Automated conflict resolution between multiple clinical pathways:

An aid for family practitioners

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Context:

By 2018 it is estimated that the number of people in the UK with three or more long-term conditions will have grown from 1.9 million to 2.9 million. To improve the quality of healthcare over 250 clinical guidelines have been published by the National Institute for Clinical Excellence, however, they almost entirely focus on single conditions. As a result, applying multiple guidelines to one patient can lead to conflicting recommendations for care. In the last twelve months we have developed a specialised version of the Business Process Modelling Notation (BPMN) which allows us to model pathways in a user-friendly format and incorporate data critical to the process. Using this notation means we can apply software-based constraint solvers to explore these pathways and detect instances of conflict relating to medication or lifestyle advice. In addition we have undertaken a mixed-method investigation of the management of multi-morbidity in primary and secondary care settings and used process mining techniques to analyse multiple prescriptions for multimorbid patients and the number of potentially serious interactions

Objective:

The resolution of a conflict can entail different compromises and affect different measures such as time, resource, and cost. In this study we will investigate automated methods of detection of conflicts across multiple clinical pathways used in treating patients with multimorbidity. We will consider the specific nature and parameters of each guideline, specific conditions of individual patients, and propose solutions that resolve the conflict. The study has just completed the first of its three years and is funded by the Engineering and Physical Sciences Research Council (UK).

Constraint solvers and Z3:

Constraint solvers efficiently solve problems specified as logical statements. SAT solvers require problems to be defined using simple combinations of true/false values, whereas SMT (Satisfiability Module Theories) solvers express problems in first-order logic and employ "theories" such as integer arithmetic or quantifiers to more powerfully solve complex problems.

We define logical statements to describe the syntax (nodes and arc connectivity) and semantics (dynamic behaviour over time) of clinical pathways (Fig. 1), particularly with regard to their dependence on and interaction with data. Further logical constraints are specified to impose conditions such as those restricting interaction between medication, scheduling, or personnel constraints. The Z3 solver then produces a model which satisfies the specified logical definition and constraints, giving the valid (or invalid) execution paths and identifying conflicting activities and data.

This approach is expected to be more efficient than simple state-space exploration, and will provide a suitable basis for extension to recommend changes to the processes which will avoid or minimise conflict.

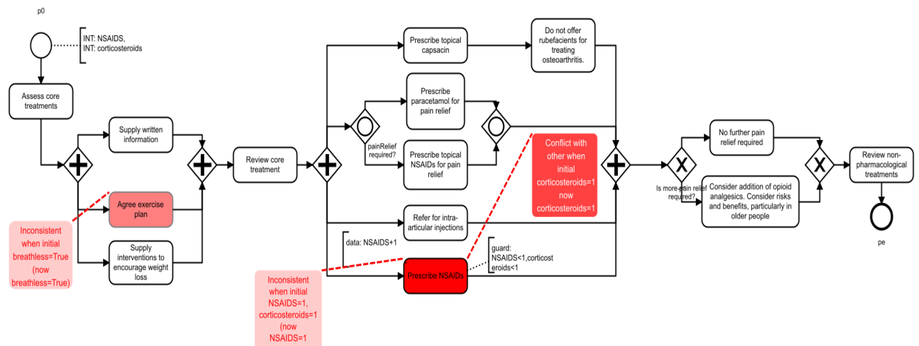

Figure 1: Excerpt of Osteoporosis pathway showing areas of potential conflict

Three-phase design:

Phase 1: Modelling clinical pathways: Built on the graphical process modelling language BPMN we have produced formal models of six clinical pathways representing some of the most common chronic diseases including Chronic Obstructive Pulmonary Disease (COPD) and Osteoarthritis. (see Figure 1).

Phase 2: Recognition and resolution of conflict: We have begun the process of detecting conflicts between various steps on each "pathway" using **CONSTRAINT SOLVERS** particularly Z3 previously used successfully to detect conflict in the composition of static models of processes .

Phase 3: Development of a prototype software tool and case study : Creation of a prototype web-based tool that allows the user to produce and save models of pathways, and identify and resolve conflicts between them.

Mixed Methods Multimorbidity study: Exploring the management and prevalence of polypharmacy

Objective: For our tool to be relevant and effective we must understand the current management of multimorbid patients and its associated polypharmacy. Therefore, we first qualitatively identified any issues faced by clinicians in primary and secondary care when managing these patients then quantitatively assessed current levels of polypharmacy (and the interactions between medication) within primary care.

Design: Mixed methods: Semi-structured interviews . Anonymised patient prescription data extracted in primary care with one or more of: Hypertension; Depression; Osteoarthritis; Chronic Obstructive Pulmonary Disease; Type 2 Diabetes; or Ischaemic Heart Disease.

Setting: Seven family practices, two hospitals, and two community pharmacies in the West Midlands, UK.

Participants: Primary care physicians (x12), secondary care consultants (x11) and community pharmacists (x4) recruited using purposive snowballing. The data of 8874 patients were extracted from five primary care centres resulting in 798947 prescriptions.

Results: Barriers to the successful management included de-prescribing, the burden of medication and disease on the patient, and limitations within the evidence base. Prescriptions increased with age demonstrating high polypharmacy. We have used **PROCESS MINING** in the analysis of prescribing patterns to determine the prevalence of concurrent medication and severity of interactions. We plan to further develop novel process mining algorithms to gain insights into and visualise the prevalent patterns of polypharmacy.

Process mining:

The need to understand and optimise organisational performance is not unique to healthcare, and in industries such as telecoms or finance, a methodology known as "Process Mining" has become an established and successful method to identify how an organisation can best deploy resources to meet the needs of its clients and customers. Process mining uses routinely collected data recording the interaction between service provider and user. It requires the iterative application and refinement of algorithms to determine patterns of activity from the data, identifying and refining or processes by which services are delivered.