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Implementation and evaluation of an Asbru-based decision support system for adjuvant treatment in breast cancer

Claudio Eccher[a,*], *Andreas Seyfang*[b], *Antonella Ferro*[c]

[a] *Fondazione Bruno Kessler, Trento, Italy*
[b] *Vienna University of Technology, Vienna, Austria*
[c] *Medical Oncology, S. Chiara Hospital, Trento, Italy*

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ABSTRACT

The domain of cancer treatment is a promising field for the implementation and evaluation of a protocol-based clinical decision support system, because of the algorithmic nature of treatment recommendations. However, many factors can limit such systems' potential to support the decision of clinicians: technical challenges related to the interoperability with existing electronic patient records and clinical challenges related to the inherent complexity of the decisions, often collectively taken by panels of different specialists. In this paper, we evaluate the performances of an Asbru-based decision support system implementing treatment protocols for breast cancer, which accesses data from an oncological electronic patient record. Focusing on the decision on the adjuvant pharmaceutical treatment for patients affected by early invasive breast cancer, we evaluate the matching of the system's recommendations with those issued by the multidisciplinary panel held weekly in a hospital.

1. Introduction

The gap between practice and best evidence in delivering health care services has been known well since long ago [1]. Although not always achieved, a major goal of health care systems is the provision of safe, cost-effective and evidence-based health care [2].

Clinical Practice Guidelines (CPGs), defined as "...systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" [3], promise to efficiently disseminate the ever increasing amount of available clinical knowledge in order to reduce the undesired variation in the provision of care and thus to improve the quality of the care [4].

In real clinical settings, expert clinicians distil CPGs into simpler and more structured clinical protocols, i.e., a comprehensive set of rigid criteria describing the steps to managing a disease adapted to the local workflow and the available resources, easily usable in practice.

The main challenge in the practical use of guidelines and protocols, however, is the efficient dissemination of their content. Traditional paper dissemination of CPGs is relatively ineffective in influencing physicians' behavior [5], and the

* *Corresponding author at*: Via Sommarive 18, 38123 Povo, Trento, Italy. Tel.: +39 0461 314 161.
E-mail addresses: cleccher@fbk.eu, claudio.eccher@gmail.com (C. Eccher).
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huge effort of guideline creation may not be matched by the level of adherence to them in everyday practice [6].

By delivering specific options and recommendations to the user depending on the disease and patient conditions in an automated fashion, Computerized Decision Support Systems (CDSS) can improve the compliance of clinicians with protocols, especially when integrated into the clinical workflow [7,8].

The domain of oncology is a promising field of application for CDSS', because pharmaceutical treatment protocols are largely algorithmic, yet often complex. The cure of breast cancer in particular has seen an explosion of life-saving treatment advances in recent years and an overwhelming range of therapies and drugs is available today. To decide the best therapy, the oncologist has to assess and combine several different patient and disease parameters (patient age, tumor morphology, hormone responsiveness, disease stage, etc.), a job computerized systems are particularly good at.

The integration of a CDSS into the IT infrastructure of a hospital, however, remains challenging as the data available in the Electronic Patient Records (EPR) at the point of care rarely meet the information referred to in the CPG in a direct way.

To ensure the best quality of care, many cancer treatments are decided in a discussion attended by experts of the different specialties involved in the cancer diagnosis and care. At the same time, many decisions are still taken by single physicians and there is demand for a support of those less familiar with the protocol in all its details.

This results in the following question discussed in this paper: *How close can the decision of a CDSS, based on parameters found in the EPR, resemble that made by a multidisciplinary expert panel?*

The OncoCure project explored this question by designing a CDSS to implement the breast cancer treatment protocols used in the Medical Oncology Unit (MOU) of the S. Chiara Hospital of Trento (Northern Italy). In a first step, we compared the recommendations produced by the CDSS with recommendations by an expert panel. The result of this comparison is presented here. In a second step, we plan to deploy the CDSS in those cases where an expert panel is not available.

The remainder of this paper is organized as follows. In the next section, we describe related work. In Section 3 we describe the protocol concerned, the OncoCure CDSS, and the modeling process. In Section 4, we discuss how we explored the capability of the OncoCure CDSS as a supporting tool in the decision process; the results of the evaluation are expounded in Section 5. Finally, in Section 6, we discuss the results and their implication for designing effective CDSS'.

2. Related work

Supporting the execution of clinical guidelines and protocols by CDSS' has a rich history. Early systems, dating back as far as 1987 [9], directly encoded the guideline in question in a knowledge-based system. A more recent system deployed at the Tenon hospital in Paris is OncoDoc2 [10]. It increased the compliance rate of decisions from 79% to 93% [11]. In this system, the user enters the patient data, thereby browsing the knowledge base manually. In contrast, the OncoCure CDSS directly connects with the EPR, relieving the user from data entry.

To facilitate the modeling task, various formal and semi-formal languages were developed and several comparisons of these languages were published [12,13]. Latoszek-Berendsen et al. [14] discuss them in the wider context of guideline development and impact.

Of these approaches, the DeGeL framework [15] is the closest to our system because it uses Asbru (compare Section 3) which is also used in the OncoCure project. The DeGeL framework features a set of distributed tools, focusing on the hybrid representations, in which parts of the guideline are specified in a more formal way while others remain free-text. It incorporates the Spock execution engine [16] which is able to process hybrid guideline models, e.g., hybrid Asbru [17]. The above is complemented by IDAN [18], a temporal abstraction mediator for the Spock engine mentioned above, and MEIDA [19], a framework for mapping the Computer Interpretable Guidelines (CIG) terms to specific EPRs using medical standard vocabulary. Similarly to our architecture, MEIDA adopts a Virtual Medical Record (VMR) approach mapping the local database schema into the VMR schema. The OncoCure project fully formalized the protocol, which meant that executing fully formal Asbru was possible. In fact, recently the fully formal Picard module was included into DeGel, and evaluated in the cardiology and Pre-Eclampsia/Toxemia of pregnancy domains [20]. In the last case, cross-over "in-vitro clinical evaluation" was performed with the help of 36 different clinicians at an OB/GYN department using realistically simulated clinical data based on a set of clinical scenarios and decision points within them. The simulation results demonstrated that the correctness of the physicians' decisions relative to the guideline increased in the CDSS arm from 32% to 98%, while the completeness of applying the guideline increased from 47% to 93%; and that the variance amongst different decision points, scenarios, and clinicians decreased considerably.

KDOM [21] is another general framework for the integration of guideline models with specific EPRs, evaluated by mapping a guideline encoded in Guideline Interchange Format version 3 (GLIF3) to two EPRs. Differently from our system, where we separated the database mapping from the abstraction rules, KDOM uses a mapping ontology with both the property group that conceptualizes the abstract knowledge and the group to map CIG fields to the target EPR table(s).

In the cancer domain, MATE [22], which is based on the CREDO software platform [23], focuses on supporting the decision of patient management options during breast cancer multidisciplinary meetings. It combines seven guidelines and adds multimedia support to the decision process and achieved a compliance of 93.2% in 1056 analyzed cases. While it is much more comprehensive than the OncoCure system, it contains its own data entry facilities for its stand-alone EPR, while OncoCure is integrated into an existing EPR used at the point of care.

Another system to support breast cancer follow-up was developed by Abidi et al. [24] using the Guideline Elements Model (GEM) to mark up the guideline before modeling the recommendations as a Protégé [25] ontology. They developed a web-based execution engine to combine the ontology representing the guideline and associated domain knowledge and