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Intelligent Pervasive Monitoring Solution of COVID-19 Patients

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Abstract. The COVID-19 pandemic transforms the healthcare delivery models and accelerates the implementation and the adoption of telemedicine solutions at all levels of the healthcare system. Telehealth services ensure the continuity of care and treatment of both inpatients and outpatients during this pandemic, while reducing the spread of the virus through hospitals. The aim of this paper is to present an intelligent remote monitoring system with innovative data analytics features for COVID-19 patients. The i-COVID platform provides remote COVID-19 patients monitoring. The presented solution is addressed to patients with mild COVID-19 symptoms, as well as it can be used for post intensive-care monitoring. The platform offers advanced analytic capabilities using Proactive AI, to detect health condition deterioration, and automatically trigger personalized support workflows. Remote monitoring of COVID-19 patients using bio-sensors, seems to be an effective tool against the COVID-19 pandemic, as reduces the number of visits to patient screening centres and hospital admissions.

Keywords. COVID-19, mHealth, Remote Patient Monitoring, Virtual Care

1. Introduction

The COVID-19 pandemic transforms the healthcare delivery models and accelerates the implementation and the adoption of telemedicine solutions at all levels of the healthcare system [1,2]. During the pandemic, several remote monitoring programs were implemented to offer healthcare services either to COVID-19 or non-COVID-19 patients [2-5]. For example, telemedicine systems can provide easy access to health services, overcoming physical barriers and transportation for chronic patients with heart diseases or diabetes [6,7] as well as to kidney transplant recipients [8]. In addition, telehealth services ensure the continuity of care and treatment of both inpatients and outpatients during this pandemic and the related restrictive measures applied by several countries, while reducing the spread of the virus through hospitals [9,10]. Furthermore, remote

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monitoring systems have been found valuable for the continuity of clinical trials during the pandemic [11] or to respond to COVID-19 outbreaks in uncontrolled environments [12]. The aim of this paper is to present an intelligent remote monitoring system with innovative data analytics features for COVID-19 patients in the context of the i-COVID project, which is implemented in the frame of the Open Call of the COVID-X Horizon 2020 project[2].

2. Methods

To achieve the aim of the study, user requirements have been recorded through interviews with healthcare professionals from 'Evangelismos Hospital', Athens, Greece, from December 2021 until January 2022. Based on the interviews results, a dataset was defined for remote monitoring of COVID-19 patients. This dataset includes eight biosignals and four COVID-19 related questionnaires, as these were defined by healthcare professionals to support monitoring of the patients' status. The platform design and development was based on the user requirements and related scientific work [13], and focused on three main axes: (i) Easy access to health services and ensuring continuous care during the pandemic supporting teleconsultations and virtual visits, (ii) Automated and remote health monitoring and coaching for COVID-19 patients, allowing for more effective treatment management and personalized care, using multimedia content, automated reminders, biosignal acquisition, and continuous monitoring of the system for its proper execution, and (iii) Contribution to data collection and analysis of COVID-19 patients' data to enhance research and knowledge generated about the disease and its effects, as well as the formulation of relevant public health policies based on real and relevant data. For this project a preexisting platform is used. BioAssist platform is an integrated IoT solution [14,15]. Several platform adjustments took place to enable the provision of vital signs monitoring services, incorporating a Personal Health Record (PHR) for the COVID-19 patients. Specifically, Bluetooth-enabled wearable devices for measuring biosignals relevant to each patient's condition and a mobile application will be provided to the patients. The COVID-19 patients may perform biosignal measurements and self-assessments (questionnaires, symptom reporting) daily, following the doctor's instructions. The platform features also a two-stage helpdesk (primary and medical) to support and coordinate service provision, including embedded video-conference functionality. Four different questionnaires regarding COVID-19 have been integrated in the i-COVID platform. Using wearable and medical devices, for each patient, specific biosignals have been recorded. Heartrate, Oxygen Saturation, Body Temperature, Respiratory Rate, Daily Physical Activity (like the number of steps), Sleep Quality, Anxiety level, and blood pressure can be recorded on the platform. The majority of the measurements are automatically transmitted to the platform's mobile application and stored in the user's PHR, which also includes information such as medical test results, medications, and allergies, and is accessible to the clinicians, enabling them to make well-informed decisions and offer personalized care to their patients. All the above data will be recorded in the remote monitoring platform. Furthermore, the modular distributed architecture of the system allows easy integration with external systems and

[2] https://www.covid-x.eu/.

the incorporation of additional modules for effective assessment and gamification of disease management that can be added as plugins in the basic platform.

3. Results and Discussion

The i-COVID web application has been developed (Figure 1) to support the provision of remote monitoring services in the context of the project using state-of-the-art applications and technologies. The i-COVID platform deployment was based on related health information systems used in other scientific research projects [16-18]. The platform includes roles for all involved stakeholders as well as end-user hardware (smart devices) for the patients. The i-COVID main users are COVID-19 Patients and the Healthcare Professionals. The expected benefits for COVID-19 Patients include care continuity, easy access to all healthcare services using a single mobile application, while the application usage provides innovative features for continuous, effective and personalized care.

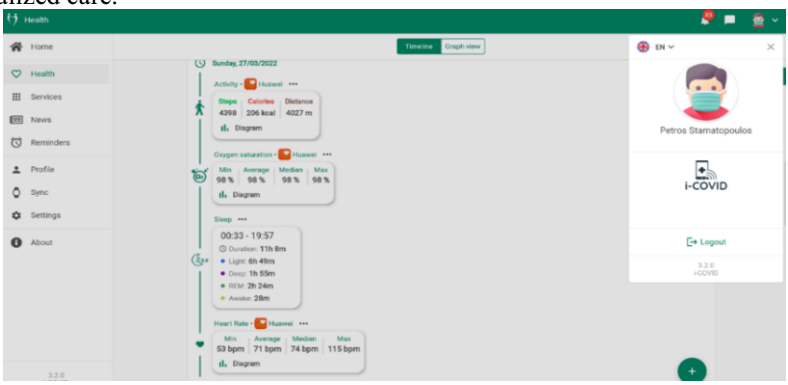

Figure 1. i-COVID Web Platform Timeline.

The i-COVID solution is expected to be also valuable for the healthcare professionals as it allows them to monitor easily more patients and add new patients anytime, while boosting patient loyalty. Finally, the solution is expected to be advantageous also for healthcare institutions, as it enhances the organisation's online presence and reduces the number of patient visits and hospital admissions, giving better pandemic management results. The i-COVID platform is expected to increase the efficiency of the care providers against COVID-19. The i-COVID solution may be offered to patients with mild COVID-19 symptoms, while it may also be used for post intensive-care monitoring.

4. Conclusions

The i-COVID platform is used by the Evangelismos Hospital (National and Kapodistrian University of Athens) to provide remote COVID-19 patients monitoring. Evangelismos Hospital enrolls COVID-19 patients to the i-COVID study, to reduce hospital overcrowding and the associated risks for virus spreading. Remote monitoring of COVID-19 patients using mHealth and IoT technologies seems to be an effective approach against the challenges of the COVID-19 pandemic, as it reduces the number of

visits to patient screening centres and hospital admissions. In the frame of the project, the platform will be enhanced with additional features that offer advanced analytic capabilities using Proactive AI, to detect health condition deterioration, and automatically trigger personalized support workflows. Data analyses can also be used to pre-existing datasets to examine correlation between the collected and stored data, to further contribute to COVID-19 policy making and other health related interventions. Future work includes the evaluation of the presented solution and the assessment of the provided services.

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