Brief Report

Using Smart Devices for monitoring elderly patients in rural areas of Calabria after COVID-19 Vaccination: Experiences within the SI-4CARE Project

Alessandro Gallo * , Salvatore Fregola , Margherita Menon , Filomena Talarico , Stella fragkiadaki , Dionysia Kontaxopolou , Katarina Vukojevic , Danira Matijaca , Miljkovic Miodrag , Srdjan Kožetinac , Alessio Merola , Vlado Dimovski , Anamarija Kejžar , Ivan Radevic , Danica Stevovic , Vlatka Martinovic , Katja Matesan , Roberta Matkovic , Guido Piccoli , Francesco Esposito , Nicola Mayera , Elisabetta Pedace , Darjia Semrov , Pietro Hiram Guzzi

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Using Smart Devices for Monitoring Elderly Patients in Rural Areas of Calabria after COVID-19 Vaccination: Experiences within the SI-4CARE Project

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

1 University of Catanzaro; hguzzi@unicz.it
2 Municipality of Miglierina; sindaco@comunemiglierina.it
3 ALOT; SI4CARE-TEAM
4 Soverato Hospital ASP Catanzaro;
5 University of Split School of Medicine, 21000 Split, Croatia; katarina.vukojevic@mefst.hr
6 1st Department of Neurology Aiginition University Hospital Athens ; d.kontaxopoulou@hotmail.com
7 Special hospital Merkur, Vrnjačka Banja, Serbia; miljkovicdzoni@gmail.com
8 University of Ljubljana, Topniška ulica 31, SI-1000 Ljubljana, Slovenija / Slovenia; anamarija.kejzar@fsd.uni-lj.si,
9 UCCP Reventino
10 Regione Calabria
11 University of Montenegro, Faculty of Economics Podgorica, radevic@ucg.ac.me,
12 Director, Public Health Center Tivat, Montenegro, danica.stevovic76@gmail.com
13 Health Insureance and Reinsurance Fund of Bosnia and Herzegovina, vlatkamartinovicsi4care@gmail.com
14 Teaching Institute for Public Health of Split-Dalmatian County
15 University of Lubjiana, Faculty of Civil and Geodetic Engineering, Darja.Semrov@fgg.uni-lj.sj
16 EthosLab, Catanzaro, Italy
* Correspondence: a.gallo@ethoslab.com;
† 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).

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 the survey of the status quo, each partner has developed some pilots to to support the development and monitoring of the policy actions. In particular Partner number three, Municipality of Miglierina, designed and developed a pilot related to the use of wearable device for monitoring elderly patients in rural areas. With the collaboration of the complex unity of primary cares (UCCP) of the Reventino area, the pilot is based on the use of smart wearable device to monitor some parameters of elderly people after the vaccination for flu and covid. This paper focuses on the design and implementation of the system and describe its application in the Municipality of Miglierina, the presentation of the results and the discussion of the strengths and weaknesses will be presented in detail in a future work. Finally, the possibility of extending the experiment to the other Adriatic-Ionian region is presented.

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

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1. Introduction

The analysis of the demography across the Adriatic Ionian (ADRION) Countries shows an increase in adults with declining functional capacities and largely dependent on the help of others and in need of long-term care services. The rise in the fraction of elderly people also determines higher expenditures for healthcare and long-term care systems.

Consequently, the need for improving healthcare expenditure and the elderly's life quality arises. 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: applied to a healthcare system, it creates social value with practical impacts on society, aggregating needs and interests, increasing civic participation and strengthening 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 actors' efforts in delivering healthcare services to the elderly. The lack of integration and coordination of innovative ICT tools for healthcare providers 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 will contribute to the creation of an influential transnational ecosystem for the Social Innovation application in integrated healthcare services for the ageing population in ADRION through a collaboration network and a shared strategy translated into regional and national action plans, implemented and monitored within pilots in telemedicine and accessibility to healthcare facilities, once innovative approaches have been tested and backboned by an ICT Decision Support System.

Each partner, after the analysis of the Status Quo (SQ) and the survey of current best practices (BP), has designed some pilots together with the stakeholders (SH) and partners to demonstrate the achievements of the Wish Lists (WL). We here 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 is able to respond to the needs of the local population.

The pilot is based on testing the effectiveness of the wearable device for monitoring the healthcare status of older adults after covid-19 vaccination [1,2].

Vaccination is recognised as the most prominent measure for controlling COVID-19 disease [2–6]. 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 got 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 hospitalisation. Therefore, the Italian government launched the campaign for the fourth vaccination dose in the elderly, with novel versions of vaccines tailored for Omicron variant [7].

Since elderly 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]. Therefore we designed the following project: a cohort of volunteers who receive

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the fourth BNT162b2 vaccine are monitored for 96 hours. Participants fit a wearable device which monitors six physiological parameters recorded into a dedicated web server. Additionally, a dedicated mobile line is used to monitor patients daily and report an ad-hoc questionnaire reaction and other symptoms. The project aims twofold: supporting the vaccine's safety and demonstrating the efficacy of telemedicine and telemonitoring within the SI4CARE project. The output of the pilot will finally be evaluated within the decision support system developed within the project.

2. Materials and Methods

2.1. Wearable Devices

We selected as wearable devices the SiDLY telemedicine wristbands (SiDLYCare PRO) https://www.hospital.sidly.eu/. The whole telemedicine setup is composed by a telecare platform, a mobile application, and a telemedicine wristband.

SiDLYCare PRO, depicted in Figure 2 is a bracelet able to monitor vital parameters and to connect patient with familiars or caregivers. It is equipped with an internal micro SIM able to connect to mobile phone and data networks . The bracelet has a visible SOS button on the top that is able to send a customised message through a phone call, via SMS and via the web interface. Main characteristcs of the bracelet are listed in Table 1. The functions of the SiDLYCare PRO bracelet include:

- 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 sending 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 alarm. Bracelet can send three signal of alarms: (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.

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Figure 1. SiDLYCare PRO bracelets.

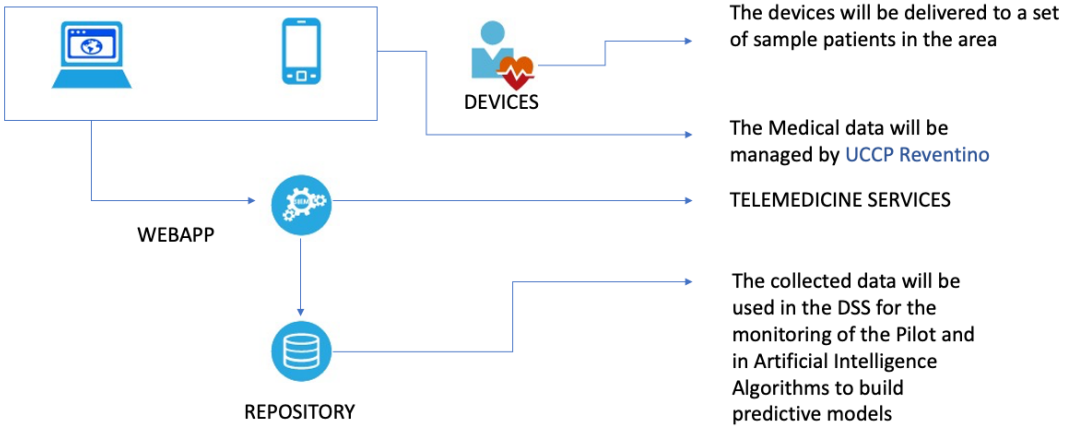

Figure 2. Figure depicts the architecture of the proposed system. Device are delivered to a set of patients selected by medical doctors from the cohoort of patient which receive the fourth dose of the vaccine. During the monitoring device stores the parameters in a secure cloud which is compliant with the GDPR regulation. UCCP reventino monitor such parameters through the web app provided by the SiDLY system. Finally, anonymised parameters of the patients are collected into a secure repository. Such data are then gathered and used to feed a decision support system of the project to monitor the pilot and to learn a predictive model based on neural networks.

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Table 1. SiDLY Bracelet characteristcs.

Autonomy	48 H after full charge
Charging time	3 hours
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	51mm x 33mm x 15mm
Weight	41g

2.2. Parameters

We collect following parameters through the bracelet:

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

Moreover we store following data through the web questionnaire:

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

2.3. Data Managing and Analysis

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

- Cluster Analysis;
- Classification of patients.

Both functions are implemented by wrapping the sklearn library of the Python Programming language. Cluster Analysis aims to build group of patients with similar characteristics. Classification of patients, performed by using a multiclass perceptron, aim to classify patient with or without side effects starting from first hours status, thus supporting healthcare.

3. Results

This section discusses the proposed architecture. During the SI4CARE activities the Municipality of Miglierina was responsible to implement three pilots. In particular to implement the Pilot we are discussing in such article, the architecture depicted in Figure 2 was designed and implemented. SiDLY wristbands were delivered to each patient for the time interval of monitoring after the foruth dose of the vaccination.

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 cares (UCCP) of the Reventino area. Preliminary results of the project show the strength of such an approach suggesting the the possibility to extend the experiment in the other adriatic-ionian regions, also taking into account the complexity of the extension of the network referring both to the number of devices used and to the

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management of the data collected. Another key point is the need to train healthcare professionals in the use of the devices and in the management of the data collected. Finally, a fundamental aspect to take into consideration is the economic, financial and organizational impact required.

5. Author Emails

Alessandro Gallo a.gallo@ethoslab.com ,
Salvatore Fregola s.fregola@ethoslab.com,
Margherita Menon margherita.menon@alot.it,
Filomena Talarico f.talarico@ethoslab.com,
Stella Fragkiadaki st.fragkiadaki@gmail.com ,
Dionysia Kontaxopolou d.kontaxopoulou@hotmail.com ,
Katarina Vukojevic kvukojev@gmail.com ,
Danira Matijaca danira.matijaca@mefst.hr ,
Miljkovic Miodrag mmiljkovic@vrnjcispa.rs ,
Srdjan Kožetinac srdjan@vrnjcispa.rs ,
Alessio Merola merola@unicz.it ,
Vlado Dimovski vlado.dimovski@ef.uni-lj.si ,
Anamarija Kejžar ,
Ivan Radević ivan@radevic.me ,
Danica Stević danica.stevovic76@gmail.com ,
Vlatka Martinović vlatkamartinovicsi4care@gmail.com ,
Katjia Mateśan katja.matesan@nzjz-split.hr ,
Roberta Matković roberta.matkovic@nzjz-split.hr ,
Guido Piccoli guido.piccoli@alot.it ,
Francesco Esposito fraesp56@gmail.com ,
Nicola Mayera nicola.mayera@regione.calabria.it ,
Elisabetta Pedace epedace84@gmail.com ,
Darja Semrov Darja.Semrov@fgg.uni-lj.si ,
and Pietro Hiram Guzzi hguzzi@unicz.it 0000-0001-5542-299.

6. 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 Vučetić, Public Health Center Tivat, Montenegro.

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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

References

1. Gepner, Y.; Mofaz, M.; Oved, S.; Yechezkel, M.; Constantini, K.; Goldstein, N.; Eisenkraft, A.; Shmueli, E.; Yamin, D. Utilizing wearable sensors for continuous and highly-sensitive monitoring of reactions to the BNT162b2 mRNA COVID-19 vaccine. *Communications Medicine* **2022**, *2*, 1–8.
2. Mercatelli, D.; Pedace, E.; Veltri, P.; Giorgi, F.M.; Guzzi, P.H. Exploiting the molecular basis of age and gender differences in outcomes of SARS-CoV-2 infections. *Computational and Structural Biotechnology Journal* **2021**, *19*, 4092–4100.
3. Hiram Guzzi, P.; Petrizzelli, F.; Mazza, T. Disease spreading modeling and analysis: A survey. *Briefings in Bioinformatics* **2022**, *23*.
4. Kumar Das, J.; Tradigo, G.; Veltri, P.; H Guzzi, P.; Roy, S. Data science in unveiling COVID-19 pathogenesis and diagnosis: evolutionary origin to drug repurposing. *Briefings in Bioinformatics* **2021**, *22*, 855–872.
5. Galicia, J.C.; Guzzi, P.H.; Giorgi, F.M.; Khan, A.A. Predicting the response of the dental pulp to sars-cov2 infection: a transcriptome-wide effect cross-analysis. *Genes & Immunity* **2020**, *21*, 360–363.
6. Gallo Cantafio, M.E.; Grillone, K.; Caracciolo, D.; Scionti, F.; Arbitrio, M.; Barbieri, V.; Pensabene, L.; Guzzi, P.H.; Di Martino, M.T. From single level analysis to multi-omics integrative approaches: a powerful strategy towards the precision oncology. *High-throughput* **2018**, *7*, 33.
7. Acuti Martellucci, C.; Flacco, M.E.; Soldato, G.; Di Martino, G.; Carota, R.; Caponetti, A.; Manzoli, L. Effectiveness of COVID-19 Vaccines in the General Population of an Italian Region before and during the Omicron Wave. *Vaccines* **2022**, *10*, 662.