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## Supporting a Medication Management Model with Digital Documents

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### Abstract

Medication management is an approach to addressing medication-related adverse patient events. We have formulated a model of essential medication-related information components to support pharmacists undertaking this task, because there is currently little technology to support such decision-making. We believe the system should identify necessary components but not mandate their presence because of the dilemma of missing information. A possible additional answer lies in supporting communication and acknowledging the contribution of knowledge, rather than attempting to provide all possible information. Our model underpinned a document-centric approach, using XML-based XForms, to develop a decision support tool. This allowed rapid development of a simple dynamic tool that shows promise for simple decision support in the health environment.

### Keywords

Medication management, digital documents, decision-making, XForms

### INTRODUCTION

Medication management (MM) broadly describes a set of relationships and decisions through which primary healthcare practitioners and patients work together to produce specific drug therapy outcomes (Canadian Pharmacists Association 2004), and is an approach to addressing medication-related adverse events. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has specified the necessary information components required for MM and identified ready accessibility to patient-specific information as a prime aim for those involved in the MM system (Rich 2004). The growing number of healthcare practitioners involved in patient care also indicates a need for better information exchange across healthcare settings using electronic communication (Kuilboer et al. 1997).

There is considerable, though fragmented, activity in the area of electronic decision support systems (EDSS) to support medical care (The National Institute of Clinical Studies 2002) – but little such activity exists to support pharmacists, apart from traditional pharmacy functions such as dispensing, or retrieval of drug information from electronic sources (Calabretto, Warren & Bird 2005). Despite the importance of implementing EDDS, it remains difficult to change clinical practice, even though identifying the common elements required for success is crucial (Bates & Gawande 2003). These elements include: a taxonomy to describe information needs (Ely et al. 2000); a sound understanding of the “information space” (Coiera 2003) and the communication contexts affecting effective decision-making. We believe this to be an issue of growing need for pharmacists undertaking MM reviews (increasingly common in Australia under Enhanced Primary Care items of the Medical Benefits Schedule).

There is no suitable model described in the literature to support our concept of medication management. Those cited generally describe processes or guidelines, rather than the issues relevant to our study. A commentary by Cameron (2005) on medication management models and other pharmacist interventions describes two models. The first well-described Medication Management Model actually refers to a medication review process involving

a home care nurse, consultant pharmacist and primary physician using a set of guidelines to address four high risk medication problems in the high-risk elderly population (Frey & Rahman 2003), including: prevention of unnecessary therapeutic duplication; issues around cardiovascular medication; use of psychotropic drugs in patients with recent falls; or confusion and psychotropic drugs in patients with assessment of recent confusion. These guidelines have grown out of earlier published criteria for determining potentially inappropriate medication use in the elderly (Beers 1997) that have been subsequently updated (Fick et al. 2003). A second model is the pharmacist intervention program, PHARMAssist that consists of six monthly meetings between participants and pharmacists to discuss correct and safe medication use, supported by a medication record that participants are encouraged to maintain and share with other health care providers (Cameron 2005).

Other (medication management) models in the literature describe broader application of the term including collaborative service delivery (Gilbert et al. 2002), disease-based pharmaceutical care such as asthma (Saini, Krass & Armour 2004), primary care pharmacy (Carmichael et al. 2004) and substance use disorders in patients with severe mental illness (Mueser, Drake & Wallach 1998). Lacking an existing model on which to base our project, therefore, we were forced to develop an appropriate model of our own.

A document-oriented user-interaction paradigm is an intuitive way of supporting clinical documentation, as well as an effective mechanism to allow information communication between individuals involved in the healthcare process (Lenz et al. 2002). The document-oriented view of a data structure, supported by XML, also matches the organisation of healthcare data (Schweiger et al. 2005) very well. 'XForms' is an XML-based next-generation markup language for defining WWW user interfaces that show particular promise in the provision of models for human-computer interaction and decision support based on a document metaphor. XForms provides ease of authoring, reuse, device independence, accessibility (Honkala & Vuorimaa 2004) and structural flexibility (Schweiger et al. 2005).

The aim of the present study is to identify a document-oriented model to support MM. This model is implemented in XForms technology to offer a suitable format for feedback, evaluation and potential ongoing use. The model is based on essential information for MM as initially established from observations in a hospital setting; and then refined using feedback in a community setting.

## **METHODS**

### **The Hospital Scenario**

Data collection for this part of the study occurred in four adult teaching hospitals. Semi-structured questionnaires were distributed to participating Medical Officers (MOs) and pharmacists; and used as the basis for a follow-up, audio-taped interview. Work practice observations on pharmacists occurred during their ward visits and de-identified document samples were used as information sources. MO interviews sought to elicit information required to initiate a medication order; any difficulties they had in providing this information; and their perspective on the information requests they received. Pharmacist interviews sought to elicit information about what information they needed for MM; what was often missing; and how they dealt with this lack when it occurred. Questions also sought perceptions about decision support systems and goals for patient care, but these are not reported in this paper. These complementary techniques were used to ensure that the widest context could be captured.

Transcribed data were analysed using QSR NUD\*IST Vivo version 1.1 (nVivo) software, which uses a document-based approach, providing tools for: categorising, coding, relating and manipulating document text; and a node system to support qualitative concept analysis. Visual qualitative models were also developed using nVivo's ability to draw "directed graphs", which allow objects (data or concepts) to be joined by simple or arrowed lines, representing inter-relationships. The model was later represented using Unified Modelling Language (UML) notation, which proved more effective for the design of the digital document interface and allowed better representation of model changes between hospital and community scenarios.

### **The XForms document**

The XForms digital document prototype utilised the formsPlayer (version 1.3.5.1018) browser plug-in to allow viewing in Microsoft Internet Explorer (IE), though for our evaluation we designed a simple HTML browser developed in Microsoft Visual Basic (VB). The VB viewer provides simple patient file manipulations: view existing patients, open patient file and add a new patient. The patient files exist as unique XML files. Security was not required for this stage as implementation was for standalone operation.

### **The Community Scenario**

Pharmacists were selected for this scenario on the basis of accreditation to conduct home medication reviews (HMRs), and were interviewed using the same interview tool used with pharmacists in the hospital scenario.

They then tested the electronic document prototype, where they were asked to enter representative medication review cases to check the appropriateness of the information model, interface design and useability. Where possible, the first author observed prototype use. Interview data were analysed as for the hospital scenario. Participant feedback on the hospital data model noted differences in business requirements from those of their hospital colleagues.

### Limitations

The major limitation of this qualitative study was the small number of participants involved in both scenarios, although data triangulation from a number of sources contributed to the model's validity. The study was a proof of concept intended to be further tested in medication review field studies to validate the model and approach.

## RESULTS

### The Hospital Scenario

Nine medical officers and 11 clinical pharmacists were recruited, providing 9 MO questionnaires, 8 MO interviews, 11 pharmacist interviews and 12 pharmacist work practice observations. Pharmacists were observed for a total time of 23.8 hours (average 2.0 hours per pharmacist, range 1-3.5 hours). During work practice observations, there were a total of 95 'patient information encounters' (average 8.6 per pharmacist, range 3-12). For our purposes a 'patient information encounter' is defined as an encounter where the pharmacist was involved in reviewing, evaluating or discussing a patient using documented information or information sought from another health professional. Each patient was only counted once, even when there was more than one case of information use or exchange for this patient. Fifty-three sample (de-identified) documents were collected from pharmacists.

### Information used by hospital pharmacists

Pharmacists' information sources were categorised into three groups: conversation; online; or from paper, as described by Paepcke (1996), because information obtained through conversation may not be a candidate for electronic representation. From interviews, most information used by pharmacists was directly related to medication and on paper. The main sources were inpatient drug charts and patient case notes, and many used personal patient summaries. The results of pharmacist work observations are presented in **Table 1**. The observation findings were consistent with interviews, the majority of medication-related information being from paper sources (65.3% of occasions of use), although conversation was a significant component. Conversations were an important avenue of information not available on paper or which required clarification. The use of online information reflected what was readily available in the hospital setting.

Information sources	Patient information encounters	(%)	Encounters per hour	Encounters per pharmacist
Medical officers	34	10.6	1.5	3.1
Nursing staff	29	9.1	1.3	2.6
Patients	20	6.3	0.9	1.8
Other	8	2.5	0.4	0.7
<b>Conversation (total)</b>	<b>91</b>	<b>28.4</b>	<b>4.0</b>	<b>8.3</b>
Laboratory	14	4.4	0.6	1.3
Other	6	1.9	0.3	0.5
<b>Online (total)</b>	<b>20</b>	<b>6.3</b>	<b>0.9</b>	<b>1.8</b>
Medication	72	22.5	3.2	6.5
Patient case notes	51	15.9	2.2	4.6
Own documentation	40	12.5	1.8	3.6
Patient meds or aids	9	2.8	0.4	0.8
Other	37	11.6	1.6	3.4
<b>Paper (total)</b>	<b>209</b>	<b>65.3</b>	<b>9.2</b>	<b>19.0</b>
<b>Total</b>	<b>320</b>	<b>100.0</b>	<b>14.0</b>	<b>29.1</b>

Table 1: Information sources used by pharmacists during ward rounds

### **Information used by Medical Officers**

From MO interviews, diagnoses / active problems, allergies and (current) medications were information types most frequently mentioned in the process of ordering medications. Patient-related information included: objective data; co-morbidities; and pathology. Other medication-related information included: most effective treatment; possible drug interactions; and previous adverse drug events.

### **The initial information model**

Formulation of the nVivo model was centred on those information components (from interviews and observations) crucial to an informed decision about a patient's medication: ubiquitous components (e.g. name); and components whose lack was identified as a problem – that is, components representing “essential” information without which an informed decision could not be made – which were often sought through conversation during work practice.

At this stage, no attempt was made to address information granularity. For example, a pharmacist might simply mention “the medical notes” in one case, but later refer specifically to missing diagnosis or weight. This issue of whether a specific information component is required at a particular time, or whether a broader information source is required as a ‘sweep’ for possible relevant information, illustrates the difficulty of classifying health-related information via neat hierarchical trees.

This first model underwent a number of iterations to develop a hierarchical structure which could inform the design of an artefact to support MM. The model was eventually refined using UML, to have four main categories – patient, medication, treatment and investigation information – with relevant information sub-components. This refinement removed some components such as drug information (resources), other staff and medical notes, but a major goal was to consider the *essential* elements required for MM. The removal of a component such as 'drug information', was not a problem because we are avoiding the traditional notion of a decision support system. Such reference information could (and probably should) be obtained outside of this consideration. The missing data could, in any case, be obtained via communication with other health professionals. Of particular note is the ability to capture current medication, which remains an elusive goal. The issue of current medication was a significant and consistent component of missing information. Identifying the: types of medication (prescription, over-the-counter, complementary); origins of medication use (prescription, health professional recommendations, self-initiated); sources of medication (pharmacy, supermarket, health food stores, on-line purchasing) shows clearly why this is a significant challenge. Similarly, MM issues are particularly important in the success (or otherwise) of medication-related therapy. In the case of chronic disease or the elderly, such issues may have a significant impact on success. The two main 'subsections' suggested here were social and compliance issues.

### **The Community Scenario**

Six accredited pharmacists were interviewed and all were able to perform prototype testing (average years of total pharmacy experience: 19.5 (range: 5-32), average years undertaking HMRs: 5.0 (range: 2-8)). We were able to observe two pharmacists during prototype testing.

### **Information used by HMR pharmacists.**

The major source of patient information for the HMR pharmacist was the referral form from the General Practitioner (GP i.e. family physician), supplemented by the history of dispensed medications obtained from the patient's community pharmacy. The other information sources most often used by HMR pharmacists were drug information resources (hard copy or electronic / online). All experienced missing or incomplete information, with laboratory results and other clinical information such as actual reason for referral, history of, or indications for medications, weight, etc. being the main issues. The interviews and prototype testing showed the core information elements were appropriate. The patient context i.e. evaluation of a patient in a chronic care scenario vs. an acute hospital scenario (including missing information components mentioned during interviews) was a major influence on changes to the model. **Figure 1** represents the final model and highlights components amended from or added to the hospital model because of the community context.

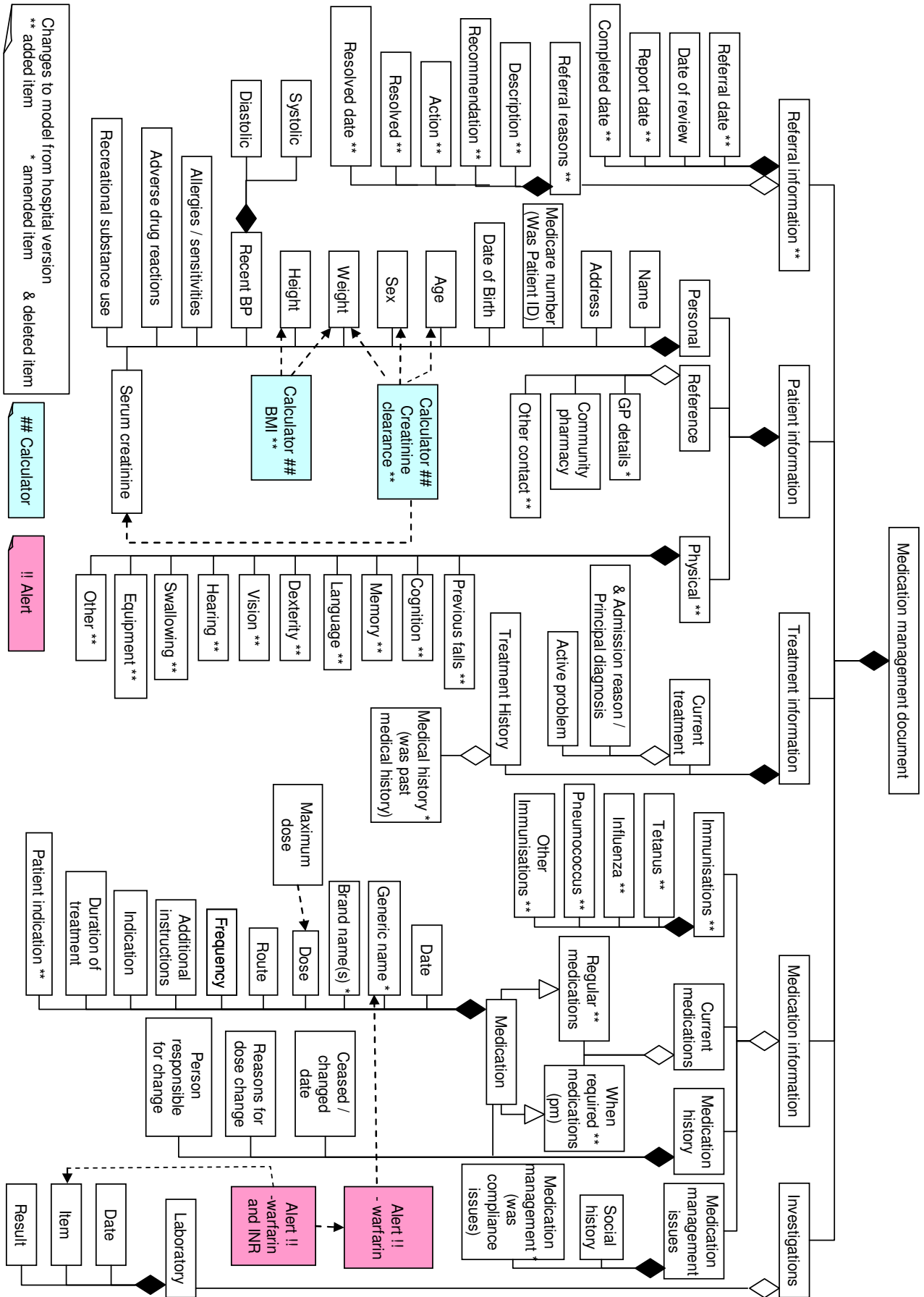


Figure 1: Information Model

## Development of the XForms document

The digital document was developed from the information model and was modified after testing with HMR pharmacists. Within the document, each major information category was represented by a separate tagged “page”, which not only allowed a logical grouping of document elements but minimised the need for page scrolling and improved useability. Grouping elements on the page also reflected the model, except for information relating to contacts. HMR pharmacists agreed that these did not need to be referred to often and could be placed to one side. The appearance of the interface has been kept as simple as possible to provide the look-and-feel of a physical document as suggested by user group experience. Positive comments on its simplicity were received during prototype testing and an example of the post-test document is shown as **Figure 2**.

XForms development was rapid, although lack of a specific XForms development environment was a problem. While XML syntax support was available, checking for logical errors and other error-trapping was a manual process; and, inconsistencies in the implementation of the W3C XForms 1.0 standard in the IE plug-in required workarounds.

An advantage of XForms is the dynamic relationships between data components, enabling the use of XML

The screenshot displays a web-based XForms document interface. At the top, there is a navigation bar with five tabs: "Patient details", "Treatment Information", "Medication", "Investigations", and "Health Professional Contacts". A "Save document" button is located on the right side of this bar. Below the navigation bar, the "Patient Details" section is active, showing the following information: Name: Mario Milano; Address: 205 Wattle Street Malvern, SA, 5061; Medicare number: 23; Date of birth: 1953-12-31; Age: 65; Sex: M. Below these details are fields for Weight (kg): 70, Height (cm): 168, and BP - Systolic: 130, Diastolic: 85, each with a date and a numerical value. The "Date reviewed" is 2005-04-25, with a link to "edit personal details".

Below the patient details, there are three sections for managing clinical data:

- Allergies (substance, description, date of reaction, entered by):** This section contains two entries: "peanuts swollen tongue 2004-09-02 GP" and "amoxicillin rash 2005-06-21 entered by self". A control bar below allows for editing, adding new allergies, or deleting existing ones.
- Adverse Drug Reactions (substance, description, date of reaction, entered by):** This section contains one entry: "ibuprofen nausea and vomiting 2004-01-01 self". A control bar below allows for editing, adding new ADRs, or deleting existing ones.
- Recreational substance use (description, date, entered by):** This section contains one entry: "alcohol intake - 2 per day 2005-06-21 GP". A control bar below allows for editing, adding new substances, or deleting existing ones.

Figure 2: The XForms Document

Events to generate alert messages once a value threshold is reached. We used this to flag observations and out-of-date lab data; and implement other specific clinical advice (e.g., “IF the drug name = “warfarin” THEN check to see is there is a laboratory test = “INR”). Dynamic calculators can also be implemented, e.g. to calculate renal clearance, though some functions are cumbersome in the current XForms expression language, e.g. calculating the difference between two dates requires using the date-to-now() function for the two dates and then finding the difference between these two values.

Element display in XForms relies on Cascading Style Sheets and the use of “pseudo-classes”, but since IE does not support pseudo-classes or CSS attribute selectors, controlling data element display can be frustrating. One

important advantage is the speed of the dynamic processes in the browser client – XForm document loading slows noticeably as size increases (evident as the prototype grew to incorporate post-test changes). Once loaded, however, the speed of user interaction (for data entry, display of alerts) is good.

## DISCUSSION

Representing Health information and designing tools to support health professionals in their clinical decision-making endeavours remain significant problems – further complicated by the problem of missing or inaccurate information and its potential impact on system design. Our experience suggests this is as true for pharmacists in MM as it is for medical professionals.

We believe there may be a role for approaching decision support from a different perspective. Our premise, that 'typical' decision support systems cannot provide all the information needed to support patient-centred decision making and thus health professionals rely on their knowledge to a significant degree, proved to be correct in our experience. We therefore sought to capture a core of 'essential' information components to support these people, where the core components were identified by empirical observation of information-seeking behaviour.

Investigating medication-related information issues for pharmacists and MOs in the hospital setting provided the basis for a preliminary explicit model of essential information components, which was further refined to adapt the model to a community setting, potentially providing a generic model for MM.

Such a model must acknowledge the difficulties presented by attempting to ensure that necessary information is not missing and adapting to differing contexts. We feel that design should model essential information components but not mandate their presence. A possible answer may lie in providing the model of essential information, supporting the communication process, and acknowledging the contribution of knowledge rather than attempting to provide all information – clearly, this is very difficult. In line with the requirement for a flexible information model, we require a technological artefact that allows similar flexibility of structure and representation; and communication of information. As the document is the pervasive metaphor for human representation of information in the Health environment, a digital document representation shows promise in this role. XML-based "XForms" enabling a structured interchange of data, workflow, support of forms, decoupling of data, logic and representation offers promise in addressing the document-centric challenge of information representation and sharing.

Our XForms document (based on the information model) was designed for simplicity and to visually reflect a 'traditional document' as much as possible. Simplicity was a desirable constantly mentioned by participants. XForms' functionality allowing simple decision support functions such as alerts and reminders is practical and can be made unobtrusive. Although terse, XForms shows promise in the rapid development of a prototype for support of MM and XML events are promising for implementing simple decision support such as alerts. As an emerging model, however, there are practical problems with the level of standards adoption and tools to support design.

The nature of our digital document begs comparison with the Clinical Document Architecture (CDA). CDA is part of the HL7 family of standards and is an XML-based document markup standard that specifies the hierarchical structure and semantics of clinical documents for information exchange. The paradigm of the present research emphasised an unrestricted approach to the information needs of MM (e.g., without taking the HL7 RIM as a starting point). Our focus on human-to-human communication is also rather different from the classic spirit of machine interchange that marks HL7 – although this does not preclude engineering a CDA-compliant format from our model as future work.

## FUTURE RESEARCH

We are currently evaluating the document prototype in a community scenario involving GPs and HMR pharmacists, testing its applicability to MM for aged care. We are looking for opportunities where our model can be used for beneficial MM interventions with the aim of improving the quality, efficiency and safety of MM.

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