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Brief Report

Using Smart Devices for Monitoring Elderly Patients in Rural Areas of Calabria after COVID-19 Vaccination: Experiences within the SI4CARE Project

Alessandro Gallo [1,2], Salvatore Fregola [1], Margherita Menon [3], Filomena Talarico [1], Stella Fragkiadaki [4], Dionysia Kontaxopolou [4], Katarina Vukojevic [5], Danira Matijaca [5], Miodrag Miljkovic [6], Srdjan Kožetinac [6], Alessio Merola [2], Vlado Dimovski [7], Anamarija Kejar [7], Ivan Radevic [8], Danica Stevovic [9], Vlatka Martinovic [10], Katjia Matesan [11], Roberta Matkovic [11], Guido Piccoli [3], Francesco Esposito [12], Nicola Mayera [13], Elisabetta Pedace [14], Darja Semrov [15], Pietro Hiram Guzzi [2,16,*] and the SI4CARE Partners Members [†]

1 Ethos Lab, University of Catanzaro, Viale Europa, 88100 Catanzaro, Italy
2 University of Catanzaro, Viale Europa, 88100 Catanzaro, Italy
3 ALOT, SI4CARE-TEAM Street Cipro, 16, 25124 Brescia, Italy
4 1st Department of Neurology, Aiginition University Hospital, Vasilissis Sofias Street 72-74, 11528 Athens, Greece
5 Department of Anatomy, Histology and Embryology, University of Split School of Medicine, Šoltanska 2, 21000 Split, Croatia
6 Special Hospital Merkur, Cara Dušana 3, 36210 Vrnjačka Banja, Serbia
7 School of Economics and Business, University of Ljubljana, Topniška ulica 31, SI-1000 Ljubljana, Slovenia
8 Faculty of Economics Podgorica, University of Montenegro, Jovana Tomaševića 37, 81000 Podgorica, Montenegro
9 Public Health Center Tivat, 85320 Tivat, Montenegro
10 Health Insureance and Reinsurance Fund of Bosnia and Herzegovina, Trg Heroja 14, 71000 Sarajevo, Bosnia and Herzegovina
11 Teaching Institute for Public Health of Split-Dalmatian County, Vukovarska ul. 46, 21000 Split, Croatia
12 UCCP Reventino Place G. Perri, 1, 88041 Decollatura, Italy
13 Regione Calabria, Road Europa, 88100 Catanzaro, Italy; nicola.mayera@regione.calabria.it
14 Soverato Hospital ASP Catanzaro, 88068 Soverato, Italy
15 Faculty of Civil and Geodetic Engineering, University of Lubjiana, Kongresni trg 12, SI-1000 Ljubljana, Slovenia
16 Municipality of Miglierina, Street B. Telesio, 88040 Miglierina, Italy
* Correspondence: hguzzi@unicz.it or sindaco@comunemiglierina.it
† SI-4CARE Members: Sokratis G. Papageorgiou (1st Department of Neurology Aiginition University Hospital Athens), Evangelia Stanitsa (1st Department of Neurology Aiginition University Hospital Athens), Efthalia Angelopoulou (1st Department of Neurology Aiginition University Hospital Athens), Dimosthenis Pavlou (School of Topography and Geoinformatics University of West Attica), Jovanka Vucetic, Public Health Center Tivat, 85320 Tivat, Montenegro, jovankavuc@gmail.com (Address: Istarska bb, 85320 Tivat, Montenegro).

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Abstract: The SI4CARE project is a transnational project which aims to develop both strategy and action plans to improve health and social care in the Adriatic–Ionian region. Starting from a survey of the status quo, each partner has developed some pilots to support the development and monitoring of the policy actions. In particular, partner number three, the Municipality of Miglierina, designed and developed a pilot related to the use of wearable devices for monitoring elderly patients in rural areas. With the collaboration of the complex unity of primary care (UCCP) of the Reventino area, the pilot is based on the use of smart wearable devices to monitor some parameters of older adults after their vaccinations for flu and covid. This paper focused on the design and implementation of the system. It describes its application in the Municipality of Miglierina. Presentation of the results and a discussion of the strengths and weaknesses will be presented, in detail, in future work. Finally, the possibility of extending the experiment to other Adriatic–Ionian regions is addressed.

Keywords: telemedicine; telecare; telemonitoring; older; COVID-19; SI4Care

1. Introduction

A demographic analysis of the Adriatic–Ionian (ADRION) countries shows an increase in adults with declining functional capacities, who are largely dependent on the help of others and in need of long-term care services. The proportionate increase in the fraction of elderly people in populations also causes higher expenditures for healthcare and long-term care systems.

Consequently, the needs to improve healthcare expenditure and the quality of life of elderly people arise. The achievement of these goals requires the development of healthcare services for an increasing number of ageing people. Information technology-based solutions (ICT), Artificial Intelligence (AI) and social innovation are three critical factors for successful advancement in providing better services. ICT and AI are the fundamental pillars for developing efficient solutions. Social innovation plays an important role here when applied to a healthcare system, as it creates social value with practical impacts on society, aggregates needs and interests, increases civic participation and strengthens social cohesion. The SI4CARE (Social Innovation for integrated health CARE of ageing population in ADRION Regions) project addresses the following: The fragmentation of institutional capacities and in actors' efforts in delivering healthcare services to the elderly. The lack of integration and coordination of innovative ICT tools for healthcare providers, which is usually tested and implemented in isolation. The need for a shared vision across PAs on effectively facing this changing health demand pattern in an integrated and socially innovative way.

SI4CARE has ten partners: University of Ljubljana Slovenjia PP01, Jožef Stefan Institute Slovenjia PP02, Municipality of Miglierina (MoM) Italy PP03, University of Split School of Medicine Hrvatska PP04, Teaching Institute for Public Health Split-Dalmatia County Hrvatska PP05, Health Insurance and Reinsurance Institute of Federation of Bosnia and Herzegovina PP06, National and Kapodistrian University of Athens Public Health PP07, Institution "Health Center" Tivat PP08, Special hospital for treatment and rehabilitation Merkur PP09, and Regional development fund of central Macedonia PP10.

SI4CARE contributes to the creation of an influential transnational ecosystem for social innovation application in integrated healthcare services for the ageing populations in ADRION, through a collaborative network and a shared strategy, translated into regional and national action plans. The regional and national action plans are to be implemented and monitored within pilots in telemedicine and in accessibility to healthcare facilities, once innovative approaches have been tested and fundamentally supported by an ICT Decision Support System.

The transnational cooperation of diverse public administrations and different professional orientations is key to the SI4CARE project, since all the partners share a priority interest in the innovation of healthcare services for the elderly population through the application and combination of tools, procedures, actors and stakeholders. The rationale of the integration is that regional and local best practices in Social Innovation for healthcare service improvement exist, but are often circumscribed to single cases and are isolated, lacking penetration into regional and national policies. Consequently, the need for cooperative and integrative efforts has arisen. Therefore, a transnational and interdisciplinary approach is necessary so as to share experiences, scout for best practices and effectively produce real innovations that can be replicated. Finally, the personalized medical approach depends on the availability of data at a transnational level and an effective standard for collecting this data.

Each partner, after an analysis of the Status Quo (SQ) and a survey of current best practices (BPs), has designed pilots, together with the stakeholders (SHs) and partners, to demonstrate the achievements of the Wish List (WL). We herein report the activities of the Municipality of Miglierina.

As Miglierina Municipality is a small and relatively isolated village with a high share of elderly residents, it is highly interested in social innovations based on the digital transformation of health and social care delivery systems. Together with the Complex Care Unit of the Reventino (associations among medical doctors providing basic healthcare

facilities), the MoM has designed a novel digitally-supported health infrastructure which can respond to the needs of the local population.

The pilot was based on testing the effectiveness of wearable devices for monitoring the healthcare status of older adults after their covid-19 vaccinations [1,2].

The optimization of the vaccination strategy is currently an essential challenge in all countries. Recent works demonstrated that the use of a topology-aware approach may outperform other methods [3,4].

Vaccination is recognised as the most prominent measure for controlling COVID-19 disease [2,3,5–7]. In Italy, vaccination was mandatory for some categories of workers (e.g., healthcare workers) and highly recommended for older adults. Thus, a significant fraction of older adults received three vaccines (BNT162b2 mRNA produced by Pfizer-BioNTech and mRNA-1273 Spikevax produced by Moderna). As reported by many independent studies, both vaccines had efficacy in preventing symptomatic COVID-19 and severe hospitalization. Therefore, the Italian government launched a campaign for a fourth vaccination dose for the elderly, with novel versions of vaccines tailored for the Omicron variant [8].

Since older people may present severe side effects and have difficulties moving (absence of public transportation and living in remote areas), there is a need to introduce advanced telemonitoring systems. In recent works, the effectiveness of telemonitoring some physiological parameters has been demonstrated [1,9,10]. Therefore, we designed the following project, wherein a cohort of volunteers, who received the fourth BNT162b2 vaccine, were monitored for 96 h. Participants were fitted with a wearable device which monitored six physiological parameters recorded into a dedicated web server. Additionally, a dedicated mobile line monitored patients daily and reported on reactions to an ad-hoc questionnaire and on other symptoms. The project aims within the SI4CARE project were twofold: to support the vaccine's safety and to demonstrate the efficacy of telemedicine and telemonitoring. The output of the pilot is, finally, to be evaluated within the decision support system to be developed within the project.

Novelty and Impact of the Work

The key points of this work are the following:

- The design and implementation of a telemedicine project in a transnational cooperative and interdisciplinary environment;
- the use of such a project in a real application scenario in a rural area;
- the use of both hard and soft technologies: wearable devices and a platform for data management and analysis.

2. Materials and Methods

2.1. Wearable Devices

We selected, as wearable devices, the SiDLY telemedicine wristbands (SiDLYCare PRO) https://www.hospital.sidly.eu/ (accessed on 1 November 2022). The telemedicine setup comprises a telecare platform, a mobile application, and a telemedicine wristband. The selection of the platform was from within the certified platforms already in use in the Calabria Region in order to make the project directly repeatable in other contexts. In particular, this device may also be used in other regions.

SiDLYCare PRO, depicted in Figure 1 is a bracelet which is able to monitor vital parameters and to connect patients with people they are familiar with or with caregivers. It is equipped with an internal micro SIM able to connect to mobile phones and data networks. The bracelet has a visible SOS button on the top that can send a customized message through a phone call, via SMS and via the web interface. The main characteristics of the bracelet (depicted in Figure 2) are listed in Table 1. The functions of the SiDLYCare PRO bracelet include the following:

- Adjustable fall detector with alarm output
- Alert for geographical limits (exit from the predefined geographical area)
- Vital Signs Measurement (Heart Rate and SpO2)

- Activity parameters measurement (pedometer)
- Environmental parameters measurement (barometer)
- Bracelet status (worn, removed, etc ...)
- SOS button (with embossed Braille symbols) that emits alarms via a two-way voice call and sends SMS with geographical position detected by GPS to preset reference numbers
- Battery status warning
- Medicines reminder

A global positioning system (GPS) sensor is also on board. It is used to detect the user position, and it is used to send the position in case of an alarm. The bracelet can send three alarm signals: (i) a user-invoked alarm (SOS); (ii) in case of a detected fall; (iii) when the user moves away from a predefined geographical area.

We initially tested 20 wristbands which were reused after the testing period.

Table 1. SiDLY Bracelet characteristcs.

Autonomy	48 H after full charge
Charging time	3 h
Type of charge	Induction
Unauthorized Call Protection	Only numbers listed as authorized can call
Waterproof	IP67 category can be used in the shower or bath
Dimensions	51 mm × 33 mm × 15 mm
Weight	41 g

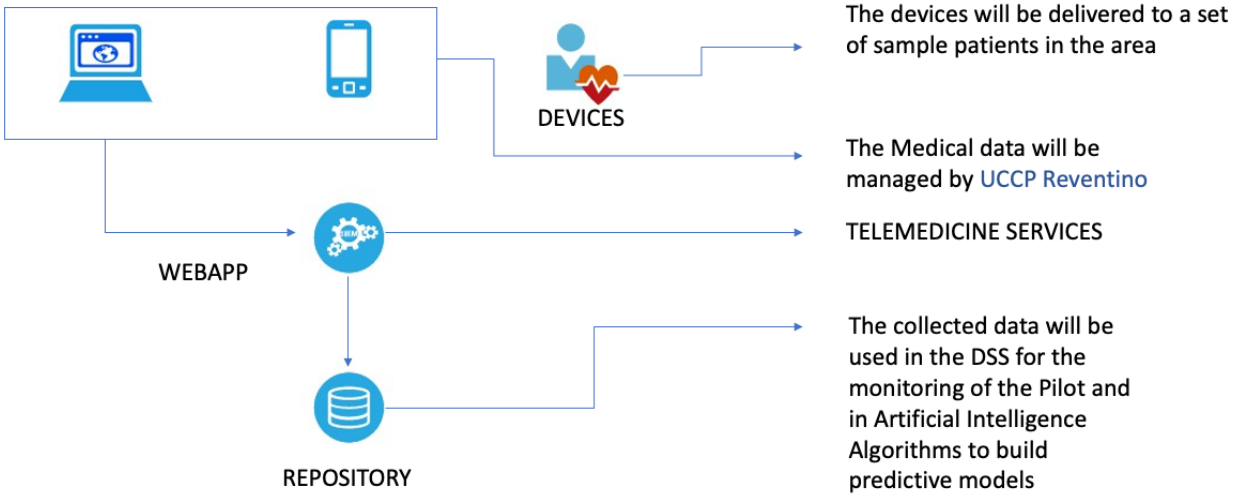

Figure 1. Figure depicts the architecture of the proposed system. The devices were delivered to a set of patients selected by medical doctors from the cohort of patients who received the fourth dose of the Covid vaccine. The monitoring device stores the parameters in a secure cloud compliant with the GDPR regulations. The UCCP reventino monitored the parameters through the web app provided by the SiDLY system. Finally, the anonymized parameters of the patients were collected into a secure repository. Such data were then gathered and used to feed the decision support system of the project to monitor the pilot and to learn a predictive model based on neural networks.

Figure 2. SiDLYCare PRO bracelets.

2.2. Parameters

We collected the following parameters through the bracelet:

- Vital Signs Measurement (Heart Rate and SpO2);
- Activity parameters measurement (pedometer);
- Environmental parameters measurement (barometer).

Moreover, we stored the following data through the web questionnaire:

- General status;
- Measured Temperature;
- Presence of Headache;
- Sickness Status.

The integration of the parameters collected by the bracelets and the data collected through the web questionnaire reflected the experiences discussed in some recent works [1,11,12].

2.3. Data Managing and Analysis

After collecting the data into the secure cloud, an ad hoc-designed software module extracted the parameters of the patients to enable advanced analysis. Currently, the software module has two main analysis functions:

- Cluster Analysis;
- Classification of patients.

The Database of the application was implemented using My-SQL database. The security of the data was guaranteed by data encryption and a one-time password protocol. Both functions were implemented by means of wrapping the sklearn library of the Python

Programming language. Cluster Analysis aimed to build a group of patients with similar characteristics. The classification of patients, performed using a multiclass perceptron, aimed to classify patients with, or without, side effects starting from the status of the first hour, so as to support healthcare.

We plan to do a dual evaluation. First, a medical evaluation of the results, in terms of the ability of the system to predict possible adverse events. We also plan to learn a deep neural network, based on LSTM architecture, that could predict adverse events, or events that should be reported, based on a time series analysis. Furthermore, in relation with the aims of the project, we plan to demonstrate the effectiveness of the system, in terms of the well being of the patients, and the improvement of the healthcare system, in terms of the monitoring of the patients.

3. Results

This section discusses the proposed architecture. During the SI4CARE activities, the Municipality of Miglierina was responsible for implementing three pilots. In particular, to implement the pilots, we discussed the architecture depicted in Figure 1, which was designed and implemented. SiDLY wristbands were delivered to each patient for monitoring after the fourth dose of the vaccination. Currently, the system is fully implemented and tested in its preliminary version. The system was released to the final users, who are starting to collect data.

4. Conclusions

The SI4CARE project is a transnational initiative which aims to develop innovative strategies to improve health and social care in the Adriatic–Ionian region. Within this project, the Municipality of Miglierina designed and developed a project based on the use of wearable devices for monitoring elderly patients in rural areas, with the collaboration of the complex unity of primary care (UCCP) of the Reventino area. Preliminary results of the project showed the strength of such an approach, suggesting the possibility of extending the experiment to other Adriatic–Ionian regions, taking into account the complexities of extending the network, referring both to the number of devices used and to the management of data collected. Another key point is the need to train healthcare professionals in using the devices and in managing the data collected. Finally, fundamental aspects to take into consideration are the economic, financial and organizational impacts involved.

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Abbreviations

The following abbreviations are used in this manuscript:

MoM	Municipality of Miglierina
GPS	Global Positioning System
ADRION	Adriatic Ionian
ICT	Information Communication Technology
BP	Best Practices
SQ	Status Quo
WL	Wish List
AI	Artificial Intelligence

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