A Definition of a Coaching Plan to Guide Patients with Chronic Obstructive Respiratory Diseases

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Abstract. With such a noticeable increase in the number of people with chronic obstructive respiratory diseases the effectiveness of traditional healthcare systems has worsened significantly over the last years. There is an opportunity to develop low cost and personalized solutions that can empower patients to self-manage and self-monitor their health condition. In this context, the PHE project is present whose main goal is to develop coaching solutions for remote monitoring of patients and that can be provided through the exclusive use of the smartphone. In this work we explore how patients with chronic obstructive respiratory diseases can adopt healthier behaviors by following personalized healthcare coaching plans used throughout their daily lives. We explain how a coaching plan can be defined to guide the patient and explore the mechanisms necessary to operate automatically and adapt itself according to the interactions between the patient and the system. As a result, we believe to be possible to enhance user experience and engagement with the developed system and consequentially improve his/her health condition.

Keywords: CORD · mHealth · Personal healthcare · Self-monitoring

1 Introduction

Chronic obstructive respiratory diseases (CORD) affect a large percentage of the world's population and is already the third leading cause of death in the world [1, 2]. Furthermore, is estimated that just in Europe, the cost of respiratory diseases exceeds the €380 billion [3]. Moreover, CORDs are progressive and worsen over time. This means that there is a high prevalence of CORD throughout a person's life cycle (asthma starting in early ages and other chronic obstructive pulmonary diseases are detected from the middle-age onwards). The progressive deterioration of CORDs often leads to frequent exacerbations, which in turn results in frequent hospital admissions. As such, patients require regular medical consultations and constant monitoring of their health throughout their daily lives. Health care in the context of CORD management has traditionally been provided through either face-to-face interventions between the

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patient and the healthcare professional, separated by periods without structured support or by the use of self-monitoring tools (such as flow meters, handheld spirometers, oximeters) and self-management tools (such as symptom diaries, manuals, pamphlets and web resources) between consultations. The reality, however, is that the constant monitoring of patients' condition has become a burden on the healthcare providers [4] and traditional healthcare delivered through health professionals' face-to-face interactions becomes more difficult to achieve. As such, the necessity to develop cost-effective solutions to monitor and treat patients with CORD has increased significantly in recent years [5]. In this scope, concepts such as mobile health (mHealth) have emerged towards the self-management of the patient's disease, by providing mobile systems that are capable of monitoring patients' health status and giving customized feedback about activities and behaviors that can be done to improve health and wellbeing [6, 7]. Furthermore, mobile devices now offer a wide set of features and embedded sensors and the development of solutions that can exploit these components without or with minimal access to external devices other than the smartphone itself seem to be adequate and easy to integrate in the daily lives of patients to measure and monitor patients' current health condition and support them in the management of their diseases [8]. Therefore, coaching solutions delivered through smartphones (mCoaching) that can combine data gathering and processing, gamification elements for user engagement and support to behaviors change seem to be an ideal platform to deliver both simple and effective self-management interventions, while maintaining or improving quality of care and reducing costs, specially in the context of CORD management [9–12].

The work here proposed is part of the PHE project[1] which aims to empower people to monitor and improve their health using personal data and technology assisted coaching. To achieve this goal, PHE will apply innovative and intelligent measuring and monitoring tools for preventive healthcare and allow cost-saving and self and home-care solutions with increased patient involvement. Furthermore, PHE project will exclusively use the smartphone and its embedded sensors to acquire all the necessary data to provide personalized support to the CORD patient. In this work we explore the personalization given to the CORD patient by providing him/her a coaching plan to follow and to adopt healthier behaviors throughout his/her daily life. A conceptual definition of the coaching plan is presented which includes four different phases of operation (initialization, execution, completion and post completion). We describe each of these phases and explain how the coaching plan can enhance the personalized healthcare provided to the patient and define a proactive mechanism which is not completely dependent on user input but also capable of adapting itself based on the data collected over time while the patient uses and interacts with the PHE system.

[1] https://itea3.org/project/personal-health-empowerment.html.

2 Proposed Model

The work here proposed has been extended from [13] in which an architecture for the coaching module to support self-monitoring of CORD patients was defined. This coaching module is responsible for processing patient data and generate recommendations to improve patient's health condition accordingly. Furthermore, and as will be explained, the proposed model can operate independently from the PHE system due its generic structure. Three main type of users have been identified which interact with the PHE system: patient, healthcare professional and health manager. The first user is the main user and will interact with the developed system by inserting clinical information and receiving recommendations to adopt healthier behaviors and improve health condition and wellbeing. The healthcare professional can access patient clinical information and provide specific guidelines (through coaching plans). The health manager can access and update available domain knowledge (which includes rules and associated variables, recommendations, user profiles and non-specific coaching plans). In this section, we first describe the architecture of the defined coaching module considered for the CORD Management in the PHE system and associated components. The Coaching Plans component is then discussed in more detail as it represents the novel feature proposed in this work.

2.1 PHE Coaching Module

According to Fig. 1, three main layers have been identified for the considered architecture: Service Layer, Business Layer and Data Access Layer. Within the Service Layer, a Web API has been developed to provide a set of services that can be accessed internally within the PHE system, but also externally by other systems. The Business Layer includes four main components which combined allow the definition and model of knowledge regarding a certain domain. The Rules component specifies the set of conditions associated to the patient's clinical data and that are necessary to identify possible recommendations to send to the patient. These conditions require the

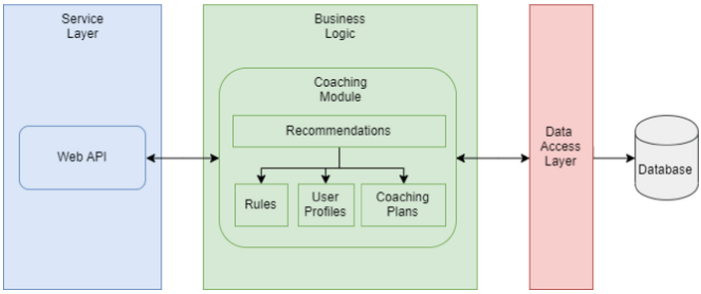

Fig. 1. Coaching module architecture for self-monitoring of CORD

validation of different health variables, which in the case of this work correspond to both patient demographic data and health state (for example, gender and weight, smoke exposure, etc.). Besides that, each health variable has an associated periodicity and to measure/collect its current value a mechanism has to also be defined to promote a specific interaction between the patient and the system (for example, to know if an exacerbation was detected within the last week, the associated health variable has to be updated weekly using an interaction mechanism such as a visual notification). The definition of each rule and corresponding recommendation is structured in a clinical matrix format and are based on scientific evidence. Figure 2 shows an example of a rule that was defined for a recommendation to send to the patient.

```
rule "Asthma"
when
    variable0:Variable(Name=="Asthma",Value=="yes")
    variable1:Variable(Name=="Pregnancy",Value=="yes")
    variable2:Variable(Name=="Sex",Value=="female")
then
    recommendation.setRecommendation("Counsel women with asthma regarding the
    importance and safety of continuing their asthma medications during
    pregnancy to ensure good asthma control.");
end
```

Fig. 2. Rule example for CORD

User Profiles specifies all the characteristics that can identify a certain profile which is assigned to the patient. So far two main groups have already been identified (Asthma and Rhinitis). Furthermore, the remaining groups will be defined using clustering techniques to identify users sharing characteristics related to patient's demographic data, context, etc. The Coaching Plans component includes the selected recommendations to be provided to the patient in a given time frame. Furthermore, each coaching plan is related to a specific health topic which has been identified according to the literature on clinical evidence and medical guidelines. This component will be discussed in the following subsection of this work. The recommendations component verifies and processes the received data according to the defined Rules, User Profiles and Coaching Plans and selects suitable recommendations. The Data Access Layer serves as a middle layer between the Business Logic Layer and the different data sources and controls all the read, insert, update and delete operations on the database. The database contains information regarding the patient's clinical data, health variables associated with recommendations, the history of provided recommendations and respective feedback. It also contains knowledge provided by health professionals, rules used for the generation of recommendations, the defined user profiles and respective characteristics, and the coaching plans provided to each patient. The coaching module has been developed using JBoss Drools framework as it provides intuitive rule language for non-developers, supports flexible and adaptive process, enhances intelligent process automation and complex event processing and is easy to integrate with web services.

2.2 Coaching Plan

According to the literature [1], and in the context of CORD, coaching plans refer to different topics related with the management of the disease. In the case of this work, we have identified 15 minor and 5 major topics through the study of current medical guidelines and clinical evidence to drive individualized coaching. For that we considered the results published in American College of Sports Medicine, American College of Rheumatology, Allergic Rhinitis and its Impact on Asthma, British Thoracic Society, The Association of Chartered Physiotherapists in Respiratory Care, Australian and New Zealand guidelines for the management of chronic obstructive pulmonary disease, Global Initiative for Asthma, Global Initiative for Chronic Obstructive Lung Disease, Royal Dutch Society for Physical Therapy, National Asthma Education and Prevention Program, National Institute for Health and Care Excellence, Direção-Geral da Saúde. Norma sobre Diagnóstico e Tratamento da Doença Pulmonar Obstrutiva Crónica, Portuguese Ministry of Health and U.S. Department of Health and Human Services. Each considered topic is presented in Table 1.

Table 1. Topics for CORD management

Major topic	Minor topic(s)
Chronic Respiratory Diseases	Symptoms
Concomitant Diseases	Respiratory Infections; Sleep Disorders; Rhinitis; Food Allergy
Exposition to External Agents	Smoking Habits; Occupational Hazards; Allergens
Non-pharmacological Therapies	Physical Activity and Exercise; Breathing Exercises and Airway Clearance Techniques
Pharmacological Therapies	Adherence and Inhaler Techniques; Devices and Active Principles; Vaccinations
Other	Anxiety; Depression; Stress; Nutrition

Four steps have been identified to define a coaching plan in the context of the PHE system: Plan Initialization, Plan Execution, Plan Completion and Plan Post Completion.

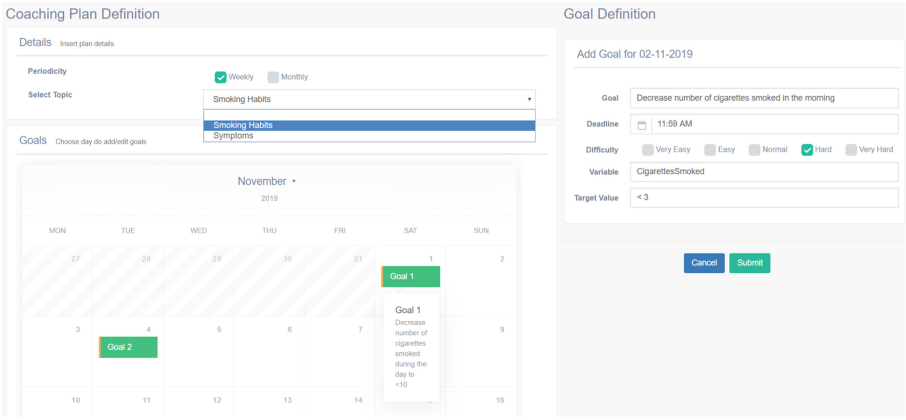

Fig. 3. Manual coaching plan and goal definition

Plan Initialization. The coaching plan initialization is a process that can configured manually or automatically by the user. Manual coaching plans are defined either by the healthcare professional or the health manager and differ by the fact that they can target a specific patient (coaching plans created by the healthcare professional) or not (coaching plans created by the health manager). Automatic coaching plans are created by the patient himself/herself and are based on the coaching plans defined for the associated user profile.

As can be seen in Fig. 3, coaching plan has an associated periodicity which can be weekly, monthly or non-repetitive. The user must then select the topics and intended goals to be achieved with the coaching plan. We define a goal as a desired state regarding a specific patient-related variable according to a certain topic. For example, in the context of smoking habits, one objective could be to decrease the number of cigarettes smoked per day. Furthermore, to achieve a certain goal a list of intermediate goals can also be defined. Following the given example, intermediate goals which would allow the patient to decrease the number of cigarettes smoked per day could be to start the coaching plan and smoke a maximum of 3 cigarettes in the morning, 3 cigarettes in the afternoon and finally 3 cigarettes in the evening/night. This means that when defining a goal and its associated intermediate goals, the user should also define a deadline to achieve each identified goal. The flowchart presented in Fig. 4 shows the coaching plan initialization process that was described.

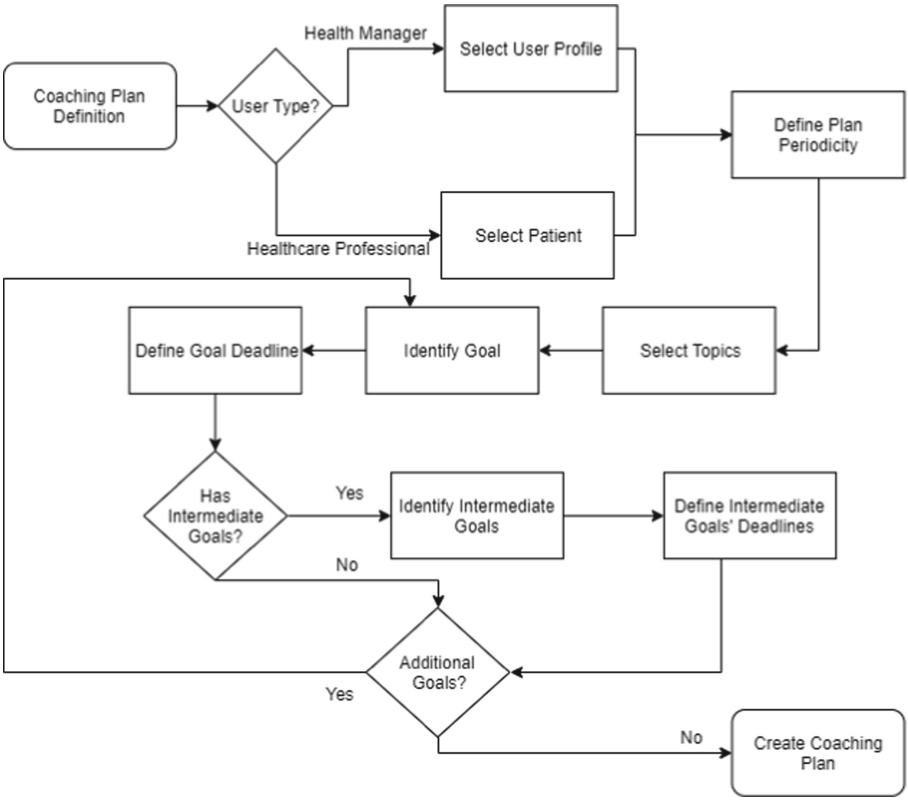

Fig. 4. Manual coaching plan initialization flowchart

Plan Execution. In the second step, the coaching plan is put into practice and the targeted patient is monitored according to the goals identified. As such, all patient-related variables considered for the coaching plan are collected through patient interaction with the PHE system by having the patient insert new records and values for those variables. The coaching framework will process those values and whenever a recommendation is verified (if those values trigger all the conditions necessary to activate a recommendation) it will be sent to the smartphone and provided to the patient in different formats (such as an alert or a notification). In parallel, the coaching framework will also verify if any goal established for the coaching plan was achieved and update the coaching plan accordingly. The flowchart presented in Fig. 5 shows the coaching plan execution process that was described.

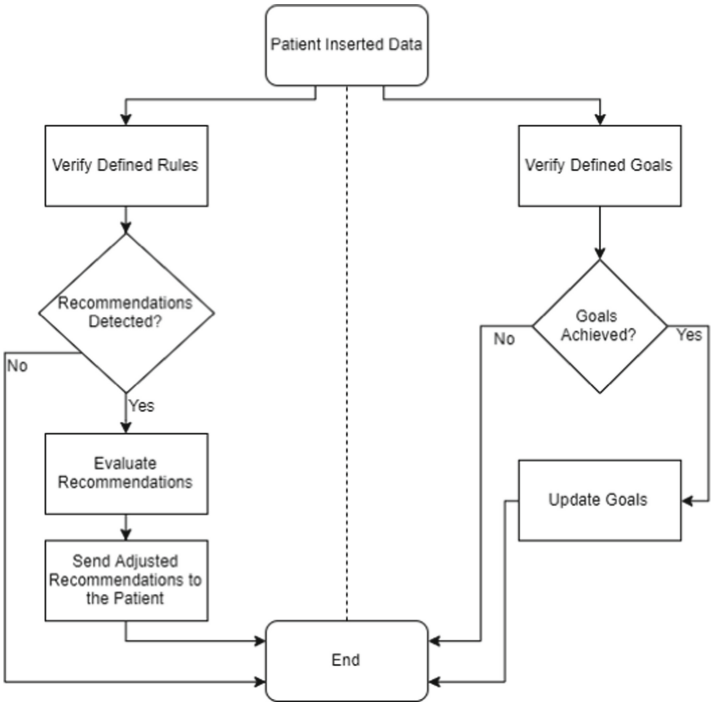

Fig. 5. Coaching plan evaluation flowchart

The ideal time to provide recommendations to the patient will depend on the feedback provided while using the developed system. Several feedback mechanisms are defined to identify the best moments during the day to provide recommendations to the patient and to filter positive recommendations among all the available recommendations:

- Recommendation Evaluation – Whenever a detected recommendation is provided to the patient, he/she can rate the same whether they liked or disliked it. This way, unwanted recommendations can be filtered in future similar scenarios.
- Goal Evaluation – Whenever patient data is inserted which can modify the current state of a defined goal, it will be evaluated to understand whether the patient was capable of achieving the desired state configured in the coaching plan or if the state associated to an already achieved goal was deteriorated into a previous state.
- Patient and System Interaction Evaluation – Different data can be obtained from the interaction between the patient and the system. In this case, it is considered both system utilization rate (which corresponds to utilization times and frequency of use of the system, and response time (verify whether the patient answered a provided recommendation or not and the corresponding response time). This information can then be used to readjust deadlines and understand the most adequate times during the day to interact with the user.

This way it will be possible to avoid unnecessary and very repetitive interactions with the patient which may tire him/her and only increase his/her disinterest to keep using the developed system. All the previous feedback mechanisms are considered in the adaptative goal setting procedure that is executed automatically every day to evaluate and readjust goals based on user performance for that day. For this, we have taken into account the model proposed by Akker and colleagues in [14] where they defined an automated personalized goal-setting feature in the context of physical activity coaching in which they determined the goal line for an upcoming day by combining either stored data from that day of the week or in default parameters defined by the healthcare professional with the new acquired data. We have considered a similar process which updates the coaching plan goals automatically every single day by comparing the current acquired data from that day with the historical data (or with the default parameters in case no data was provided by the user until then) for the same day. We have considered both goals completion rate and average goals' difficulty as performance measures to identify if the user improved or worsened and depending on the difference between both values the goals for the upcoming days will be updated accordingly. After that we will consider the data obtained from patient and system interaction to measure if an established deadline to achieve a certain goal could also be adapted depending on the average utilization rate and response time that is obtained.

Plan Completion. The third step considered is the completion of the defined coaching plan. The condition necessary to complete a defined plan, and as explained above, is whenever the defined goals (excluding all the intermediate goals) have been achieved. After this the patient is provided with a report containing all the information on his/her performance while executing the coaching plan which includes the total number of goals achieved (including all the intermediate goals) and other metrics such as the time needed to achieve those goals, the number of deteriorations verified, the number of generated recommendations while following the coaching plan, the number of approved and disapproved recommendations, among others.

Plan Post Completion. The last step is the coaching plan completion in which the achieved results are verified after the plan has been completed. As such, whenever the patient provides more clinical data after he/she has completed a coaching plan, that information will be verified once again to understand if the patient health condition was deteriorated and if any achieved result has been compromised (For example, if the patient completed a smoking cessation coaching plan successfully and then started smoking again). As a result, the healthcare professional will be notified so that he/she can set a new coaching plan for that patient.

3 Conclusions and Future Work

The increasing number of people suffering from CORD has led to an overload of healthcare resources to monitor and support patients in the management of their disease. Traditional methods of aiding these patients are no longer cost-effective nor adequate more so when new treatments combining technological developments become more relevant and allow patients to better self-monitor and self-manage their health

condition. In this context, mobile coaching technologies can exploit the different features and embedded sensors available on the smartphone and are now being considered as an alternative option to directly monitor patients with CORD. The solution proposed by the PHE system brings further advantages by providing a healthcare solution that does not require any additional external devices other than the smartphone itself and that is therefore more friendly and appellative cost wise to the patient and that can be easily integrated in his/her daily life.

In this work we have presented the overall architecture of the coaching module which is integrated in the PHE system and that is composed, among several components, of a coaching plan which is used to guide patients with CORD to adopt better and healthier behaviors. We have provided a conceptual definition of the different phases necessary for this component to operate correctly and explained how it can automatically adapt itself to the user preferences and interactions with the PHE system.

As future work we intend to integrate the defined coaching plan in the developed protype for the PHE system and study its effectiveness and usability in a real case scenario. After that, and as we collect more data from the interactions between the patient and the PHE system, we will be able to apply more intelligent mechanisms (predictive analytics) to enhance the interactions and recommendations provided to the user and predict whether a certain interaction or recommendation is adequate at a given moment in time or not.

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