



# Monitoring Chronic Respiratory Disease Patients Efficiently (ANAPNEO Project)

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**Abstract:** In recent years, chronic respiratory disease patients do not have regular and frequent communication with their physicians, as they should, for various reasons: lack of time, economic difficulties or negligence; this in turn may induce exacerbation of their chronic condition and possible hospital admission. On the other hand, closer connectivity of humans and systems, through use of the latest technologies of smartphones, clouds and intelligent data mining, can ensure uninterrupted care and chronic ailment crisis avoidance. In this paper is described an integrated solution that: A) Connects chronic respiratory disease patients to their physicians through a cloud infrastructure and online services, and a mobile application, thereby enabling regular monitoring of patients and avoidance of medical emergencies. B) Proposes a new, sustainable and innovative business model that provides at low cost and at significant savings to the national health system, a preventive health service for chronic patients, by combining human medical expertise with state-of-the-art online service delivery based on cloud computing, data analytics and mobile applications. ANAPNEO project is to create a personalized solution for the optimal interaction between the patients with COPD and the medical staff that monitors and supports them. At the end of the day ANAPNEO a) facilitates patient communication with treating physicians through online services and mobile applications, ensuring ongoing patient monitoring and medical emergency avoidance, b) improves the quality of life of chronic patients, combined with a very significant cost reduction and c) proposes a new, sustainable and innovative business model that ensures, at low cost and significant savings for health organizations, preventive health service and personalized approach support for chronic patients, combining human medical experience with modern online services.

**Keywords:** Mhealth, Mobile Applications, Analytics, Chronic Respiratory Diseases

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## 1. Introduction

### 1.1. Scope of the Project

The current state of research in both the field of Chronic Obstructive Pulmonary Disease (COPD) and the field of technologies that can be used for the sound and efficient management of medical data is rapidly changing with new results emerging each day. Almost all health care providers have the responsibility of managing patients with chronic respiratory diseases by providing medical support to the patient on a regular basis. The frequency of these visits usually depends on the severity and nature of the disease. However, visits to check the patient's state of health are quite expensive

and according to the current literature ineffective [8]. For example, many patients do not follow or forget doctors' instructions, neglect to take their medications and lifestyle rules, and often postpone doctor visits. When the patient visits the doctor only once, maybe twice a year (which is already a big effort for both sides due to the current state of the health system), it means that the patient has to self-manage his chronic respiratory illness. Unfortunately, most of the time, without an effective way. This results in an exacerbation of the disease, which could lead to hospitalization. Such incidents dramatically reduce a patient's quality of life and add enormous costs to the healthcare system.

COPD patients do not have frequent contact with their doctor as they should, for a variety of reasons, mainly due to

lack of time, negligence or financial difficulties, risking seizures and possible hospitalization. In this paper, we describe our solution based on the project with the distinctive title "ANAPNEO" which presents a modern approach with connection of patients and systems, using the latest technologies of smart phones, cloud computing, ensuring uninterrupted treatment to avoid chronic disease seizures and consequent of the patient.

According to the World Health Organization, 450 million people worldwide suffer from COPD. COPD is the leading cause of death worldwide [9]. It is estimated that COPD is responsible for more than three million deaths per year, while worldwide it is responsible for more than 29 million years of disability-adjusted life. life-years). The total cost of drugs, hospitalizations for the whole treatment of the disease is huge e.g. in the US 30 billion dollars per year are spent [10]. The World Health Organization has classified COPD as one of the five most dangerous diseases of the next millennium and is coordinating efforts to address it, such as the Global Initiative for Chronic Obstructive Lung Disease (GOLD). In Greece, the figures are also very aggravating. Nine adult smokers out of 100 in our country suffer from the disease (8.4%), ie about 600,000 Greeks are ill. 56%, ie about 336,000 of them do not know that they suffer from the disease and in fact half of the sufferers continue to smoke ignoring the risk they are at because of the disease [1].

Usually, COPD is recognized when it is already well advanced, either during an acute exacerbation of the disease, or because the symptoms have become so severe that the patient is forced to see a doctor. The disease lasts for many decades, while in its advanced form, it seriously reduces the quality of life of patients and fixes them at home in machines with continuous oxygen supply due to respiratory failure. In the final stages the patient often needs hospitalization, even in an intensive care unit, greatly increasing the health costs. Although COPD is a disease of the lungs, it can have significant systemic effects (other vital organs are also affected, such as the heart, muscles, etc.). In addition, it is associated with many co-morbidities (such as heart failure, metabolic diseases, sleep apnea-hypopnea syndrome, depression, etc.), making patient management particularly difficult.

Therefore, the prevention of the disease in general and especially its exacerbations is the primary concern of the medical community and of this proposal. Several studies have done research on how providing medical care with the help of IT tools and online services could improve patients' quality of life and reduce COPD exacerbations.

Systematic literature references include studies conducted to examine whether telemedicine care (telemetry / telephone calls / home visits from specialized nurses) has improved the management of chronic diseases. Several studies have used mobile application technologies to monitor patients and deliver medical care in a cost-effective way for both patients and doctors [2-6].

Nevertheless, no study used technologies and architecture similar to ANAPNEO's approach. A key difference of the

system architecture of our approach with the above studies is that the ANAPNEO system will implement mobile applications for both doctors and patients. Therefore, patients can use an alert and interaction service for immediate emergency alert. An additional feature of the ANAPNEO system will be that the mobile application addressed to the patient will automatically collect data from mobile devices (eg GPS location), which can be used in future data analysis. In addition, the most interesting feature of the ANAPNEO approach, which has not been taken into account in other studies, is the support of data processing using cloud computing technologies, to help physicians dynamically adapt treatment plans to their patients, with a particular economical and efficient way. The combination of cloud computing technology, data analysis and mobile application technologies provides health services that improve patients' quality of life and significantly reduce healthcare costs.

Some projects focus on combining text analysis and storage, providing high computing power in short intervals for new drug analysis, and establishing secure communication that will enable medical documentation [7]. None of the above projects investigates the use of cloud computing environments for synthesizing services to offer new quality functions in the field of health, does not meet modifiable safety requirements, does not provide user interfaces (frontends) in cloud computing applications, as developed in ANAPNEO.

The bottom line is that while patients and their physicians are following current knowledge and guidelines for managing the disease, the actual management of chronic diseases needs a thorough upgrade. Therefore, in order to achieve better classification of the disease, better monitoring of patients and more effective management and treatment of exacerbations, with the help of ANAPNEO, it is proposed to create a technological product that will use information technology to manage patients' medical data and the possibility providing easy and personalized treatment with the use of applications for smart phones [11-15].

## 1.2. Project Objectives

The main goal of the ANAPNEO project is to create a personalized solution for the optimal interaction between the patients with COPD and the medical staff that monitors and supports them.

The ANAPNEO project proposes the creation of a product, which will use information and communication technologies to manage the medical data of patients suffering from COPD and will enable the provision of easy and personalized treatment, using applications for smart phones.

The result of the ANAPNEO project is the better monitoring of patients and the most effective management and improved treatment of COPD exacerbations, the provision of personalized advice, guidance and monitoring of chronic COPD patients and the immediate industrial utilization of the produced technology.

Objective 1: Design, Implementation and Evaluation of the COPD Patient Self-Management System.

The implementation of innovative ideas in the field of online services in medicine and the production of a technological product that will contribute to the improvement of patients' health and the saving of resources needed for the management of medical services.

Objective 2: Creating new ways of self-management of COPD patients and interaction with medical staff to improve their quality of life.

The innovative approach to the way the patient interacts with the medical staff that monitors him will have a decisive effect on improving the patient's quality of life, through the most complete and complete monitoring of the disease. In addition, the use of information and communication technologies will significantly reduce the cost of health care for both the patient and the national health system.

Objective 3: Commercialize innovative technologies to support individualized chronic patient self-management approaches.

The economic utilization of the technological product is a key parameter of the sustainable design and implementation

of the ANAPNEO project. By achieving this goal, the aim is to highlight the innovative idea and the product produced as a result of research and technological activity.

## 2. Project Implementation Methodology

### 2.1. Implementation Approach

The approach of the ANAPNEO project is based on the know-how of the members of the project team mainly from involvement in similar projects. The know-how is reflected in a series of methodologies, which are subsets of an integrated methodological framework and are applied according to the specific needs of each project. It is worth mentioning that for the needs of each project the project team modifies the methodologies and tools so that they adequately meet the requirements of ANAPNEO. The steps for the implementation of the Project are shown in Figure 1 and correspond directly to the corresponding sections of work, which are described in detail below.

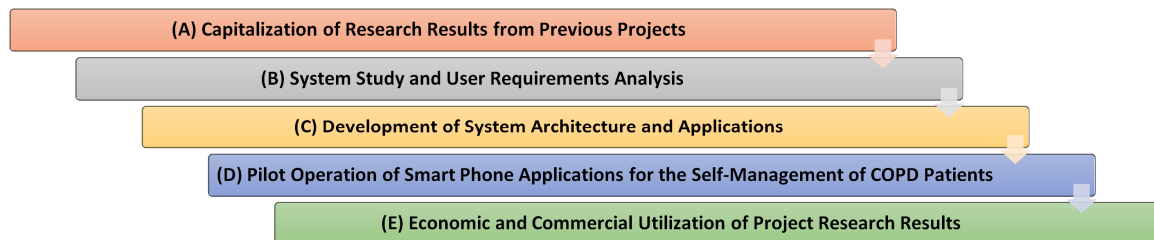


Figure 1. Steps for implementing the ANAPNEO project.

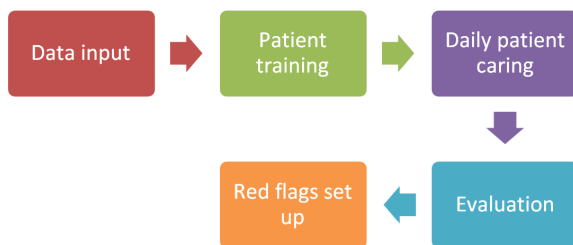


Figure 2. Implementation algorithm ANAPNEO project.

### 2.2. Steps of Implementation

Characteristics of the methodological steps that will be used are critical requirements which must be met in each case, making the given methodology suitable for the context, environment and objectives of each project.

The ANAPNEO project will include the following project implementation methodologies, due to its interdisciplinarity and complexity:

1. Modern Educational Approaches.
2. Methodology for Implementation of Information Systems / Internet Applications.
3. Project Management Methodology.
4. Quality Management & Assurance Methodology.

Based on this methodology, the life cycle of the Project consists of four stages / phases, which indicate the progress of the overall project:

1. Starting Stage: Defining the vision (final system) and the business environment that will operate, as well as the general & individual objectives of the project ANAPNEO.
2. Development Stage: Detailed identification of the characteristics of the final system, technological analysis & design of its architecture, final planning of implementation actions / repetitions.
3. Construction Stage: Implementation & completion of the components and subsystems of the final system and validation of the system transition plan in real conditions.
4. Pilot Operation Stage: Transition of the system to real conditions. Tasks such as installation, training & user support and settings are included until users are completely satisfied.
5. Horizontal Actions: It concerns all the actions of management and publicity of the project ANAPNEO as well as the study actions for the commercial utilization of the results of the Project.

### 2.3. ANAPNEO Algorithm

1. Introduction of anthropometric and laboratory (spirometry) data of patients and their classification according to the severity of the disease (A, B, C, D) in the central database (CENTRAL DATA BASE).
2. Patient education in the operating system they will use

on their Smartphone, which will include certified questionnaires and measurement of biomarkers (such as measurement of Oxygen saturation, measurement of heart rate / minute, measurement of maximum inspiratory flow).

3. Daily monitoring (self-assessment) and recording of patients' symptoms using questionnaires and measuring biomarkers.
4. Evaluation of the overall condition of the patient per month (CCQ questionnaire).
5. Establishment of alarm points (RED FLAGS) for the patient to refer to his doctor.

### 3. ANAPNEO Project Presentation

#### 3.1. System Study and User Requirements Analysis

This section aims to analyze the requirements of users in relation to the system under development and to design a complete set of mock-ups (UI Mock-ups) for the characteristics of the system interface.

The aim of this section is to produce the final design solution that will be in line with the functional characteristics of the system at the level of architectural solution but also the needs and requirements of users, based on usage scenarios and design approach.

##### 3.1.1. Protocols for the Collection and Analysis of Medical Data

The object of this activity will be the recording of medical, therapeutic and nursing data completed by the medical staff and concerning the documentation of treatments and other medical data of patients suffering from COPD. There will be precise definition and standardization of procedures and workflows for the receipt and use of available medical data and their enrichment to harmonize with the specifications of use and analysis of existing health standards. This action will finalize the methodologies for the management, control and quality assurance of medical data, which will be followed during the implementation of the project.

##### 3.1.2. Collection and Analysis of End-User Requirements

This activity focuses on the needs and expectations of users in relation to the system under development. Based on the research that will be carried out with the participation of end users, the appearance and the expected functionality of the system will be determined.

Key issues with collecting receivables include:

- (a) supporting the activities of user groups through the system.
- (b) the creation of services that have been designed with their participation but also by interdisciplinary teams and
- (c) ensuring the availability of the technologies necessary for the execution of the project.

The collection of requirements will be done through interviews with the users of the systems (medical staff and patients). Usage scenarios will then be created which will be described as sequences of events. Script development is an

activity that involves users, usability experts and software engineers. The scenarios should be understandable to the end users and correspond to their idea for the application, while at the same time being sufficiently technical so that the software engineers can support the logic of the system. Finally, all the scripts will be recorded in UML.

##### 3.1.3. System Design and Evaluation

This activity will design the system architecture based on user requirements, usage scenarios and the design to be performed in previous activity. The result will be the overall system architecture, its distribution into functional modules and components, with detailed specifications for each of them, including operational and operational requirements, as well as details on software interactions and interfaces.

The architecture should address the diversity of equipment (hardware and software) and allow for future changes, updates and upgrades. This activity will identify the general methodologies, technologies and standards that will form the basis for the technical and scientific work to be performed during the development of the system.

#### 3.2. Development of System Architecture and Applications

The purpose of the module is to create two applications, the Patient Application and the Doctor Application. In addition, there will be a web portal where both doctors and patients can execute their usage scenarios.

##### 3.2.1. Development of a Medical Data Service System

This activity will develop the "backend system" of applications that will be hosted in a cloud computing environment to ensure the cost-effectiveness of the proposal. The Medical Data Server (Health Server) will be at the top level of the architectural coatings of the "backend system", implementing the formats and protocols through the applications and the "user interface" (frontend). It will send the incoming requests to the appropriate services in the cloud computing and return their answers to those who made the request. It will also manage push notifications and SMS requests to the respective clients.

##### 3.2.2. Application Development for Doctors and Patients

The purpose of the second section is to create two applications, the Patient Application and the Doctor Application. In addition, there will be a web portal where both doctors and patients can log in and have the same functionality as in mobile applications. This feature will help increase potential users, including patients and doctors, who do not (yet) use smartphones. All interface applications will provide data entry functionality through a Graphical User Interface (GUI) and send requests and data sets to the appropriate services in the cloud and show responses to requests. users. It will also manage in-app notifications and outgoing text messages (SMS) to the respective patients / doctors. In addition, this module contributes (via interface applications) to the development of an innovative cloud-based computing platform.

### **3.2.3. Medical Data Management and Analysis Service**

The purpose of the activity is to focus on the implementation of the functionality of the basic services of the data warehouse such as loading, search and access. Data analysis services will be implemented on the basic functionality of the repository, in such a way that we recognize existing standards for displaying medical data and related procedures (eg electronic medical record standards or HL7 recommendations and standards) as much as possible. In addition, in this action, based on existing data analysis services, we implement high level and customized corresponding services.

### **3.3. Productive Operation and Business Evaluation of Smart Mobile Phone Applications for the Self-Management of COPD Patients**

The aim of this module is to integrate all technologies and theoretical background into a unified system, which will be evaluated repeatedly, in order to ensure its productive operation and optimize its performance.

#### **3.3.1. Pilot Application of Productive Operation of Smart Mobile Phone Applications for the Self-Management of COPD Patients**

As part of the pilot implementation of the Integrated System for the Self-Management of COPD patients, all subsystems will be integrated in order experimental operation to start. The pilot implementation of the production operation will be carried out with the help of medical staff. Actions have been taken in order to have support from health professionals such as pulmonologists and health care providers.

#### **3.3.2. Integrated System Production and Evaluation**

This activity will collect all the results of the Research and Development activities and will create a unified system. The aim is to ensure the interoperability of the subsystems and to test the system in real operating conditions. This will be done through a series of experimental tests, with the aim of checking the overall functionality and producing the final system for evaluation. The aim is to evaluate the usability of the system but also quality characteristics such as whether the quality of the daily life of chronic patients is affected by the Integrated System for the Self-Management of COPD patients. In addition, for the specialized staff, the goal is to evaluate the capabilities of the system in relation to their requirements but also its adaptability and ease of use to the needs of different specialties. The results of the evaluation will be processed and analyzed in order to facilitate the development team in the production of the final product, thus preparing the phase of commercial utilization of the results.

#### **3.3.3. Development of a Toolbox for Interoperability with Other Patient Management Systems**

This activity will develop all the tools and computer interfaces - Application Programming Interfaces (APIs) that are necessary so that in the future the Integrated System for the Self-management of patients with COPD can be

functionally and informatively connected to any patient management system or other eHealth information system. The interfaces will be developed using opensource methodologies to ensure high interoperability and the easiest possible integration of the system and its information into future external systems. In this way the viability of the system increases exponentially and ensures an excellent market response from manufacturers of complementary eHealth systems.

## **4. Conclusions**

Having done extensive research in the development of mobile applications for monitoring patients with chronic respiratory diseases, the ANAPNEO project proposes a complete solution that improves the lives of patients with chronic obstructive pulmonary disease (COPD) through the evaluation, continuous monitoring of patients and reviewing the severity of the disease with online alerts. In addition, it reduces the emergencies, hospitalization and mortality of these patients. The methodology already developed in previous studies, which is proven to be cost-effective and commercially viable, is expected to significantly reduce the cost of COPD management and is used to build a technological product that has the following results:

1. Facilitates patient communication with treating physicians through online services and mobile applications, ensuring ongoing patient monitoring and medical emergency avoidance.
2. Improves the quality of life of chronic patients, combined with a very significant cost reduction.
3. It proposes a new, sustainable and innovative business model that ensures, at low cost and significant savings for health organizations, preventive health service and personalized approach support for chronic patients, combining human medical experience with modern online services.

The technological solution proposed by the ANAPNEO project in order to achieve the above results, is based on cloud computing, service center architectures (SOA) and Web Services, analysis of large databases and software for smart phones and has the following characteristics:

1. Uses improved service technology using data analysis.
2. Provides high security, flexibility, adaptability to the end user.
3. It is scalable in other medical environments, through the orchestration technology of computer services and secure cloud computing.
4. Provides "Proof of concept" both from a technical point of view and from the use with chronic patients.

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