature is to test the usability of the application for the type of users of the system.

2. Chronic Obstructive Pulmonary Disease

COPD is a chronic pulmonary disease that has not a cure, but is preventable and treatable. It is characterized by airflow limitation that is not fully reversible and by inflammatory disorders with higher incidence in males in mid-life or later. Nowadays, COPD is one of the main causes of chronic mortality and morbidity and it is expected to reach in 2030 the 4th place of the most deadly diseases much due the increase of tobacco consuming.

Risk factors contribute for a faster decline of the pulmonary capacity, obstructing airways and raise the number and the degree of symptoms such as dyspnoea, chronic cough or sputum production. These side effects bring several functionally limitations and have a high impact on patients day-to-day routine.

COPD coexists with other diseases like cardiovascular disease, osteoporosis, serious infections, presence of diabetes, lung cancer and it may have impact on patient’s prognosis. Exacerbations are important events in the course of the disease, because they negatively affect patient’s quality of life, accelerates the rate of decline of lung function, are associated with significant mortality and have high socioeconomic costs. The number of exacerbations enhance with the progress of the disease causing more visits to hospitals and healthcare providers [6].

3. OneCare Sensing and General Architecture

OneCare Sensing is a system to continuously monitor biomedical values at home. It has an Android application (it is written in Dalvik and compiled to run without JVM) for Tablet and smartphones that receives the measurements from medical wireless devices as blood pressure monitors, scales and glucometers by Bluetooth and send them to the OneCare servers (Fig. 1). It allows the possibility for the healthcare professionals to monitor patient’s state of health at distance and provides assistance whenever any relevant changes occur. Measurements are available in the OneCare portal to be consulted by the patient, families or by healthcare provider [7].

4. Added Value

This project aims to integrate a new module, OneCareTablet Spiro, in OneCare Sensing to monitor COPD patients in a completely portable way. It must allow patients to have their values monitored from home, work place or other place they wish, allowing a quicker intervention of the healthcare providers with the reduction of the number of acute events. Thus, prevention, early detection and prompt treatment of exacerbations are vital to reduce the burden of COPD. To cover this lack, calculate the GOLD classification (a worldwide classification metric for disease status of patients with COPD), detect important changes in the patient status and send the information to the OneCare Sensing

³ ISA Intellicare Homepage: http://www.isasensing.com/pt/
platform (Monitor COPD).

Fig. 1: OneCare Sensing schematic [7].

To the healthcare responsible is crucial to maintain COPD patients stable and they can manage this by accessing to patient’s data on the web portal, allowing an on-time intervention and triggering a feedback action to the patient. The COPD monitoring solution will send notifications to healthcare responsible every time monitoring values fall from a certain level, increasing the ability to respond to rapid changes in the health status of patients. Besides the existing graphs, there will be a new intuitive option for the visualization of the data by the healthcare responsible: GOLD’s classification presented in Fig. 2 with patient’s grade highlighted (Supervise COPD).

The airway obstruction can be easily identified during the expiration, therefore in COPD’s expiratory flows are changed. According to GOLD, Spirometry is a test to measure the amount of air a person can breathe out, the amount of time to do so and it is required to make a clinical diagnosis of COPD. In the presence of post-bronchodilator, if the value of FEV1/FVC is below 70% and the value of FEV1 is below 80% of the predictive values, confirms the presence of persistent airflow limitation and thus of COPD [8].

However, the goals of COPD assessment are to determine the severity of the disease, its impact on patient’s health status and the risk of future events such as exacerbations, hospital admissions or even death and prescribe the right therapy. Studies like the one conducted by Gary Parkes [9] show that only assessing the degree of airflow limitation using spirometry is not enough. In addition, it is need to collect data from the patient's quality of life and from the respiratory crisis historical data. To bring this information together, GOLD produced a combined assessment of COPD, Fig 2. For further information on COPD see e.g. the Global Initiative for Chronic Obstructive Lung Disease (GOLD) [6].

As said on literature and recommendations for COPD management, spirometry is the most reliable, robust and objective method to determine lung capacity, providing numeric measurements with physiological and clinical meanings. There are other methods to diagnose a patient COPD such as respiratory sounds, chest x-rays or CT scan, but they are not easily reproduced at patient’s home or work. So, to design this system to monitor COPD patients, the choice fell on integrate a portable spirometer in OneCare Sensing.

An evaluation process of spirometers available in marketplace was made based on PECA (Plan Evaluate Collect Analyze) process and was chosen the Vitalograph’s spirometer COPD-6 (Fig.5a), the product COTS evaluated with higher classification. Although, instead of measuring the value of FVC, it measures FEV6, it was found that, for portable lung monitors, this respiratory value is highly correlated with FVC and it is even more reproducible than the FVC, according to F.W. Rosa [10].
After a patient has been diagnosed with COPD, it will need an effective COPD management plan: access and monitor disease, reduce risk factors, manage stable COPD and manage exacerbations. This project will include these components, except the second one. Each component has its own requirements to perform it well, so our solution includes one monitoring option for each component: Full, GOLD and Simple monitor. It should be noted that not all COPD’s patients have the need to perform a full monitoring.

Fig. 2: Combined Assessment of COPD [8].

Fig. 3: Biomedical values for COPD monitoring.

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3 ISA Intellicare Homepage: http://www.isasensing.com/pt/
The patient execute different tests and measurements according to the selected type of COPD monitoring, having the possibility to collect values from the Spirometry Exam, oxygen level and heart rate from Pulse-Oximetry, symptoms from the answer to questionnaires and historical data by introducing the number of crisis patient had over the last year, as in Fig 3.

Given what is said in norm “Diagnose and COPD Treatment”, patients with FEV1 value below 50% of the predictive value may be considered to perform pulse oximetry test [11]. Then, if the level of oxygen saturation in the blood is below 92%, the patient is indicated to visit the hospital. So, the application will check the biomedical values measured by the full or simple monitoring options for these conditions and send a notification to the healthcare responsible if needed. The same procedure is applied to GOLD monitor, “Manage stable disease” module, that for each time the system get valid parameters allowing the determination of the GOLD classification and if this classification decreases one level since the last GOLD monitoring, it will also send a notification to the healthcare provider.

5. OneCareTablet Espiro: First results

To date, the application covers the implementation of Simple Monitoring (Fig.4). After performing some tests, the application’s life cycle has performing well since selection of the monitoring option (Fig.4a) to the send of measurements to server (Fig.4b) and posterior visualization on OneCare portal (Fig.5b)), so it is already possible for who accessed patient's account to follow his COPD status.

Given the fact that each monitoring option is a sequence of interfaces, after COPD monitoring parameters be collected, it is presented to patients a summary for they decide if measurements can be sent to server or, for some reason (a bad performing test, e.g), they have to be rejected.

However, it was detected some issues during the communication to the external devices between the screen of spirometry acquisition values and oximetry acquisition screen: once it takes an amount of time that does not help usability of this COPD monitoring system mainly by elderly patients. We plan to improve this situation by providing more clear instructions for patients do not giving up on their monitoring plan.

![Fig. 4: a) COPD’s monitoring type screen b) Spirometry test acquisition values screen.](image)

6. Conclusion and future work

This monitoring system especially designed for COPD patients seems to be promising. OneCare Tablet Spiro is innovative and extremely wanted by patients and health care professionals in order to decrease the negative impact of this chronic disease. It must be user-friendly to promote the attendance of patients in the system and increase their feel of security on it, because typically they do not feel comfortable with this technology due to their age.

Now that the either the spirometer and pulse-oximeter have been integrated, we will continue to develop the other monitoring types (Full and Gold) with the integration of the questionnaires as well as a health alerts notification system, inasmuch as the part of the interface for manual data collection of parameters has been done and automatic acquisition through external devices too.

*Global iniciative for chronic Obstrutive Lung Disease.*
The development of this system is still ongoing, thus there are still no notifications alerts and the GOLD classification of patients to show.

Fig. 5: a) Vitalograph’s COPD-6 spirometer b) Measurements visualization on OneCare Sensing portal.

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