Automated conflict resolution between multiple clinical pathways:
An aid for family practitioners

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EPSRC Engineering and Physical Sciences Research Council

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 and primary care plays a pivotal role in the management of these patients. To improve the quality of healthcare some 253 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.

Software system specifications and patient care guidelines both consist of procedures and executions of ordered sequences of actions, activities or tasks. To help identify possible conflicts one option successfully used in software engineering is to transform sequences of events into logical statements and use constraint solvers to detect conflict in their composition. Here we will be applying the same theory into modelled pathways of care to determine how we might detect and resolve conflicts in the management of patients.

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).

Labelled Event Structures, Sequence Diagrams, and the detection of conflict

LES describe distributed systems by means of a set of events and causal dependencies between parts of the system. Sequence diagrams describe the (partial) ordering of messages between components in such systems. Care pathways represent sequences of medical procedures that should be applied to a patient, involving interaction between many parties (e.g. GPs and specialists), locations or other resources. Combining aspects of LES and sequence diagrams will therefore allow us to formally model the behavioural semantics of clinical pathways designed in BPMN.

LES has also been used for the behavioural interpretation of composition of models, incorporating constraints, or "composition glue" between models. We will use this to describe and analyse conflicts between clinical pathways for multiple morbidities.

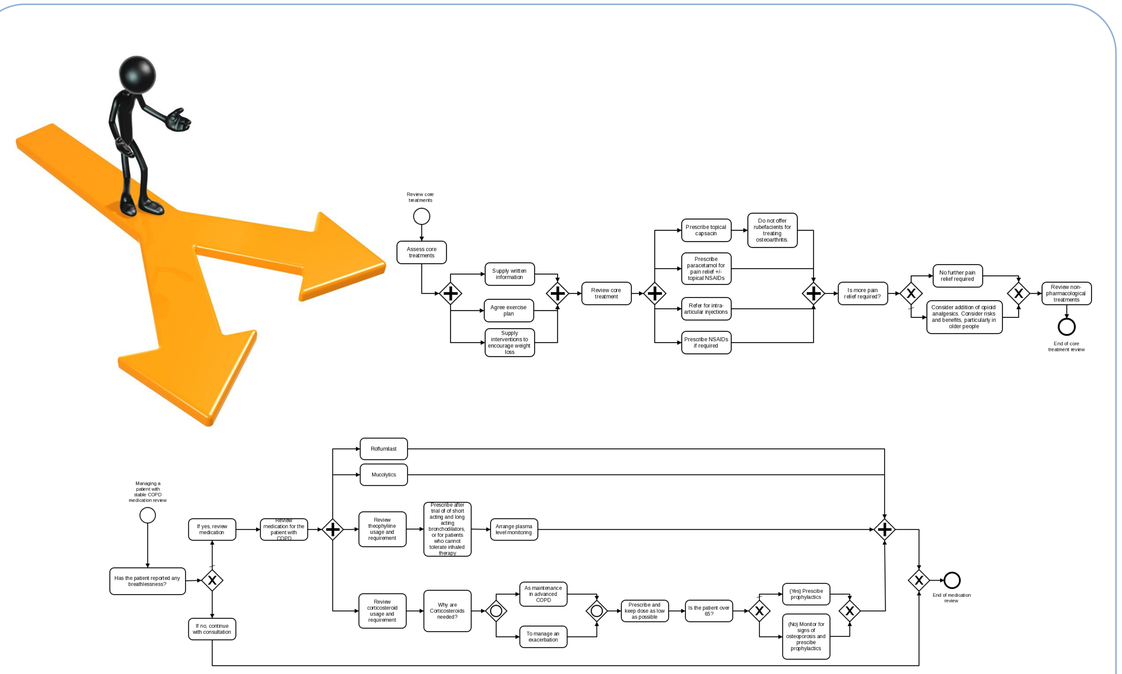

Figure 1: Excerpts from two potentially clashing clinical pathways – Osteoarthritis (above) and COPD (below)

Case Study:

We will use an example originally described by Boyd et al [2005] of a 79 year old lady with multiple morbidities including osteooarthritis, and COPD. To evaluate whether our method can automatically detect the published conflicts, we will use the models of the six pathways we have defined in Phase 1, which we know have conflict (see Figure 1). Using Alloy or Z3 as outlined in Phase 2, we will validate whether we can detect the published conflicts and also any other conflicts which may exist between the models. The software will then be able to suggest ways in which conflicts can be resolved using the minimum numbers of changes to each pathway. A team of clinicians including Turner will confirm if the conflicts discovered (and the suggested resolutions) are medically valid and are applicable to the clinical management of the patient.

Three-phase design:

Phase 1: Modelling clinical pathways: We will build on the graphical process modelling language BPMN to accurately model six clinical pathways representing some of the most common chronic diseases including Chronic Obstructive Pulmonary Disease (COPD) and Osteoarthritis. We will produce a formal model that captures care pathways unambiguously (see Figure 1). This formal representation will be based on labelled (prime) event structures (LES) and sequence diagrams (see Box) .

Phase 2: Recognition and resolution of conflict: Using Alloy [Jackson 2006], and its underlying SAT-solver, it is possible to automatically detect whether the ordering of events specified in a sequence diagram are in conflict with the ordering of events in another sequence diagram [Bowles J, Alwanain M, Bordbar B, Chen Y, 2015]. This corresponds in care guidelines to a referral or medical conflict, for example when two pathways prescribe drugs which should not be used at the same time. We will use an analyser to automatically identify the parts of the pathway models and "composition glue" which are in conflict. We will use automated methods for changing those parts of pathway models which are causing conflict. For example, if the conflict is caused by referral, we need to reschedule appointments accordingly.

Phase 3: Development of a prototype software tool and case study

For the final phase, we will create a prototype tool consisting of a plug-in with a Front End Model Editor to allow the user to produce and save models of pathways, and identify and resolve conflicts between them.