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Personalised Care Plan Management Utilizing Guideline-Driven Clinical Decision Support Systems

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Abstract. Older age is associated with an increased accumulation of multiple chronic conditions. The clinical management of patients suffering from multiple chronic conditions is very complex, disconnected and time-consuming with the traditional care settings. Integrated care is a means to address the growing demand for improved patient experience and health outcomes of multimorbid and long-term care patients. Care planning is a prevalent approach of integrated care, where the aim is to deliver more personalized and targeted care creating shared care plans by clearly articulating the role of each provider and patient in the care process. In this paper, we present a method and corresponding implementation of a semi-automatic care plan management tool, integrated with clinical decision support services which can seamlessly access and assess the electronic health records (EHRs) of the patient in comparison with evidence based clinical guidelines to suggest personalized recommendations for goals and interventions to be added to the individualized care plans.

Keywords. Chronic disease management, personalized care plans, multimorbidity

1. Introduction

A growing share of the population (15% in 2010) in OECD countries is over 65 and expected to reach 22% by 2030 [1]. Older age is associated with an increased accumulation of multiple chronic conditions [2]. The clinical management of patients suffering from multiple chronic conditions is very complex, disconnected and time-consuming with the traditional care settings. Integrated care is seen as a means to transform health services to meet these challenges of 21st century by addressing the growing demand for improved patient experience and health outcomes of multimorbid and long-term care patients [3].

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Care planning is a prevalent approach of integrated care, where the aim is to deliver more personalized and targeted care creating shared care plans that map care processes (care pathways) by clearly articulating the role of each provider and patient in the care process. In the state of the art practices, the multidisciplinary teams (MDT) meet face-to-face to discuss and revise the care plans of several patients at once, in regular time intervals; usually monthly. Individualized care plans are created by manually going over the standard steps of care pathways, i.e. template care plans which are documentation of the optimal management for typical, defined disease patterns.

Although implementation of integrated care via these manual processes is already an enhancement over traditional fragmented care practices, we believe significant improvement can be achieved if MDTs can be equipped with intelligent services to suggest personalized goals and interventions for the care plan of the patient based on the most recent context of the patient and evidence based guidelines.

In this paper, we present a method and corresponding implementation of a semi-automatic care plan management tool, integrated with clinical decision support services which can seamlessly access and assess the electronic health records (EHRs) of the patient in comparison with evidence based clinical guidelines to suggest personalized recommendations for goals and interventions to be added to the individualized care plans.

2. Background

Clinical guidelines are used in the healthcare domain to improve the quality of care [4]. It has been demonstrated that clinical guidelines provided as real-time decision support systems improve patient care significantly [5] and decrease undesired practice variability [6]. Yet, the success of clinical decision-support systems requires that they are seamlessly integrated with clinical workflows [7].

Several methodological approaches exist to implement clinical guidelines into operational practice. Narrative guidelines can be formalized via computer interpretable guideline representation languages such as Arden Syntax and PROforma[8]. These can be served as modular CDS services to be utilized by hospital information systems during patient treatment to provide alert and reminders about missing or contraindicating interventions (e.g. EBMeDS [9]). However, this does not directly support healthcare professionals to follow a standardized plan of care for a specific condition as a clinical workflow. Clinical pathways are appropriate for that purpose, however clinical guidelines and care pathways are often viewed as separate entities, their synergistic potential remaining only partially exploited [10].

In this paper, we present an approach to effectively integrate clinical guidelines and care pathways: we will demonstrate that it is possible to semi-automatically personalize care pathways to create individualized care plans, by automatically processing knowledge in clinical guidelines and patient's EHRs. In this way, it will be possible to follow the recommendations of clinical guidelines as a clinical workflow executed via integrated care plans for addressing the demanding needs of patients suffering from long-term chronic conditions.

3. Method and Results

In order to ensure wide adoption, we have chosen to build a standards-based architecture, where widely accepted industry standards are chosen as building blocks of our implementation. In the following, we first briefly present these standards, then outline the details of the architecture that integrates these to implement an intelligent platform to support integrated care by enabling the personalization of care pathways as care plans dynamically in the light of evidence based guidelines.

Machine Processable Care Plan Model

As a machine processable standard based care plan model, we have chosen HL7 FHIR STU3 Care Plan Model [12] developed based on the guidance provided in HL7 Care Plan Domain Analysis Model (DAM) [13]. It is a FHIR resource to clearly document the *Health Concerns* addressed, targeted *Goals*, and planned *Activities (*such as Medication Requests, Diet Plans, Procedure Requests, Appointments, Referrals, etc.)*, Outcomes* achieved, *Care Team Members* and their responsibilities in detail.

3.1. Addressing the needs of interoperability to access EHRs: HL7 FHIR

To seamlessly access and assess the EHRs of the patient to provide individualized care plan goals and activities, there is a need for a technical interoperability layer between the local care systems and care plan development environment. We have chosen to build our technical interoperability layer based on HL7 FHIR STU3 clinical resources and RESTful interfaces. The Personalized Care Plan Development Platform (PCPDP) accesses patient's most recent EHRs through these FHIR based interfaces implemented on top of the proprietary APIs provided by local EHR systems in our pilot sites.

3.2. Addressing the needs of interoperability with CDS Services: CDS Hooks

CDS Hooks [14] is open API for CDS services. It provides a standard based mechanism to share the patient context with CDS services via FHIR resources, and to present the results of the CDS process as information cards or suggestion cards in a standard schema.

3.3. Addressing the needs of authoring and sharing of CDS logic: GDL

Guideline Definition Language (GDL) is a formal language for expression CDS logic based on clinical models and terminology systems [16]. Direct support for FHIR resources and CDS Hooks added in the version 2 of GDL makes it ideal to develop CDS logic in the project.

3.4. Personalized Care Plan Development Platform

As depicted in Figure 1, the Personalized Care Plan Development Platform (PCPDP) is implemented as a Web based portal, which can access the most recent context of the patient via FHIR based interfaces developed on top of local APIs. PCPDP implements the HL7 Care Plan DAM, and enables health professionals to design a care plan for a patient from scratch by selecting health concerns to be addressed from the EHR of the patient, and setting goals and activities to address the needs of this health concern.

To be able to intelligently propose individualized suggestions for goals and activities for the selected health concerns, PCPDP is integrated with external CDS services via CDS Hooks API. The retrieved patient context as FHIR resources are passed as prefetch data to CDS services. Within CDS logic, processing these patient specific diagnosis, lab result, medication data enables the selection of individualized goals and interventions for this specific patient. As response, textual recommendations as *information cards* and computable recommendations as *suggestion cards* are received in conformance to CDS Hooks API. In suggestion cards, the recommended goals and activities are represented as FHIR resources (such as *MedicationRequest*, *Goal*, *Appointment* resources) which can readily be included into the care plan model. The finalized personalized care plan can be shared back with the local EHR Systems by exporting the care plan as a FHIR *CarePlan* resource serialized as a JSON instance.

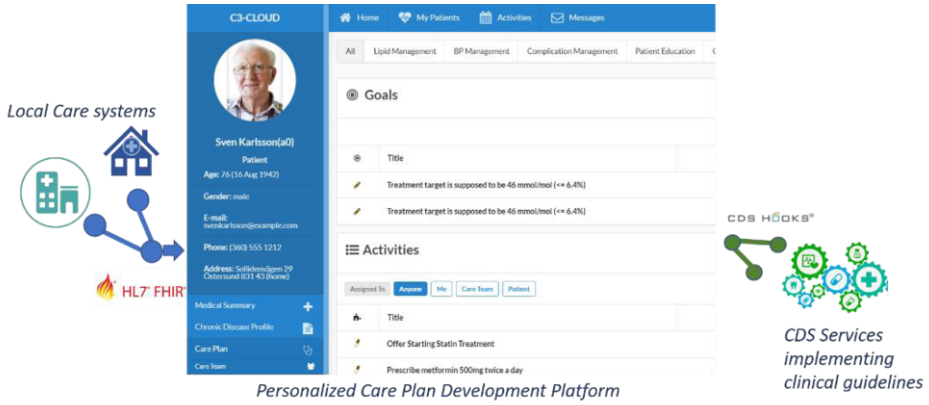

Figure 1. Proposed Architecture for Personalized Care Plan Development Platform.

To demonstrate the validity of the approach, we have examined NICE Type 2 diabetes in adults: management clinical guideline (NG28) [15]. 19 flowcharts have been designed by clinical experts covering the recommendations of NG28. These flowcharts have been examined in detail, the ones that can provide computable suggestions via CDS services have been identified and the inputs and possible outputs of these possible CDS services have been specified as FHIR resources. The specifications of these CDS services have been validated once again by clinical experts. Among the validated CDS specifications, till now 7 CDS services have been implemented in conformance to CDS Hooks API, namely: Blood Pressure Management, Blood Glucose Management, HbA1c Targets, Lipid Management, QRISK2 Cardiovascular Risk Stratification, Foot Disease and Diet Plan. These services realize 80 clinical rules checking 108 different patient criteria and recommending 119 personalized goals and interventions to the care team.

4. Discussion and Conclusion

Usability studies held with the clinical experts have shown that the proposed method is able to address the needs of care plan personalization via CDS services implementing clinical guidelines. In a next step, the system will be validated in three pilot sites specially

to examine effectiveness of personalized care plans for chronic disease management: Basque Country (Spain), Region of Jämtland (Sweden) and South Warwickshire NHS Foundation Trust (UK) via a 15 months pilot study with 600 patients.

In this prototype, CDS services have been utilized for listing the recommendations of clinical guidelines designed for individual chronic conditions. Work is about to be completed for further CDS services covering three other major diseases: renal failure, heart failure and depression. In the second prototype, reconciliation CDS services will be implemented and validated to detect conflicting guidance by disease-specific guidelines in the case of multimorbidity.

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References

[1] OECD Factbook 2009. http://dx.doi.org/10.1787/factbook-2009-3-en
[2] The King's Fund, 'Providing integrated care for older people with complex needs: Lessons from seven international case studies'. http://www.kingsfund.org.uk/publications/providing-integrated-care-older-people-complex-needs
[3] Integrated care models: an overview, Working Document, October 2016, Health Services Delivery Programme, Division of Health Systems and Public Health, WHO Europe.
[4] K. Vanhaecht, The impact of clinical pathways on the organisation of care processes, *PhD thesis*, University Leuven, Faculty of Medicine, 2007.
[5] K. Kawamoto, C.A. Houlihan, E.A. Balas, D.F. Lobach, Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success, *BMJ* **330** (2005), 765.
[6] R. Lenz, R. Blaser, M. Beyer, O. Heger, C. Biber, M. Bäumlein, M. Schnabel, IT support for clinical pathways--lessons learned, *Stud Health Technol Inform*. **124** (2006), 645-50.
[7] S.W. Tu et al., Modeling Guidelines for Integration into Clinical Workflow, *Stud Health Technol Inform*. **107** (2004), 174-78.
[8] K. Heiden, B. Böckmann, Generating Evidence-Based Pathway Models for Different Hospital Information Systems, *Health Information Science*, Springer Berlin, Heidelberg, 2013.
[9] The Evidence-Based Medicine Electronic Decision Support, http://www.duodecim.fi/english/products/ebmeds/
[10] M.W. Beckmann, H. Schlieter, P. Richter, S. Wesselmann, Considerations on the Improved Integration of Medical Guidelines into Routine Clinical Practice - a Review and Concept Proposal, *Zeitschrift Geburtshilfe und Frauenheilkunde* **76** (2016), 369–376.
[11] B. Böckmann, K. Heiden, PathGuide - model-based generation of guideline-compliant pathways for the use in different hospital information systems, *Stud Health Technol Inform*. **192** (2013), 1089.
[12] HL7 FHIR Care Plan Resource, https://www.hl7.org/fhir/careplan.html
[13] HL7 V3 Domain Analysis Model, Care Plan, Release 1, May 2016, HL7 Informative Document, http://www.hl7.org/implement/standards/product_brief.cfm?product_id=435
[14] CDS Hooks, http://cds-hooks.org/
[15] NICE Type 2 diabetes in adults: management (NG28), https://www.nice.org.uk/guidance/ng28
[16] Guideline Definition Language (GDL), http://www.openehr.org/releases/CDS/latest/docs/GDL/GDL.html