

# Ambulatory Monitoring for Chronic Cardiac and Pulmonary Patients

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**Abstract.** In the Greek pilot of the e-Vital project, remote telemedicine services are provided to chronic cardiac and pulmonary patients who are not confined to a hospital (i.e. receiving home/ambulatory health care) with the aim of exploring the dynamics of interactive continuous chronic patient monitoring, particularly focusing on the impact on patient's quality of life, the patient's active involvement in their own care and according impact on the overall quality of healthcare provision, as well as the benefits for healthcare providers (time management, patient management, savings, etc).

The current trial in progress validates the business potential of remote monitoring services and demonstrates the technical environment that enables patient – doctor interaction regardless of location and the according communication modes and protocols. The domain for applying the envisaged service is the private healthcare sector and the users groups include individual chronic patients with cardiac and pulmonary diseases.

So far, from the patient's point of view, the service mainly appeals to patients with arrhythmias due to lightweight technology and easy processes involved in the transmission of 1-lead ECG. Asthma and COPD patients are also enthusiastic, as they can receive doctor advice in real time. From the health professional's point of view the service has real added value in the fields of diagnosis, prevention, monitoring and follow up. In the case of asthma and COPD the value of the service in diagnosis is even more apparent as these patients may be asymptomatic, when they visit their doctor and have exacerbations when they are at home. e-Vital in this case ensures that the healthcare professional will acquire the complete image of the patient condition. Finally, the experiences gained so far indicate that e-Vital could be particularly efficient in isolated areas, with shortage of experienced scientific personnel.

## Introduction

The e-Vital project aims at the market validation of a modular and ambulatory secure telemedicine platform, which is using easily wearable vital signs monitoring devices, causing minimal discomfort to patients, and which transfer critical vital parameters to doctors and/or medical experts/consultants; regardless of their location, while getting feedback to increase their feeling of comfort.

In the e-Vital project framework, remote telemedicine services are provided to chronic cardiac or pulmonary patients who are not confined to a hospital (i.e. those receiving home/ambulatory health care) with the aim of exploring the dynamics of interactive continuous chronic patient monitoring. The project particularly focuses on the impact on the patients' quality of life, the patients' active involvement in their own care and

accordingly, the impact on the overall quality of healthcare provision, as well as the benefits for the healthcare providers (time management, patient management, savings, etc).

## **1. e-Vital Operation Context**

### *1.1 Service Concept*

The e-Vital service concept emerged, as points of care move closer to the patient and the citizen/patient undertakes a more active role in healthcare monitoring and prevention. The need to provide cost-effective healthcare services for continuous telemonitoring of vital signs to patients "at risk" has been early identified, to bridge the gap in healthcare provision. This gap is created by the inability of healthcare providers to offer continuous monitoring, seamlessly to chronic patients. Since patients "at risk" may experience a sudden deterioration of their health status, continuous monitoring of their vital signs data contributes essentially in the timely detection (diagnosis) of a potential health status worsening and accordingly, to follow-up measures and improved treatment.

### *1.2 Application Area*

Two broad areas, cardiology and pulmonary medicine, have been selected for the implementation of the e-Vital services in Greece. On the one hand, although mortality rates continue to fall, coronary heart disease (CHD) is still the single most common cause of death in both men and women. Traditionally regarded as a "male" disease, coronary heart disease is also the leading cause of death for all European women. CHD, which includes such disorders as coronary artery disease and heart failure, accounts for the deaths of more women each year. In Greece for example, in 1999, the CHD death rate for every 100,000 of population is 170 for men and 58 for women (age standardized rates) [1].

The risk factors for CHD include high blood pressure, high blood cholesterol, smoking, obesity, and physical inactivity. Although medical treatments for heart disease have come a long way, controlling risk factors remains the key to preventing illness and death from CHD.

Arrhythmia is the failing and disjointed heart rhythms and is responsible for over 400,000 deaths each year. However, there are many types of arrhythmia and not all of them are fatal. For heart diseases patients, arrhythmias may act as an "alarm" for the deterioration of the patient's overall health condition and it is very important to timely diagnose and prevent risks. The umbrella of arrhythmias, addresses a wide range of heart diseases, which have different causes, impact on the patient's overall health condition, and accordingly, require various treatment methods.

Heart disease is one of the major causes of illness and death in many countries. Besides this, the number of people who are affected by the disease is growing, as the populations are getting older. Medical research and new treatments help to increase the number of survivors. But in spite of the necessity for controlling the risky situations with the use of conventional drugs or interventions, it has been proven that more security and better control are needed for these patients.

On the other hand, lung diseases rank second in Europe in terms of mortality, incidence, prevalence, and costs. Chronic Obstructive Pulmonary Disease (COPD) mortality rates in various countries in Europe range from less than 25 to more than 75 per 100,000 inhabitants, while COPD prevalence ranges from less than 2,000 per 100,000 inhabitants (i.e. France, the UK) to over 10,000 cases per 100,000 inhabitants (Germany, Italy).

Asthma has increased continuously during the last decades. Its prevalence in children now varies from less than 1 % (i.e. Poland, Latvia, Estonia, Lithuania) to more than 15% (i.e. UK, Ireland, Hungary), and in adults from less than five to more than 10%. The associated hospitalisation costs to COPD and asthma on a European level amount to 3.3 billion euros, not to mention the productivity burden / loss, which is also high, due to workdays lost.

People living with COPD, an umbrella term covering chronic bronchitis and emphysema, may suffer more than they need to because they do not accurately report their symptoms to their doctor. This is according to results of the first international survey of the disease, announced at the 11th European Respiratory Society's annual congress held in Berlin, Germany (held on 23/09/2001). Direct costs from patients suffering of COPD relate to substantial primary and secondary healthcare expenditure. Visits to the doctor are relatively frequent for COPD patients. Nearly a quarter (24%) see a doctor at least once a month and two thirds (66%) see a doctor every six months because of their disease. Furthermore, thirteen percent of patients were hospitalized for their condition in the past year and a further 29% had other emergency medical visits in the past year.

Apparently, it is crucial to address with novel healthcare services the cardiology and pulmonary fields of medicine, as they comprise diseases that affect a great amount of the population on local and European levels. CHD and COPD for example, constitute in cases not only life-threatening health conditions, but additionally entail a series of associated socio-economic costs (e.g. negative impact on the patient's overall quality of life, hospitalisation expenses, insurance expenses, etc) [2].

### 1.3 User Typology

The two main user groups of the service are the healthcare professionals and the citizens/patients. Each user group is divided into several sub-groups. More specifically, the e-Vital service in Greece targets:

- *Healthcare professionals*: including cardiologists, pulmonary specialists, GPs, and/or family doctors. Depending on the vital data to be measured by the patient and monitored remotely, this group of users can be easily expanded to address further specialties (i.e. *endocrinology*)
- *Chronically ill patients*: including patients with heart or pulmonary diseases. Focus is placed on CHD patients and patients with arrhythmias for the first case, and, for the second case on COPD patients and patients with asthma, children and athletes in particular. Older people constitute a potential user group of interest as well. Due to age, it is very common that the person's physical abilities get restricted and close monitoring of the individual's health status becomes compulsory.

Besides the main user categories identified, other e-Vital actors are also defined, since they have a direct or indirect interest and interaction with the e-Vital service. These stakeholders can be considered as third party groups, interested in the project concept and services to be deployed, and also, during the later stage of the e-Vital exploitation, as potential users/customers and/or technology suppliers. The stakeholders' domains include diagnostic centers, private insurance companies, private clinics / hospitals, free-lance doctors, pharmaceutical companies, private clinics for the elderly in particular, and system developers.

## **2. Service Implementation Methodology**

### *2.1 Application Scenario*

A service center is established at the healthcare provider's premises. It comprises the headquarters for coordinating the provided services, and in a broader view, the communication mode with the scientific personnel. A trained person and an on-call specialist doctor run the call center. The patient communication system consists of the appropriate telemedicine micro-device, that is, a wearable ECG recorder and/or a portable spirometer, and a phone device.

The patient records the ECG with the use of the device and dials the service center. The nurse who answers the call, asks the patient his/her ID number (data search can be done in multiple ways, via several search criteria. Thus, alternatively, the patient may provide his/her last name, device ID, which is also unique, etc). When instructed, the patient places the telephone mouthpiece over the speaker outlet of the device and by pressing the "send" button on his/her device initiates trans-telephonic transmission. When the device emits a signal that indicates the end of the transmission, the patient resumes conversation with the service center and is being informed on the quality of the transferred data (not from a clinical point of view).

At the medical service centre the transmitted medical data is reviewed, in order to verify the quality of the transferred data, and then, it is forwarded to the patient's doctor. If necessary, diagnosis is provided by the service center specialized doctor. The doctor receives via email the patient data and may review it via a PC, laptop, or PDA.

### *2.2 Implementation Approach*

The initial set of e-Vital services has been introduced to a trial set of users, including healthcare professionals and chronic patients that have a stable condition; however, they are in need of monitoring their health. Prior to the service implementation, work has been done so as to familiarise all user groups and support personnel with the applications and tasks to be performed, so that the trials to run smoothly.

The tasks performed include a) recruitment of internal personnel that operates the e-Vital service center, including healthcare professionals and administrative personnel, b) Selection of the patients that qualify for the e-Vital service, c) Collection of information on the patients in order to create each person's record, d) User training: Each user group, depending on the nature of the involvement in the pilot operation, received training (i.e. on the use of the ECG recording device for the patients, data handling for the service center personnel, etc)

### *2.3 Experiences Gained*

A formal and coordinated evaluation of the e-Vital ambulatory services for chronic patients is in progress. So far, the patients respond positively to the service and highly value the enhanced feeling of safety they experience via e-Vital. The latter is even more the case for the female population participating in the service evaluation. Additionally, all patients (both with cardiac and pulmonary diseases) reported that the e-Vital process of ambulatory monitoring is particularly easy to use.

The healthcare professionals acknowledge the e-Vital contribution in facilitating their everyday tasks. A larger base of patients is handled in a straightforward manner. The

cardiologists view the service as a valuable tool for monitoring heart diseases and depicting a change in the patient's condition. In the case of arrhythmias in particular, e-Vital contributes to the evaluation of the patients' description of symptoms that cannot be diagnosed for example at the doctor's office, but only at the time they occur [3].

The pulmonologists point out that in the case of asthma patients e-Vital has a significant diagnostic value. The problem so far was that the commonly used PEF (Peak Expiratory Flow) with a peak flow meter, which depends on the patient effort, with imprecise results and not reflecting the real situation of the patient could mislead the healthcare professional. Via e-Vital, FEV<sub>1</sub>, the basic measurement reflecting the narrowing of the airways, is monitored and provides input for differentiating between obstructive and restrictive patterns, for asthma diagnosis (via the FEV<sub>1</sub> variability), for assessing the severity of the condition and monitoring the patient's response to a pre-specified treatment plan, for monitoring the severity of COPD (accelerated decline of FEV<sub>1</sub> predicts the progression to severe diseases) and also assessing the suitability of patients for oxygen therapy (for example, if FEV<sub>1</sub> < 1.5L, FVC < 2L and hypoxemia, the patient needs to start oxygen administration).

The major problem with asthma and COPD patients is that they may be asymptomatic, when they visit their doctor and have exacerbations when they are at home. So, via e-Vital the doctor ensures that the complete image of the patient condition is considered.

Following the healthcare professionals feedback on the use of the service, the following application areas are identified: a) diagnosis, b) monitoring, c) treatment, and d) follow-up.

It should be noted at this point, that only the healthcare professionals familiar to new technologies were initially positive towards the e-Vital service implementation. Technophobia can comprise a remarkable constraining factor to the e-Vital success. Healthcare professionals unaware of the information society capabilities and their impact on the practice of medicine view e-Vital as a competing service that will compel them to reduce their patient base. On the other hand, the only way to appeal to the majority of the patients is to reach them via their attendant physician.

### **3. e-Vital Envisaged Socio-economic Prospects**

e-Vital is anticipated to enable early detection of critical situations at the very beginning, and therefore, actions will be taken immediately in order to establish the correct process. The anticipated social benefits include improvement in the provision of healthcare services and elevation of the patient quality of life. The citizens/patients will be able to closely monitor their health status even when at home, work, vacation, etc. The possibility for continuous care will positively impact the quality of life of these patients. In addition, the e-Vital system implementation is envisaged to enable healthcare professionals to allocate their time in an efficient and effective manner, as they will be able to manage more patients, since telemonitoring would allow the simultaneous monitoring of the health status of multiple patients. Patient management and also, data management for each patient will be improved, facilitating medication management and the completion of administrative tasks for the healthcare professionals.

e-Vital will be a novel service within the Greek market and it is expected that part of the costs previously allocated to home visits and/or visits to the hospital will be allocated to e-Vital. It is anticipated that e-Vital will positively impact hospitalization duration and according expenses, it will improve patient's morale since s/he will have an active role in monitoring his/her health condition [3].

#### 4. Conclusion

The e-Vital service enables patient-doctor continuous interaction, regardless of location and any other geographical limitation. Following the trend for healthcare service provision away of the traditional nursing areas (i.e. at the patient's homecare setting, work environment, or event at vacation, etc), e-Vital has a direct impact on the patient's overall quality of life. The citizens/patients and their families will experience increased safety due to the feedback they will receive from the doctor and the immediacy of the healthcare delivery. It is also anticipated that they will also gain time and avoid extra costs, since they will minimize the unnecessary visits to the doctor and they will avoid unnecessary hospitalisation expenses.

The enhanced monitoring capabilities of the e-Vital service will also have a positive impact on the time saving and the cost efficiency of the healthcare professionals, as the service enables the simultaneous monitoring of the health status of multiple patients. Patient management and also, data management for each patient will be improved, facilitating medication management and the completion of administrative tasks for the healthcare professionals.

The e-Vital service provision in Greece directly targets citizens that reimburse the primary healthcare services they receive, via out-of-pocket payments. Whereas virtually all Greek citizens have coverage for healthcare services through statutory insurance or the National Healthcare System, there is a large private sector consisting of consultations with physicians in private practice, visits to private diagnostic centers, as well as private hospitals for in-patient care. This is due to dissatisfaction with publicly provided services. Nevertheless, public insurance funds, sooner or later, are expected to notice the advantages of (the e-Vital and other) telematic services and, overcoming their reluctance towards innovative technological systems, employ them. This allows a perspective of a much wider user base in the future.

#### References

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