CAncer PAtients Better Life Experience (CAPABLE)

first proof-of-concept demonstration

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Abstract. The CAncer PAtient Better Life Experience (CAPABLE) project combines the most advanced technologies for data and knowledge management with a socio-psychological approach, to develop a coaching system for improving the quality of life of cancer patients managed at home. The team includes complementary expertise in data- and knowledge-driven AI, data integration, telemedicine and decision support. The time is right to fully exploit Artificial Intelligence for cancer care and bring the benefits right to patients' homes. CAPABLE relies on predictive models based on both retrospective and prospective data, integrated with computer interpretable guidelines and made available to oncologists. CAPABLE's Virtual Coach component identifies unexpected needs and provides patient-specific decision support and lifestyle guidance to improve mental and physical wellbeing of patients. The demo, designed around a use-case scenario developed with clinicians involved in the project, addresses the ESMO Diarrhea guideline. It revolves around a prototypical fictional patient named Maria. Maria, 66, is affected by renal cell carcinoma and moderate insomnia. The demo follows Maria during the first three days of using the CAPABLE system. This allows the audience to understand the scope and innovation behind this AI-based decision-support and coaching system that personalizes lifestyle and medication interventions to patients, their carers and clinicians.

Keywords: cancer, side effects, personalization, coaching, guideline, FAIR, FHIR, OMOP, AI, mHealth

1 Introduction

After the primary intervention, most cancer patients are managed at home, facing long-term treatments or sequelae, making the disease comparable to a chronic condition [1].

Despite their benefit, strong therapeutic regimens often cause toxicity, severely impairing quality of life. This may decrease adherence to treatment, thus compromising therapeutic efficacy. Also due to age-related multimorbidity, patients and their caregivers develop emotional, educational and social needs [1].

In 2019, a consortium comprising 5 universities across Europe and Israel, 3 small-medium enterprises, 1 large company, 2 hospitals and 1 patient association, was funded by the EC Horizon 2020 tender on "Big data and artificial intelligence for monitoring health status and quality of life after the cancer treatment". As a result, the CAncer PAtient Better Life Experience (CAPABLE)[1] project started Jan 1st 2020, with the objective to combine the most advanced technologies for data and knowledge management with a sound socio-psychological approach in order to develop a coaching system for improving the quality of life of cancer patients managed at home. The project addresses EU priorities such as shifting care from hospitals to home to face scarcity of healthcare resources, facilitating patients' re-integration in the society and promoting an effective, novel cancer care model for all EU citizens. The time is right to fully exploit Artificial Intelligence (AI) and Big Data for cancer care and bring them to patients' home. In this paper, we present the first proof-of-concept (POC) of the CAPABLE system, developed during the first 12 months of the project.

2 Methods

2.1 Consortium and expertise

University of Pavia (UNIPV) is the project coordinator, with the "M. Stefanelli" Biomedical Informatics Laboratory group. UNIPV is also home to the Centre for Health Technologies (CHT)[2], and the European Centre for Law, Science and new Technologies (ECLT)[3], helping the consortium to tackle the medico-legal issues related to the application of IT and AI in medicine. The project leverages a strong collaboration between universities and SMEs. University of Haifa (UoH) has leading expertise in knowledge representation for decision support and for data integration; in CAPABLE they are focusing on representation and algorithms for a) planning conflict-free treatment plans for multimorbidity patients and b) bridging the semantic gap between clinical abstractions and retrieval of raw data. Deontics ltd (DEON) developed a computer-interpretable guideline (CIG) editor and enactment engine for the PROforma CIG formalism, adapting it to the project needs. Amsterdam Medical Center (AMC) has a wide experience on standards for medical data representation while Biomeris s.r.l. (BIOM) integrates all the data collected in CAPABLE exploiting their experience in data-warehousing. Poznan University of Technology (PUT) is responsible for the patient coaching development while Bitsens JCV (BIT) provides the final user interfaces. The large

[1] The CAPABLE project has received funding from the European Union's Horizon 2020 research programme under grant agreement No 875052. www.capable-project.eu

[2] cht.unipv.it

[3] www.unipv-lawtech.eu

company involved is IBM, providing the necessary skills to exploit the latest developments in AI. Data is collected in retrospective studies and in the CAPABLE prospective clinical studies by Istituti Clinico-Scientifici "Maugeri" (ICSM) and Netherlands Cancer Institute (NKI), two leading hospitals for cancer treatment in Italy and the Netherlands. Associazione Italiana Malati di Cancro AIMAC, an important patient association from Italy networked with other associations and the European Patient Cancer Coalition contributes to maintain a patient-centred approach along the whole project execution.

2.2 Iterative development of the first POC and its components

The first POC was developed in the project, following an iterative development process that started July 1st 2020, culminating in the production of deliverable 4.1[2] in Dec 2020. Figure 1 highlights such a process and its sub-iterations. Details of the scope of each iteration are provided in the following, along with the POC architecture.

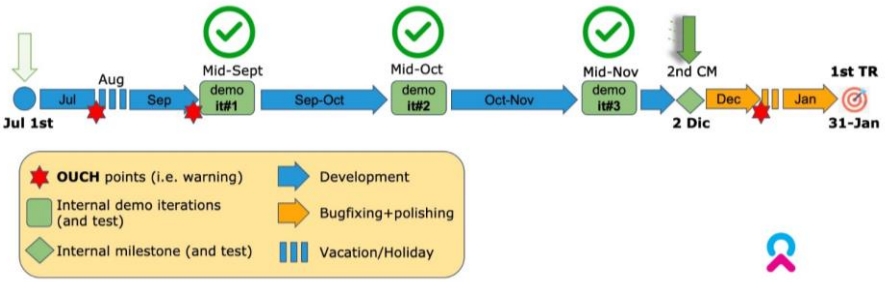

Fig. 1. Iterative development process of CAPABLE first POC.

Table 1 presents the CAPABLE system components that are part of the 1st POC, along with their main functionalities and responsible partner in the consortium. Figure 2 presents the scoped-down architecture of the 1st CAPABLE POC.

Table 1. CAPABLE first POC components.

Component (ABBR)	Role	Responsible partner	It#
Data Platform (DP)	storing and providing patient-level data	UNIPV	It#1
Case Manager (CM)	managing events related to Data Platform and providing notifications to other components	UNIPV	It#1
Physician DSS (DSS)	providing guideline-based decision support for clinicians when managing cancer patients	DEON	It#2
Knowledge-Data Ontology Mapper (KDOM)	Using ontology mapping classes to define clinical abstractions in terms of raw data and FHIR queries	UoH	It#2
GoCom Multimorbidity controller (GOCO)	checking for possible adverse interactions between clinical tasks for multimorbid patients and resolving them	UoH	It#2
Virtual Coach (VC)	providing coaching support combining clinical and non-clinical recommendations to cancer patients at home	PUT	It#2

Deontics Engine (DE)	executing computer-interpretable clinical practice guidelines (CIGs) defined using the PROforma language	DEON	It#2
Patient app	providing user interface for patients	BIT	It#3
Physician dashboard	providing user interface for physicians	BIT	It#3

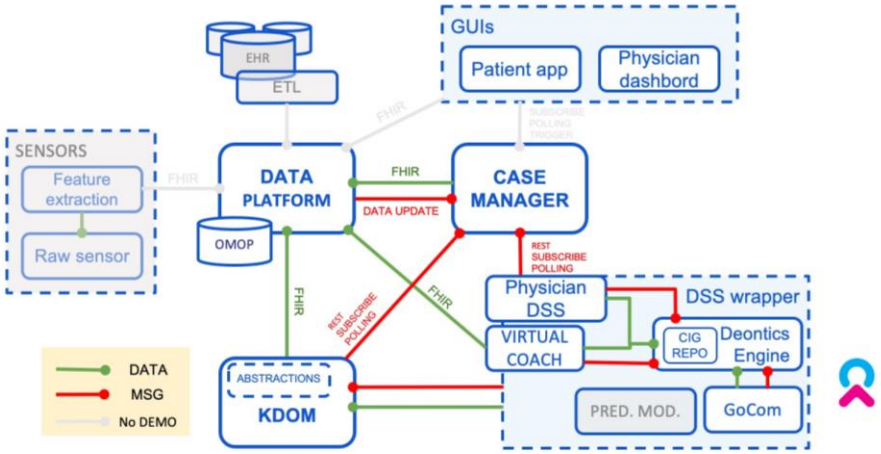

Fig. 2. General architecture of the CAPABLE system. Components and interactions that are out-of-scope for the 1st POC have been grayed-out.

2.3 Data model and FAIR principles

The infrastructure is intended to be FAIR, i.e., findable, accessible, interoperable, and reusable. This is realized by adhering to existing standards as much as possible, i.e., OMOP CDM as the persistence model for the data, and HL7 FHIR for inter-component communication. This will be complemented by advertising metadata, including characteristics of the stored data, used vocabularies, and characterization of the included population[3].

2.4 AI

CAPABLE relies on diversified AI techniques, including knowledge- and data-driven approaches to provide comprehensive decision support to both patients and clinicians thorough Virtual Coach and Physician DSS, respectively. It employs complex CIGs, with physician- and patient-oriented components, represented in PROforma and executed by DE to provide evidence-based recommendations. CAPABLE also includes two classes of data-driven models – exploratory models and prediction models that are derived from multi-modal data (clinical data, patient reported outcomes, readings from environmental and wearable sensors). Exploratory models provide a concise summary of analyzed data and will be used for indirect decision support through infographics and other visual tools. Prediction models provide patient-specific recommendations, thus

offering direct decision support. They are further divided into population and personal models – the former are derived from cohorts of patients suffering from the same type of cancer, while the latter are constructed for individual patients.

Current population models have been derived from available retrospective data provided by NKI and ICSM and they aim predicting the survival and response to treatment. They will be further refined based on prospective data. Personalized models are aimed at facilitating application of non-clinical lifestyle interventions (so called *capsules*), such as breathing exercises, meditation or physical activity. Preliminary personal models have been constructed from available retrospective benchmark data (e.g., WESAD[4]) and will be further refined with CAPABLE prospective data.

3 Results

A recording of the POC demonstration was produced on December 9th 2020, reflecting what was shown during the CAPABLE consortium meeting held on December 2nd. Deliverable 4.1, focusing on the 1st POC is publicly available[2]. A second POC is scheduled for project M18. Late-breaking results may be available to be presented live at AIME2021 in June.

4 Conclusion

With its AI-enabled components, CAPABLE is more than a personalized tool for improving quality of life, but rather an advance for the AI in medicine research community. This first POC is being extended by the project consortium and CAPABLE will start its clinical studies, testing the system with real-world cancer patients, in Jan 2023.

References

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