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mHealth application for remote health monitoring useful during the COVID 19 pandemic

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***Abstract*— The paper presents an application of mHealth – a mobile app for remote health monitoring, that facilitates using a Bluetooth enabled health measuring device and synchronizing health data to a health care services provider's web portal. The mobile app uses a public API that allows its integration in a complex platform for home care providers, allowing health monitoring of large groups of patients, monitoring vital functions, including body temperature, respiratory rate and arterial blood oxygen saturation, relevant in monitoring COVID-19 patients.**

***Keywords*— mHealth, mobile app, REST API**

I. Introduction

Given the current times, with an influenza epidemy (in Romania) followed by the COVID-19 pandemic, tools for remote health care are of great use to ease the burden on medical systems. mHealth and especially remote health care apps facilitate health monitoring of both diagnosed patients and quarantined subjects minimizing unnecessary clinic visits and hospitalizations. Patients with mild symptoms with positive COVID-19 tests are usually treated at home. Health monitoring may help detect early signs of exacerbations and signal the need for urgent health care [1].

The paper presents a mobile app for remote monitoring and for home health care to be used by Home Care Providers (HCPs). The app is developed in a research project: Dispatching and Management Center for Optimizing Home Care Integrated Services that aims to facilitate HCPs to enter the market, optimize their activities and standardize the quality of the offered services. The presented app is part of a complex platform: Center for Dispatching and Management of HCPs' Services – the CDMS platform [2], [3]. CDMS is the Romanian acronym for the title of the project. This work has been supported through the Project: Dispatching and Management Center for Optimizing Home Care Integrated Services, from Operational Competitiveness Program 2014-2020 Axis 1 – Romanian Ministry of Research, Innovation and Digitalization.

The CDMS software platform presents a two-level hierarchical architecture, depicted in Fig. 1. The lower level comprises several components:

1) a web application for managing most activities of HCPs: perform business management, financial data management, human resources management, medical data management, delivered services management, medical supplies stock management, subscriptions management, patients management, scheduling home and/ or clinic visits, management of teleassistance services;

2) a mobile app that facilitates stock management;

3) a mobile app for home visits for point of care documentation: it presents the list of appointments for the medical worker that uses it, it provides the caregiver with up to date medical recommendations and requested medical procedures to be performed for the requested patient, it uploads the results of the visits in a centralized data base, in patient's related medical files, including the results of the measurements of vital signals of the patient collected during the visit;

4) and two APIs that allow integration with devices readily available on the market: one API for environmental data and one for health data.

On top of all these components, at the superior level of the hierarchical architecture, is the CDMS level, that manages access of HCPs to the hardware and software resources needed to use the applications mentioned above.

The mobile app described in the current paper is a part of the red box in Fig. 1. It uses the health data API to synchronize health data with the web application for HCPs. This way, data recorded with this app are managed by the HCP software: data are stored for the corresponding patients in their charts, patient data reports are available, they can be consulted by authorized personnel and exported or downloaded, alarms can be automatically triggered based on the recorded values, notifications can be sent for different situations, for example in case of alarms.

II. State of the Art

mHealth refers to the general use of mobile devices for healthcare. Mobile devices may be smartphones, wearable or portable sensing devices, usually presenting wireless connectivity – this leading to the "mobile" aspect of the device. mHealth applications may be mobile applications used

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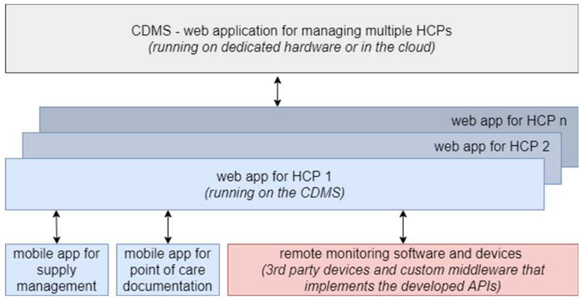


Fig. 1. Structure of the CDMS platform

for delivering health information, health advice/ awareness services to patients, medical reminder services, rapid diagnosis services, for health monitoring, for remote consultations via text or video, applications for providing documentation support to healthcare workers or students, and other types of applications, as different usages of mobile devices may be found in the health care area.

There is a multitude of mobile applications related to healthcare and this can be verified by simply searching the health care section of the main mobile app stores or by searching curated mHealth app libraries. [4] reports that more than a million health and well-being apps are available from the Apple and Google app stores. Regarding the data used by these apps, some of them are based on processing data from built in mobile phone sensors, some of them are based on self-reports and others on data gathered by separate devices that connect to the mobile phone. Regarding the health data processing location, some of the apps are only processing and storing data locally, on the mobile phone, some synchronize data with a remote server that holds users' profiles. The presented app uses a device that connects via Bluetooth Low Energy to a mobile phone and synchronizes data with a remote server.

In a pandemic context, different applications of mHealth may be useful. Two types of mHealth applications based on the analysis of mobile phone signals are of help: analysis of phone signals for tracing contacts of a subject with a positive COVID-19 diagnosis test [5] and for detecting crowded areas [6]. When considering testing new medication or existing medication for new medical conditions, ePRO applications are of great use. [7] lists mobile apps registered as helpful in the context of the COVID-19 pandemic. The list is, of course, non-exhaustive and comprises apps for contact tracing, ePRO apps, documentation apps for healthcare workers to help them get up-to-date with recent research in dealing with COVID-19. Another category of mHealth application useful in dealing with COVID-19 is remote monitoring of vital functions for both COVID-19 positive patients and for detecting patients who may present physiological changes associated with the disease and should get tested. The presented app falls in this last category.

A more comprehensive definition for mHealth for health monitoring is the following: applications and solutions developed on portable devices that use information technology and mobile communications technology in order to monitor, store, retrieve and transmit medical data to specialist or centralized centers for control and monitoring of patients, resulting in improved patient safety and quality of life.

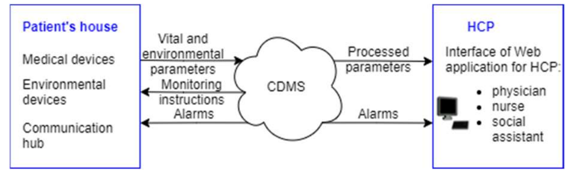
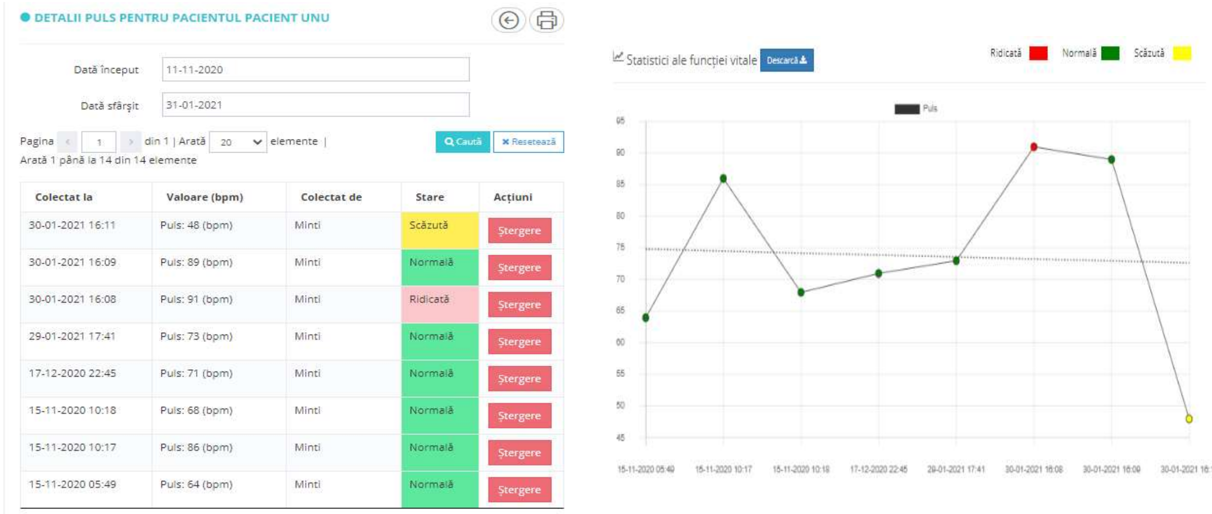


Fig. 2. Integration of the tele-assistance components in the CDMS platform

[1] proposes a combination of different technologies to help managing the diagnosis process of COVID-19 subjects that comprises mHealth solutions for collecting health data through non-invasive monitoring and by correlating health data with a probabilistic model of CODIV-19 infections, determining if a subject has a high or low risk of infection, recommending a test in case of high risk.

One of the problems in stopping the spread of the virus is considered the fact that many subjects may spread the virus unknowingly, as they do not present any symptoms. However, it has been found that, although they do not present perceivable symptoms, there are changes in their vital parameters that may indicate the infection with SARS-COV-2, like changes in the respiration rate or in the arterial blood oxygen saturation [8], [9]. These parameters should also be monitored for subjects that are already diagnosed with COVID-19 to predict when one will need intensive care like oxygen or a more powerful treatment plan. [9] and [10] suggest that monitoring SpO_2 may help detect "silent hypoxia", during which patients feel good but SpO_2 level is dangerously low.

Considering remote monitoring tools for COVID-19 patients or suspects, multiple solutions are presented in the literature, based on different technologies, not necessary on mHealth implementations. [11] presents a telemonitoring scenario for COVID-19 based on voice and/ or video calls. [12] presents the "COVID Box", which contains a pulse oximeter, a blood pressure monitor, and a thermometer. Patients are instructed to use them three times a day and a physician or a physician assistant performs a daily video consultation during which patients communicate the measurement results. [13] presents a conceptual framework for telemedicine for the coronavirus disease based on teleconsultations, teleexpertise and even teleradiology or tele-ICU (Intensive Care Unit) if required. [14] also states the pressing need for telemonitoring in COVID-19 pandemic and proposes using features like live video visits, secure bidirectional chats, self-entered data for monitoring blood pressure or temperature. [15] describes a large-scale telemonitoring program already implemented to provide virtual care to thousands of patients by phone calls and self-measured pulse oximetry. [16] presents a telemonitoring platform that automatically synchronizes data from a specific model of pulse oximeters paired with mobile phones via a smartphone app that prompts users to self-check their oxygen saturation four times a day. The mobile app also integrates an alarming function for abnormal values and it was used in a hospital scenario for ambulatory care of early discharged CODIV-19 patients. [16] concludes that this type of mHealth application has the potential to minimize usage of hospital resources without compromising the quality of patient care. In comparison to the presented telemonitoring implementations or proposals, the mobile app presented in the current work allows acquiring multiple parameters and automatically synchronizes data in a complex platform that allows creating



a) b)

Fig. 3. Web app for HCP – display vital functions for a patient: a) tabular view; b) graph view

complete electronic health records. It helps health professionals to remotely monitor different vital functions, enabling them to effectively monitor a large group of people. Among the vital functions that may be monitored by using the mobile app are blood oxygen saturation, temperature and respiratory rate, physiological parameters considered relevant in detecting and monitoring infections with SARS-COV-2.

III. Methods

The app presented in this paper acquires data from a health monitoring device, the Mintti Vision 6in1 [17] and synchronizes data with the CDMS platform using a public API. The following sections describe the components that the app integrates.

A. *The CDMS platform*

The main component of the CDMS platform is the web application for HCPs. Each HCP has a dedicated web application running in its own containers (one for data, one for the application), keeping its' data clearly separated from other HCPs subscribed to the same CDMS. The web application gathers data from the mobile app for stock management and from the point of care documentation mobile app. It also contains a tele-assistance module, that integrates all the functionalities of the platform that allow offering remote health care and monitoring. Also, two APIs, one of them described in the following section, allow data acquisition from 3rd party devices: one API for environment monitoring devices and one for health monitoring devices. The acquired data are saved in the patient file for whom it was recorded. Any mobile device that communicates with the web application must be previously registered through a web form. A unique code (called PID) is thereafter assigned to each registered device. The tele-assistance module implements the following functionalities that interact with data from the presented mobile app:

- easy management of the authorized devices: add/ remove devices, assign devices to patients,
- management of the vital functions that may be sent through the API: names (strings) and ids (numeric values), accepted minimum and maximum values,
- setting value thresholds for alarms,
- management of alarms and notifications for alarms,
- management of the data sent by the mobile devices through the APIs in each patient's chart. The section of vital parameters of a patient's chart offers a view of all the recordings, searching for recordings from a selected time interval, download functionality as a pdf file with all/ a selected group of records.

The general structure of the CDMS platform with focus on the tele-assistance aspects is depicted in Fig. 2.

For each HCP that subscribes to the CDMS center, a medical web application is created. By default, every HCP has default data in the medical information section: list of possible allergies, list of medical procedures, list of medical documents and so on. A default list of vital functions is also created, along with information that describes each of them. Default alarm thresholds are generated for each vital function. Every HCP should customize the medical section according to the offered services. For example, different vital functions may be added to the list, depending on the physiological parameters that are recorded for their patients.

As a response to an alarm generated by a vital function that goes over a certain threshold, through the web application, authorized personnel can schedule a video consultation, schedule a visit at the clinic (if the HCP offers that), send a message to the patient or upload a file like a medical recommendation letter visible in the patient's profile.

B. *The API for data synchronization*

The API allows 3rd party devices to communicate with the server (virtual or physical) hosting the web application for HCP. It allows querying the list of vital functions for which the server accepts messages and their details, and it allows

Fig. 4. Mintti Vision 6in1 health monitoring device [17]

sending messages to save values for vital functions. Through this API any device that produces health monitoring data may be integrated in the CDMS platform, the only requirement being that the producer of the device offers an SDK so that the desired data may be accessed and packaged in the form specified by the API. A similar API exists for environmental devices.

In order to get the list of accepted vital functions, one must send a JSON message that contains a valid device PID to a specified address: URL of the HCP + /api/iot/get-bio-data-list. In response, if the device PID is not valid, the server responds with a suggestive message and if a valid PID was sent, the server offers a list of the vital parameters that it accepts along with details describing them: their id and name in the system, minimum and maximum accepted values, and measurement unit type.

In order to save data, a JSON message must be sent containing a valid device PID and the values that need to be stored along with information about the vital function: measurement unit type, timestamp of the data acquisition moment. The URL is: URL of the HCP + /api/iot/save-bio-data. Multiple values may be sent in the same message. The server responds with appropriate messages, informing the user (developer) if the message is well formatted and data is successfully stored or if there is a problem with the format of the message like: a missing PID for the device, a missing timestamp, or another formatting problem. If the message was well formatted and contained all the relevant fields, the sent values are visible in the corresponding patient's chart, in tabular form and in a graph. The ECG signal is only visible as a graph. An example of how the recorded values for pulse are displayed is shown in Fig. 3. The screenshot is trimmed to show only relevant information: without menu, patient information or the whole list of recordings. Values that are between normal parameters are colored in green, items that are outside the normal threshold are colored in yellow and red items represent values that trigger alarms.

The API also allows sending additional information for each measurement through a comment section. This allows adding possible automatic interpretation of a certain device for a signal, that is not necessarily produced by all devices that acquire the specific signal. For example, when processing an ECG signal, a device may only record data points in time and display them in a graphical way, other devices may extract several features like: minimum/ maximum RR interval, respiratory rate or other features. These additional features may vary from device to device. The comment section allows packing this type of custom information with the standard information that may be defined in the vital functions section of the HCP web application. Data are transmitted only via https and the API does not allow querying for medical data for patients. It cannot be used to gain access to a patient's medical chart.

C. *Mintti Vision 6in1 health monitoring device*

The Mintti Vision 6in1 health monitoring device (Fig. 4) performs the following measurements: blood pressure measurement, obtaining systolic and diastolic blood pressure and heart rate; body temperature measurements via Infrared, recommended to be measured on the forehead; glycemia measurement, obtaining the blood glucose level; oxygen saturation in the arterial blood, obtaining the SpO_2 level and heart rate; and ECG measurements, presenting the ECG signal, and parameters that may be extracted from the signal: the minimum RR interval, the maximum RR interval, the respiratory rate, heart rate and heart rate variability.

The small device (70mm x 70mm x 18.4mm) has no user interface, it only has an on/off button. It is designed to be used with a mobile application that interacts with the devices, starting the desired measuring functions and displaying the acquired data. It connects to a smartphone via Bluetooth Low Energy (BLE). The device charges through a miniUSB port and battery life depends on usage, of course, but when using the device for performing each of the measurements three times per day, battery lifespan is more than a week.

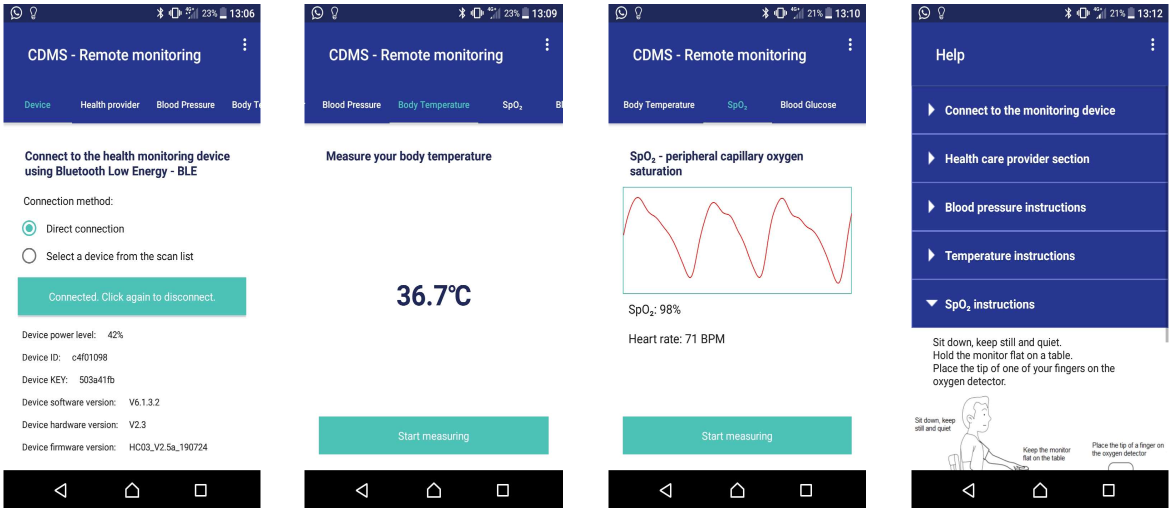
Blood pressure is measured on the upper arm, using a cuff with a special connection plate for the device. Blood oxygen saturation is acquired via photoplethysmography. For blood glucose level assessment, special strips are needed. For ECG measurement, three fingers from both hands must be placed on the device, each finger on a separate metal conductor.

The producer of the device offers SDKs for both major mobile platforms: iOS and Android.

IV. Results

A mobile app based on the Mintti Vision 6in1 SDK has been developed. Some demo screens are presented in Fig. 5. It offers the following functionalities:

- Scanning for Bluetooth devices and connection to the selected Mintti Vision 6in1 device: when starting a scan, the user is directed to turning on BLE if it is not already turned on. The list of detected BLE devices is filtered to only present Mintti Vision 6in1 devices.
- Setup information for the HCP: the user must configure the PID of the device and the URL of the HCP.
- Starting/ stopping blood pressure measurements: blood pressure measurement is performed using a hand cuff that is placed on the upper arm; results of the measurement are: systolic blood pressure, diastolic blood pressure and heart rate. Help about performing the measurement is available in the help section: position of the cuff, body posture, etc.
- Performing body temperature measurements.
- Starting/ stopping blood glucose level measurements.
- Starting/ stopping ECG measurements: The ECG signal is analyzed to compute the maximum and minimum RR intervals, heart rate, heart rate variability and respiratory rate.



a) b) c) d)

Fig. 5. Demo screens of the health monitoring app a) Connecting to the health monitoring device; b) Example screen for monitoring temperature c) Example screen for momitoring SpO2; d) Help section

- A view of results of previous measurements presented in a tabular form.
- Help and About sections. The help section aids users to use both the app and the device. Information on the device comes directly from the manual of the device.

The app is most useful when used as a part of the CDMS platform, allowing for continuous health monitoring by health care professionals. Otherwise, the producer of the device already offers mobile apps on the market that allow interacting with the device. The described app may be used in two ways:

- Directly by each patient: each patient receives a telemonitoring device and installs the app on his mobile phone and uses them to acquire his own vital parameters.
- By medical personnel: medical personnel use a telemonitoring device and a mobile phone to acquire vital signs from multiple patients: during home visits or at the clinic.

Measured vital signs synchronize with the HCP web app automatically, immediately after the measurements have been performed or when an Internet connection becomes available. This way, data recorded with this app are managed by the HCP software: data are stored for the corresponding patients in their charts, patient data reports are available, they can be consulted by authorized personnel and exported or downloaded, alarms can be automatically triggered based on the recorded values, notifications can be sent for different situations, for example in case of alarms.

The app does not require a login for data synchronization, it does require to input the HCP URL and a valid device PID, obtained from the HCP. Any telemonitoring device registered on the platform is associated with a certain patient. If the device is used by medical personnel for acquiring vital signals from multiple patients, before each measurement (or every time measurements are performed on a different patient) the device PID must be input in the applications, so that when a measurement is performed and data is ready to be packaged and sent to the HCP web application, the PID of the device associated with the right patient is available to be packaged in the message as well. The main usage scenario is when each patient performs self-measurements. In this case, the communication parameters must only be input once, before the first data transmission. The second usage scenario might still be useful during home visits performed by medical personnel or when the same device is used by multiple members of the same household. In this situation a user profile section might be useful, but this functionality is not yet implemented.

When using the app as part of the CDMS portal, the following steps are necessary: the patient must be registered in the HCP web app, the device must be registered in the HCP web app and assigned to the corresponding patient; the code of the device must be configured in the mobile app along with the URL of the HCP. Afterwards, the usage of the app is straight forward: connect the Mintti 6in1 device via BLE and perform the desired/ requested measurements.

V. Conclusions

The paper presents a mobile app for health monitoring that is part of the CDMS platform: a suite of products that target Home Care Providers (HCPs).

The mobile app works in conjunction with a health monitoring device and allows controlling the data acquired by the device and synchronizing the data with a web application for HCPs for archiving and further processing. We believe that any mHealth implementation is most useful when it allows health data to be continuously shared with healthcare professionals, a functionality that many of the mobile health apps miss. Although it may be useful for a patient to have knowledge of his vital functions, only medical professionals can correctly interpret and correlate different values to assess one's health status. This is one of the strengths of the presented mHealth app, the integration in the larger CDMS platform that allows health professionals to have a complete picture of one's medical history.

The CDMS pilot runs as a pilot in Alba County, Romania, and it has 3 subscribed HCPs. The largest HCP has already registered approximately 1000 of its patients and some of them benefit from tele-assistance services. Usability tests performed in the pilot phase of the project show that the app, integrated in the platform, reached its purpose, it is intuitive and most users are able to perform all the tasks at first usage without special training. More details about the results, whether positive or negative, of usability testing of the whole CDMS platform will be presented in a following paper, after the pilot will have run for a longer period.

A help section describes all the steps necessary in using both the mobile app and the health monitoring device. The health monitoring device is also straight forward to use, and for the general public unaccustomed with basic medical devices, instructions are available for all the measuring functions.

As mentioned, using the API for health monitoring devices, any device that allows access to its data may be integrated into the CDMS platform. The only requirement is the possibility for 3rd parties to access the health data produced by the device through an SDK or an API. We believe this is the main innovation of the remote monitoring module implemented in the CDMS platform: the ability to integrate data from devices from multiple vendors**.** The presented mobile app is an example of the usage of the API that facilitates this. Interoperability of devices from multiple vendors is a known problem. Development of separated mHealth solutions that target a small audience and that work separately is not a sustainable way of development. It leads to multiple incomplete solutions that do not allow data sharing. Using the proposed mHealth app and the proposed API integrated in the CDMS platform allows the construction of complete medical charts that comprise health data gathered in multiple fashions: during consultations, during home visits, via self-reports or by using different measuring devices.

The Mintti Vision 6in1 device has been chosen by a partner of the project that functions as an HCP with a subscription to the pilot CDMS center. Another device from the same producer, the Mintti Heartbook that only processes the ECG signal, is currently being integrated in the platform. Although the Mintti Vision 6in1 also acquires the ECG signal and it is a small portable device, it is not a wearable ECG device, the user must hold the device in his hands in a still position during the whole duration of the measurement. The Mintti Heartbook device is a wearable device, it may be strapped to the wearer's chest, offering the possibility to be worn for long periods of time. For this reason, it was chosen to be integrated in the CDMS platform.

Although telemonitoring is especially useful in monitoring sparsely populated areas – rural areas, these are the areas that also may have Internet connectivity issues and the areas where a higher percent of the population do not integrate digital solutions in the daily living. For example, some of the end users of the pilot HCPs do not have or do not use their email accounts, making them unable to benefit from the email-based notification system.

We can conclude that the mobile app integrated in the CDMS platform can provide help to medical personnel, providing access to health data for multiple patients in a centralized manner through the HCP web application. The automated alarming and notification mechanism is also helpful in monitoring a great number of patients. The proposed remote health monitoring method is extremely useful in a pandemic situation: it limits physical contact between medical personnel and patients, it allows frequent measurement of the vital signs of importance for the monitored subjects. Considering the COVID-19 situation, it facilitates detection of possible infection for undiagnosed subjects and detection of possible exacerbation of symptoms for diagnosed subjects that present mild symptoms, allowing monitoring the vital functions meaningful in this context.

REFERENCES

[1] C. P. Adans-Dester et al. "Can mHealth Technology Help Mitigate the Effects of the COVID-19 Pandemic?" IEEE Open Journal of Engineering in Medicine and Biology 1, August 2020), pp. 243 - 248

[2] V. Sandulescu, S. Puscoci, M. Petre, S. Soviany, A. Girlea, V. Bota, "Design and Development of an Integrated Platform for Management of Homecare Providers", 2019 E-Health and Bioengineering Conference (EHB), virtual conference, p. 1-4, 2019

[3] V. Sandulescu, S. Puscoci, M. Petre, A. Girlea, V. Bota, "Web application for home care providers", Stud Health Technol Inform. 2020 Jun 16;270:723-727.

[4] C. Baxter, J. A. Carroll, B. Keogh, and C. Vandelanotte, "Assessment of mobile health apps using built-in smartphone sensors for diagnosis and treatment: Systematic survey of apps listed in international curated health app libraries", JMIR Mhealth Uhealth, vol 8, February 2020

[5] L. Ferretti et al., "Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing," Science, vol. 368, no. 6491, Mar. 2020, Art. no. eabb6936.

[6] A. Alsaeedy and E. Chong, "Detecting regions at risk for spreading COVID-19 using existing cellular wireless network functionalities," IEEE Open J. Eng. Med. Biol., vol. 1, pp. 187–189, 2020

[7] Covid-19 Apps Hub Repository, European mHealthHUB, Jan 2021, Available: https://mhealth-hub.org/

[8] C.M. Petrilli et all, "Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: prospective cohort study", BMJ. 2020 May 22.

[9] R. Jouffroy, D. Jost, B. Prunet, "Prehospital pulse oximetry: a red flag for early detection of silent hypoxemia in COVID-19 patients", Crit Care,. 2020 Jun 8;24(1):313.

[10] V. Quaresima, M. Ferrari, "COVID-19: efficacy of prehospital pulse oximetry for early detection of silent hypoxemia", Cirt Care, 2020; 24: 501.

[11] T. Greenhalgh, G.C.H. Koh, J. Car, "Covid-19: A remote assessment in primary care", BMJ. 2020 Mar 25.

[12] A.V. Silven, A.H.J. Petrus, M. Villalobos-Quesada, E. Dirikgil, C.R. Oerlemans, C.P. Landstra, H. Boosman, H.J.A. van Os, M.H. Blanker, R.W. Treskes, T.N. Bonten, N.H. Chavannes, D.E. Atsma, Y.K.O. Teng, "Telemonitoring for patients with COVID-19: Recommendations for design and implementation", J. Med. Internet Res, 2020, Sep 02;22(9):e20953.

[13] R. Ohannessian, T.A. Duong, A. Odone, "Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: A call to action", JMIR Public Health Surveill, 2020 Apr 2;6(2):e18810.

[14] A.R. Watson, R. Wah, R. Thamman, "The value of remote monitoring for the COVID-19 pandemic", Telemedicine and e-Health, Sep 2020, 1110-1112.

[15] J.G. Shaw JG, S. Sankineni, C.A. Olaleye, K.L. Johnson, J.L. Locke, J. Patino, F.L. Sabi, R.J. McCarthy, "A novel large scale integrated telemonitoring program for COVID-19", Telemedicine and e-Health, 2020.

[16] O. O'Carroll, R. MacCann, A. O'Reilly, E.M. Dunican, E.R. Feeney, S. Ryan, A. Cotter, P.W. Mallon, M.P. Keane, M.W. Butler, C. McCarthy, "Remote monitoring of oxygen saturation in individuals with COVID-19 pneumonia", European Respiratory Journal Aug 2020.

[17] Mintti Vision, Product presentation, Mintti Health, Available: http://minttihealth.com/?product=mintti-vision, accessed on Jan. 11, 2021.