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An eHealth Platform for the Holistic Management of COVID-19

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Abstract. The COVID-19 pandemic has posed several challenges on citizens and health systems. Information and Communication Technology (ICT) can be a valuable tool in providing tools for self-assessment and reporting of physical symptoms, early detection of symptom changes, up to date information towards citizen empowerment, personalized recommendations and communication with healthcare providers in case of need. To this direction, this paper reports on the design and implementation of a novel technical infrastructure to support citizens with possible or confirmed COVID-19 disease. The designed platform builds upon an existing personal health record to facilitate symptom tracking, self-management, and personalized recommendations, effective communication channels between patients and clinicians and public health authorities assisting citizens to remain longer safe at home.

Keywords. COVID-19, Digital Health, eHealth, Self-management

Introduction

The coronavirus outbreak that started in China, has spread worldwide. On March 11, 2020, the World Health Organization (WHO) declared the coronavirus disease COVID-19 as a pandemic [1]. The disease has disrupted global trade, employment, and travel, while. Governments had to take strict measures to control the spread of the virus. The main objective remains to reduce the spread of the epidemic and minimize the burden of morbidity and mortality so that health care systems remain functional [2]. Even though WHO recommends [3] that all laboratory confirmed cases be isolated and cared for in a health care facility, and those with suspected COVID-19 triaged based on disease severity, national health systems in various countries in Europe and abroad have recommended citizens to stay at home as long as possible in order not to congest the healthcare facilities. In many cases isolation in health care facilities was not possible. Patients with severe and critical illness as well as those with mild disease and risk for poor outcome had to remain at home. As a result, hospitalization for COVID-19 related cases has often not been possible because of the burden on the health care system.

The current coronavirus pandemic (COVID-19) has put the need for eHealth solutions at the forefront in order to reduce the risk of cross-contamination caused by

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close contact [4]. Patients need to have a way to track their symptoms and identify in a timely manner any changes or deterioration of their health in order to seek immediate attention. In addition, isolated people need to have access to valid information in a timely manner and maintain a sense of social belonging and safety.

In response to these needs, the digital platform *"Safe in COVID-19"* was developed to assist citizens to track and monitor their symptoms at home and communicate with a designated health care provider in order to self-manage their health to minimize the demand for health care services. Patients that have the opportunity to take a collaborative role in their health, exhibit increased competence in managing their diseases which positively improves outcomes such as satisfaction, cost, health status, and function [5]. Digital platforms that offer services and educational information that are patient-centred and patient-specific have been associated with positive feedback [6], especially when face to face consultations remain unlikely to occur.

To this direction, this work describes the design of a platform, dynamically adapted according to patient preferences and medical history, to support patient-centred information, management and reporting of symptoms related to COVID-19. The platform incorporates modules for citizens, healthcare providers and public health authorities to support safety during the current crisis.

1. Methods

The Center for eHealth Applications and Services of the Foundation for Research and Technology-Hellas in response to the European and National calls for meaningful digital innovation in support of the COVID-19 crisis, developed digital eHealth tools and services based on their existing personal health record platform, in order to help citizens, healthcare providers and public health authorities to address current issues.

The development of the platform followed a detailed requirement elicitation process based on the official information and guidelines of the (i) Greek National Public Health Organization (https://eody.gov.gr/), (ii) the Centers for Disease Control and Prevention (https://www.cdc.gov/), (iii) The United Nations Public Health Unit (https://www.un.org/), and iv) the World Health Organization (https://www.who.int/). The modules of the *"Safe in COVID-19"* platform were based on already existing tools and services developed in related projects: BOUNCE (https://www.bounce-project.eu) [7], RELIEF (http://relief-chronicpain.eu) [8],[9], and iManageCancer (http://www.imanagecancer.eu/) (H2020).

"Safe in COVID-19" modules were developed to address the needs of citizens, healthcare professionals and public health authorities. *"Safe in COVID-19"* modules were an extension of the personal health record platform to support (i) symptoms recording and tracking, (ii) information (iii) personalized recommendations, (iv) communication, (v) position tracing, and (vi) public health visualizations. Privacy needs were considered at the very beginning of the system development following the privacy-by-design approach [10] for the modular architecture, data flow and interactions. The data protection in accordance with the European General Data Protection Regulation was also incorporated [11],[12].

2. Results

Through the *"Safe in COVID-19"* platform, patients are able to record and track their symptoms, healthcare providers can monitor patient progress and public health authorities can gain a detailed view of case distribution at local, regional, and national levels [13][14]. The system provides personalized alerts and recommendations taking into consideration the overall health status of the patient. Figure 1 shows the platform modules (apps in green). The platform consists of the following applications and modules.

Citizen App: The mobile application provides personalized information and assistance to citizens helping them recognise and record their symptoms on a regular basis. The patient can share their symptoms with their health care provider. Based on symptom monitoring, early warnings and alerts increase awareness to citizens. Daily self-evaluation helps citizens stay at home longer. Citizens can follow the progress of their symptoms, tracking if their symptoms are getting worse.

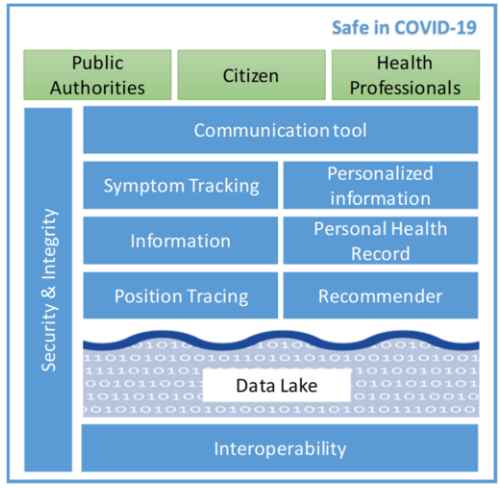

Figure 1. *"Safe in COVID-19"* Architecture.

Health Professional App: The mobile or desktop application allows professionals to remotely monitor the symptoms of their patients in real time. Early warning about symptom changes facilitate targeted action from physicians, enhancing patient safety. Though the platform health care providers are able to offer personalized instructions for treatment of the disease according to the recorded preferences, history and data provided by patients.

Public Authorities App: The desktop application provides a complete overview of the COVID-19 pandemic at a local, regional and national level. The platform tracks the symptoms for confirmed, probable or suspect cases [1] in compliance with legal regulations and approved medical protocols. The web based tool allows the monitoring of the progression of the virus, suspect cases and confirmed cases having access to real-time data. It also provides specialized filters in order to visualize data based on demographics, symptoms, underlying health conditions and others.

Symptom Tracking: Symptom tracking is based on self-evaluation and recording of symptoms using a visual analogue scale (VAS for self-assessment). The symptoms that are being tracked include coughing, sore throat, shortness of breath, fatigue, muscle pains, headache, runny nose, diarrhea and loss of taste and smell. In addition, vital signs such as body temperature, oxygen saturation, breathing rate, blood pressure and pulse are also recorded since they provide important information for the status of the patient.

Personalized information: Older adults and people with serious underlying medical conditions, have been shown to be at higher risk for severe illness from COVID-19 [15]. Those at high-risk include people 65 years or older, people who live in nursing homes, or long-term care facilities, as well as people with conditions such as chronic lung disease, asthma, serious heart conditions, immunocompromised due to cancer

treatment, smoking, bone marrow or organ transplantation immune deficiencies, HIV or AIDS and those on prolonged use of immune weakening medications. In addition, high risk people include those with sever obesity, diabetes, chronic kidney and liver disease. The app requests the recording of any underlying disease in order to provide personalized information to patients at the high risk groups.

Personal Health Record: This module facilitates the storage and retrieval of lab tests to allow direct access in the case of need [16]. Based on specific criteria, the patient is characterized as a possible case which includes any person meeting the clinical criteria, probable case for people meeting the clinical criteria with an epidemiological link, or people meeting the diagnostic criteria, and confirmed case for any person meeting the laboratory criteria [17].

Recommender: the system provides reminders in specific time intervals for self-evaluation and tracking of symptoms and vital signs based on the overall health profile of the patient including previous recorded symptoms and underlying health conditions [18],[19],[20],[21].

Position Tracing: based on patient consent [22], this module provides an automatic tracking of the position of the patient in order to facilitate the tracing of the patient contacts in case of a positive test for COVID-19. The position tracing module keeps track of the locations that the patient has been so that in case a person is tested positive for COVID-19 can easily remember where they have been so that tracing of contacts can be facilitated. This module conforms to all privacy rules. It is not a contact tracing up and therefore, does not fall into the ethical, and data privacy issues of such applications [23].

Communication tool: Input from healthcare authorities and professionals can be visualized at a glance. Citizens receive information about the progress of their disease, medical advices from assigned healthcare professionals and the results of their medical examinations. This module includes synchronous and asynchronous communication based on need.

Security and Integrity: The platform ensures the controlled access to the patient data, respects privacy and confidentiality.

Information: The platform offers the most up to date information and guidelines provided by official sources such as the public health authorities, physician associations and the government.

Interoperability: the platform has been developed using international standards in order to facilitate seamless integration with third party applications and services. In addition, interoperability with national registries such as COVID-19 case registry, citizen identification, social security numbers and other registries facilitate data quality and information exchange.

3. Discussion

The platform offers a way for citizens to track their symptoms over time enhancing a sense of safety during isolation. In addition, it offers direct and safer management of patients by healthcare providers, and better options for monitoring of the epidemic by the public authorities. Possible extensions of the current platform will include tools to address feelings of loneliness, stress, and anxiety, which may even worsen physical symptoms. COVID-19 eHealth apps posit various questions about the collection of sensitive personal data, which may potentially threaten privacy, equality and fairness [23]. There needs to be an overall ethical oversight in order to protect data privacy and

comply with ethical and social considerations. *"Safe in COVID-19"* is built upon a personal health record platform and applies all the ethical, privacy and confidentiality rules of such technologies. The patient is in full control of who they share their information, while patient consent is required in order to provide data to healthcare providers and public health authorities. On the other hand, the platform can be used as a tool to support citizens identify and track their symptoms while staying at home assisting them in tracing their symptom history and be promptly alerted in case of symptoms worsening. The coronavirus disease pandemic has revealed preparedness shortcomings in public health [2]. Digital interventions can provide opportunities to support and strengthen health systems in the diagnosis, treatment, monitoring, citizen empowerment through information, public health surveillance and epidemiology. *"Safe in COVID-19"* provides tools towards this direction leveraging on existing experience and robust implemented technologies. Uptake of the mobile eHealth resources will require a significant change in management efforts and the redesign of existing models of care [24],[25],[26]. Implementing remote care monitoring is likely to generate long-term benefits and help with the healthcare challenges as part of the national health care system. Social, organizational, and technological factors need to be addressed in order to allow the adoption of these eHealth tools. Further steps will include the involvement of patients to further elaborate requirements for usable and meaningful solutions [6]. Technology adoption barriers have decreased due to the current pandemic [27]. The health care systems can act as drivers of change and facilitate the adoption of eHealth technologies based on need. Digital transformation in health care can accelerate this change as novel technologies can be adopted to already existing ones. Coordination between the public health authorities, health providers and citizens is also important to ensure appropriate management of this crisis. It is important to note that even though digital solutions for remote care can be a valuable alternative to the isolation conditions imposed during a pandemic crisis, are not the same as face to face physical examinations which include human contact and communications [28]. In addition, financial and legal constrains in technology readiness of health care systems can also act as a barrier to significant and long term digital transformation, despite the rare opportunity of the current crisis [29]. Integration with third-party applications would enable the use of the platform as an extension of the already existing hospital information systems enhancing the digital management of COVID-19 cases [30],[31],[32].

4. Conclusion

This paper provides information about the design of the platform *"Safe in COVID-19"*. The platform was designed to address the challenges of the corona virus pandemic. The platform provides innovative functionalities and tools in support for citizens, professionals and government organizations that can be incorporated into existing systems and national initiatives to support the management of COVID-19 cases. It offers patients the capacity to systematically record the progress of their health and communicate their symptoms with a designated health professional in order to receive guidance. The platform facilitates the effective interactions between patients and health professionals helping patients feel safe at home. In addition, the platform offers educational information to promote health-related behaviours through personalized recommendations. The proposed solution has the potential to address the current crisis,

promote safety and facilitate action in case of changes in the health condition of individuals.

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