Association for Information Systems
AIS Electronic Library (AISeL)

ECIS 2015 Research-in-Progress Papers

ECIS 2015 Proceedings

Spring 5-29-2015

STRIPA: A Rule-Based Decision Support System for Medication Reviews in Primary Care

Michiel C. Meulendijk
Utrecht University, m.c.meulendijk@uu.nl

Marco R. Spruit
Utrecht University, m.r.spruit@uu.nl

Paul A.F Jansen
University Medical Center Utrecht, p.a.f.jansen@umcutrecht.nl

Mattijs E. Numans
University Medical Center Leiden, m.e.numans@lumc.nl

Sjaak Brinkkemper
Utrecht University, s.brinkkemper@uu.nl

Follow this and additional works at: http://aisel.aisnet.org/ecis2015_rip

STRIPA: A RULE-BASED DECISION SUPPORT SYSTEM FOR MEDICATION REVIEWS IN PRIMARY CARE

Prototype

Meulendijk, Michiel C, Utrecht University, Utrecht, the Netherlands, m.c.meulendijk@uu.nl

Spruit, Marco R, Utrecht University, Utrecht, the Netherlands, m.r.spruit@uu.nl

Jansen, Paul A.F, University Medical Center Utrecht, Utrecht, the Netherlands, p.a.f.jansen@umcutrecht.nl

Numans, Mattijs E, University Medical Center Leiden, Leiden, the Netherlands, m.e.numans@lumc.nl

Brinkkemper, S, Utrecht University, Utrecht, the Netherlands, s.brinkkemper@uu.nl

Abstract

The chronic use of multiple medicinal drugs is growing, partly because individual patients' drugs have not been adequately prescribed by primary care physicians. In order to reduce these polypharmacy problems, the Systematic Tool to Reduce Inappropriate Prescribing (STRIP) has been created. To facilitate physicians' use of the STRIP method, the STRIP Assistant (STRIPA) has been developed. STRIPA is a stand-alone web-based decision support system that advices physicians during the pharmacotherapeutic analysis of patients' health records. In this paper the application's architecture and rule engine, and the design decisions relating to the user interface and semantic interoperability, are described. An experimental validation of the prototype by general practitioners and pharmacists showed that users perform significantly better when optimizing medication with STRIPA than without. This leads the authors to believe that one process-oriented decision support system, built around a context-aware rule engine, operated through an intuitive user interface, is able to contribute to improving drug prescription practices.

Keywords: decision support, rule engine, expert system, medication review, polypharmacy

1   Introduction

The chronic use of multiple medicinal drugs is growing. In the Netherlands alone, seventeen percent of the chronically ill use more than five different drugs permanently; half of these patients are over seventy years of age (Stichting Farmaceutische Kengetallen, 2005). Over ten percent of Dutch hospital admissions are related to medication use (Leendertse, Egberts, van den Bemt, & Stoker, 2008). This development, known as polypharmacy, has been demonstrated to lead to a variety of clinical problems for its users, including an increasing risk of adverse effects, under-prescribing, overtreatment, and decreased drug adherence (Björkman, Fastbom, Schmidt, & Bernsten, 2002; Claxton, Cramer, & Pierce, 2001; Frazier, 2005; Kuyuma, Endo, & Umegaki, 2000; Shi, Mörike, & Klotz, 2008; Sloane, et al., 2004; Steinman, et al., 2006; Wright, et al., 2009).

Many of the problems persist because individual patients' drugs have not been adequately prescribed by primary care physicians; their dosages may be too high, or they may be incompatible with each other altogether. The causes for these problems are in many cases avoidable; errors on the part of the general practitioner or pharmacist, such as time pressure, carelessness, and the use of incomplete health records have a major impact (Velo & Minuz, 2009; Sayers, Armstrong, & Hanley, 2009).

In order to reduce these polypharmacy problems, a structured method has been developed: the Systematic Tool to Reduce Inappropriate Prescribing (STRIP) is a drug optimization process, consisting of an anamnesis of patients' actual perceived problems and drug use, and a pharmacotherapeutic analysis. It has been included in the Netherlands in a multidisciplinary guideline on polypharmacy and elderly patients (Dutch College of General Practitioners, 2012). The method leads to a newly refined individual treatment plan, omitting superfluous drugs and adjusting dosages where applicable. The STRIP process is shown in Figure 1.

To ensure that the STRIP method is incorporated into GPs' and pharmacists' daily practice, a software tool has been developed to facilitate the most time-consuming and complex step in the process: the pharmacotherapeutic analysis.
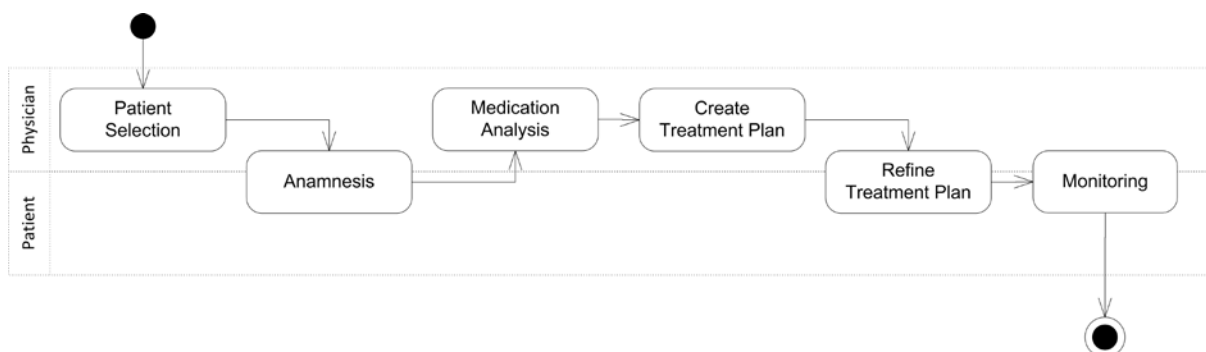

Figure 1: UML Activity Diagram depicting the STRIP process.

1.1   Status Quo of Clinical Decision Support

In the last decade, computerized physician order entry (CPOE) systems have changed from being mainly organizational aids to supporting the GP with the prescription process. Apart from the ability to register consultations, primary care information systems now also contain medical formularies, electronic medical records, and decision support systems (Van der Lugt & Klapwijk, 2008).

Nonetheless, the adoption of these systems by general practitioners is suboptimal. A recent study shows that GPs owning decision support systems use them for only one quarter of their prescriptions (Pevnick, et al., 2010). Another study showed that only twenty percent of GPs owning decision

support systems actually use them during consultations (McInnes, Saltman, & Kidd, 2006). A survey among Dutch physicians found that more than half of the owners of decision support systems rarely or never use them (Meulendijk, et al., 2013).

As to why potentially beneficial systems are underused, studies give different answers. Some show that the traditional indicators of technology adoption, perceived usefulness and perceived ease-of-use, are at least somewhat of influence to this group's attitudes as well (Ketikidis, Dimitrovski, Lazuras, & Bath, 2012; Chismar & Wiley-Patton, 2003; Yarbrough & Smith, 2007). Studies exploring influential factors particular to physicians have shown that a.o. output quality, embedding in practice, and especially time efficiency are important indicators of GPs' attitudes towards software (Boonstra, Boddy, & Fischbacher, 2004; Van Schaik, Flynn, Van Wersch, Douglass, & Cann, 2004; Yarbrough & Smith, 2007; Chismar & Wiley-Patton, 2003).

1.2   Design Objectives

In an attempt to overcome these problems and create a useful and easy-to-use decision support tool, we developed the STRIP Assistant (STRIPA). The design objectives when developing STRIPA were to create a stand-alone web application that effectively and efficiently facilitates physicians' use of the STRIP method, by optimally advising them during the pharmacotherapeutic analysis. In order to avoid the 'alert fatigue' that users complain about in comparable information systems, the decision was made not to disrupt their everyday routines, but instead design the application as an independently invokeable process (Kesselheim, Cresswell, Phansalkar, Bates, & Sheikh, 2011). This decision also enabled the creation of an autonomous user interface, free from restrictions that regularly limit plug-in applications and lead to suboptimal workflows.

STRIPA was designed to directly react to users' actions, generating its advices in response to users adding or removing drugs. In this approach it differs from most decision support systems integrated in CPOE systems, which base their advices on input available at specified moments in time (e.g. upon opening a patient's health record). To ensure that only relevant advices are displayed, the rule engine was designed to incorporate context-specific characteristics, and to work with both complex and simple rules.

While taking advantage of the independence from existing information systems, industry standards were incorporated into STRIPA to ensure successful communication with existing CPOE systems. Complete health records can be successfully transferred between STRIPA and third-party applications, leaving the classification systems of the underlying objects (e.g. drugs and diagnosed diseases) intact.

2   STRIPA Prototype

2.1   Architecture

The STRIP Assistant has been developed as a stand-alone web service, relying on Java and MySQL in the back-end and on JavaScript in the front-end. The communication between the front- and back-ends is facilitated through AJAX, using JSON as data format for its brevity. The expert system in the back-end is powered by the Drools rule engine (Red Hat Inc., 2014).

Figure 2 depicts STRIPA's sub systems, their most important components, and the interfaces they communicate through. The MySQL database holds all patient records and clinical data required to execute the decision rules. A database management system (DBMS) provides the query capabilities necessary to use it.

The *User Manager* sub system has two primary functions; it manages the current user's session and his or her specific permissions, and it supplies the rest of the system with requested patient data. Acting as a gatekeeper, every request is authenticated before it is executed and its results are returned

to the calling function. The open-source Java security framework Shiro is used to manage user sessions and authenticate requests (Apache Software Foundation, 2014).

The *Dashboard* sub system provides a user interface for recording the results of patients' anamneses. An anamnesis typically provides an individual's diagnosed diseases, complaints, prescribed drugs, self-medication, and recorded measurements. These values are either obtained or validated through communication with the patient, but GPs' and pharmacists' information systems can serve as initial sources of patient data. The *Importer* component provides users the ability to upload health records from third-party sources. These can then be edited through the user interface provided by the *Health Record Manager* component.

Finally, the *Analyzer* sub system provides a user interface for performing the pharmacotherapeutic analysis. The changes made to the health record during the process are sent to the *Rule Engine* component, which holds them in working memory. The appropriate rules are then executed and its results returned to the *Advisor* component, which shows them to the user. The user is free to heed or reject the advices provided by the rule engine. After completing an analysis, a patient's health record is updated by the *Health Record Manager* component, which in turn updates the patient data in the database. When required, the analysis' results or complete health record can be exported to a third-party application through the *Exporter* component.
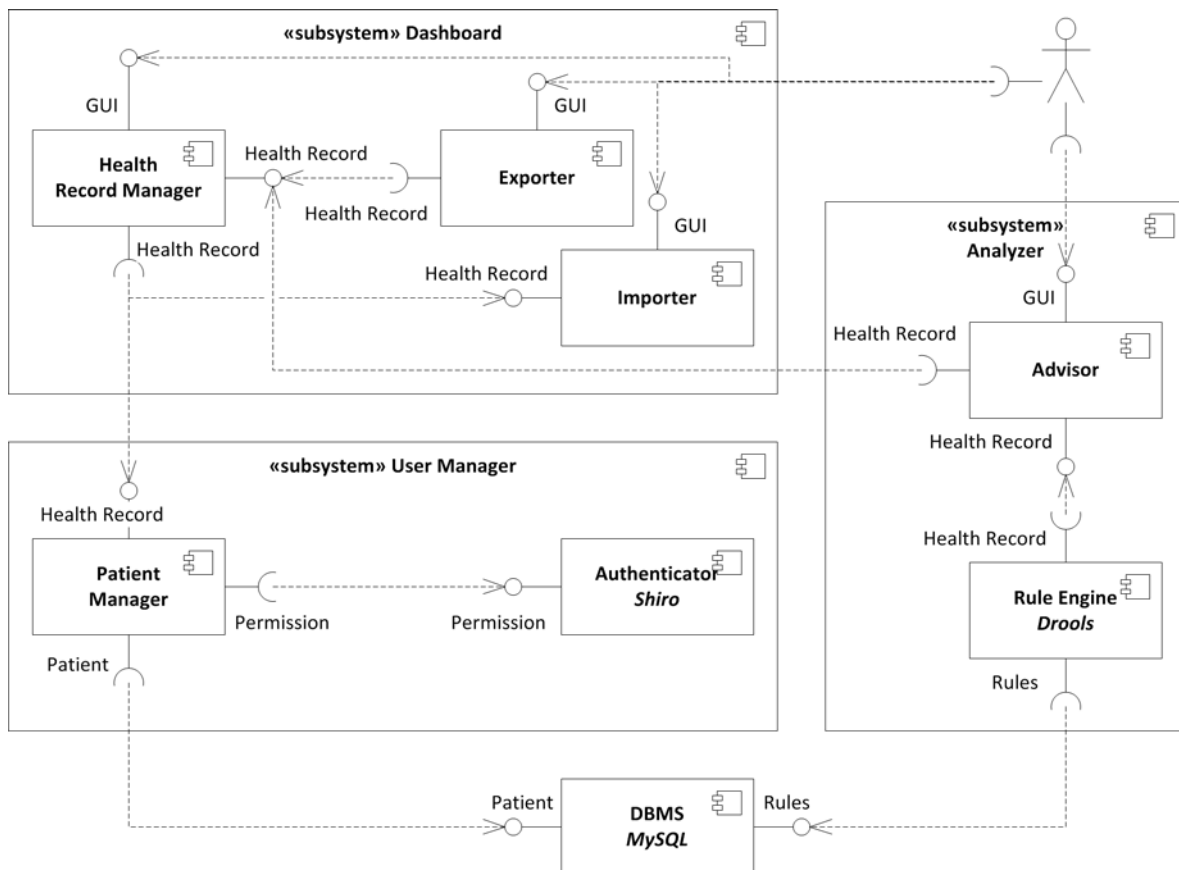

Figure 2: UML Component Diagram depicting STRIPA's architecture.

2.2 Decision Rules

The rules included in STRIPA's decision support system come from a variety of sources. Some, such as detections of drugs having clinical interactions or having the same active components, are provided as datasets by (inter)national organizations. Others, especially the rules incorporating more contextual

variables, have been established by expert panels (De Groot, et al., 2014). All rules' parameters are given unique ids to ensure they can be reliably detected by the expert system. Classification systems that have been implemented are a.o. ATC for drugs and ICPC for diseases (World Health Organization, 1998; World Health Organization, 1990).

The expert system in STRIPA relies on rules with a varying degree of complexity. All rules, however, result in advices that can either be heeded or rejected by the user. Advices can propose to *start* new medication, *stop* specific drugs, or *change* the dosage or frequency of a drug already used; any or all of these actions may be combined in any given advice. Providing multiple options (*stop Drug A or Drug B*) or even combinations of options (*either start Drug A and Drug B, or start Drug C*) is possible. The conditions that triggered the rule are included in the advice as well.

Some of the rules in STRIPA are as simple as 'Drug A and Drug B may not be used simultaneously', some require a multitude of variables. Because of this diversity, an implementation choice had to be made that was flexible, easily extendable, and did not require double declarations for conceptually similar rules.

Because of its flexibility, platform-independency, and wide-ranging capabilities, Drools was chosen as an adequate rule engine for STRIPA (Red Hat Inc., 2014). Both simple and complex rules can be modelled easily in Drools, without redundancy. Its ability for forward-chaining inference enables explaining to end-users how given advices were produced (i.e. which specific causes triggered the rules).
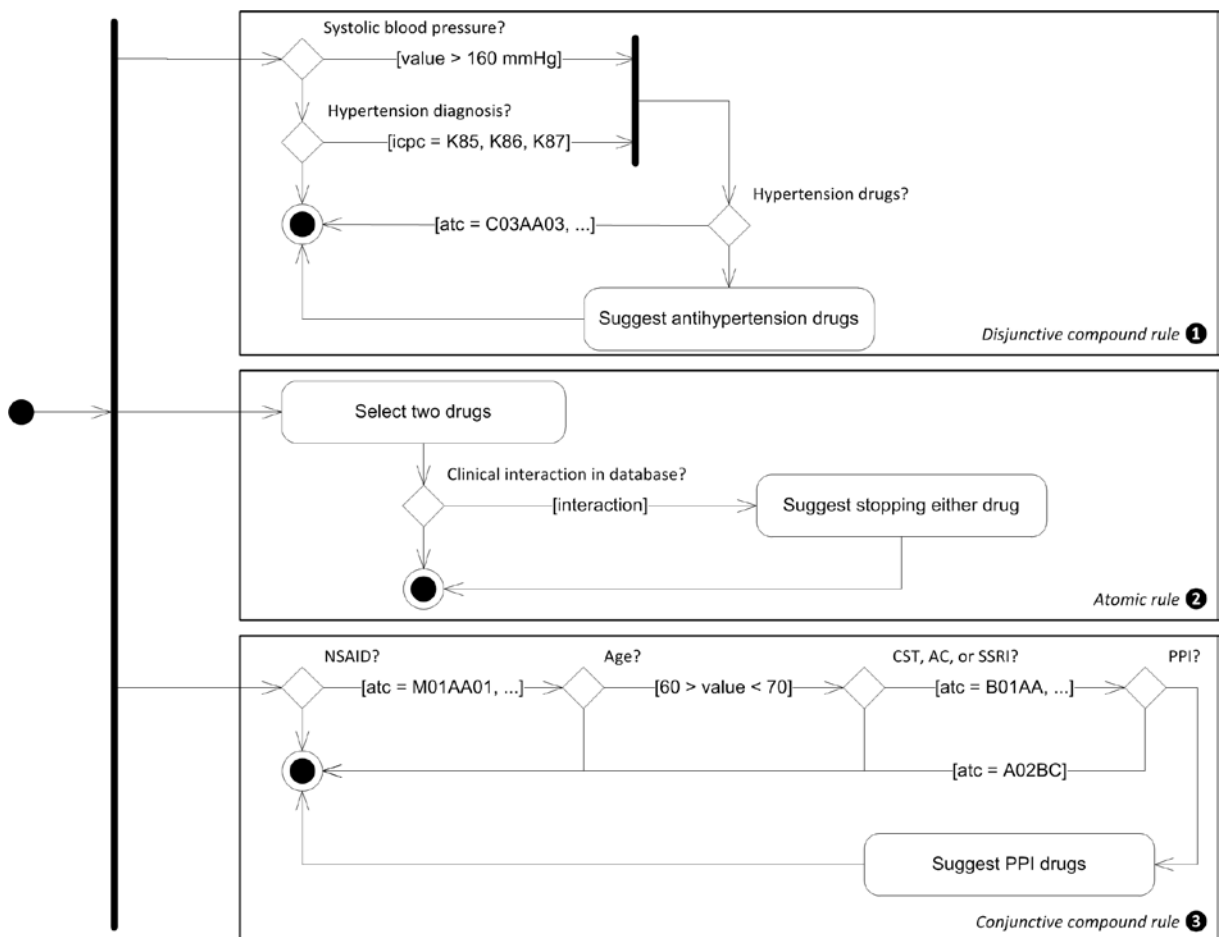

Figure 3: UML Activity Diagram depicting rules suggesting addition or discontinuation of drugs, if necessary conditions are satisfied.

The medication review domain could be modelled using three distinguishable types of rules: those based on *atomic* formulae, *conjunctive compound* formulae, and *disjunctive compound* formulae. Atomic formulae depend on a single condition only, containing no deeper propositional structure. Compound formulae, in contrast, do contain logical connectives to incorporate multiple conditions. While conjunctive operators require several conditions to be satisfied before a consequence is implied, disjunctive operators require only one of several conditions to be met. These three types of rules have been implemented in STRIPA's rule engine; the ability to incorporate multiple types of rules is one of the characteristics which sets STRIPA apart from other decision support systems in primary care. Examples of each type of rule are shown in Figure 3.

The *atomic* rule, of which hundreds of thousands of possible variations exist, was modelled by creating a single rule that could be triggered by any combination of objects validating the condition. Rule **(2)** in Figure 3 illustrates how this principle works. Any two drugs are checked for potentially dangerous clinical interactions in the database. If a match is found, an advice is created recommending the user to remove either one of the conflicting drugs.

The more complicated *conjunctive compound* rules, which depend on several conditions, were modelled independently. A table format was used to allow for more convenient correcting and editing by members of the expert panel, which was later automatically converted into code. Rule **(3)** in Figure 3 illustrates the working of a complex rule: the suggestion of adding a proton pump inhibitor, dependent on patients' age and their use of NSAIDs (non-steroidal anti-inflammatory drugs) and SSRIs (selective serotonin reuptake inhibitors), corticosteroids, or anticoagulants. Only if all conditions are satisfied (including, obviously, the current lack of a proton pump inhibitor) a suggestion is made.

Finally, some rules can be triggered by several (combinations of) conditions. Often, these rules have a preference for one (combination of) conditions over another; a more precise measurement is usually preferred over a more generic diagnosis. Rule **(2)** in Figure 3 presents an example of such a disjunctive compound rule which can be activated through several ways: recommending the addition of antihypertension drugs in case a patient suffers from untreated hypertension. Ideally, hypertension is determined by one's systolic blood pressure being higher than 160 mmHg. However, if this value is unavailable, diagnoses indicating hypertension are considered. In either case, a suggestion to add antihypertension drugs is given.

2.3 User Interface

Taking into account the literature on user interface mistakes in CPOE systems, much attention was paid to designing the user interface for STRIPA. The aim was to create an application that had the potential to be accessed through different mediums, i.e. both PCs and mobile devices. A study of non-functional requirements of medical apps was conducted, and revealed that aging users attribute more importance to user-friendliness than younger ones (Meulendijk, Meulendijks, Jansen, Numans, & Spruit, 2014). After designing an initial wireframe version based on interviews with medical experts and potential users, a prototyping process using prototypes of increasing fidelity was used to refine it (Walker, Takayama, & Landay, 2002). Early prototypes of the application were used in test sessions, where users were invited to comment on its usefulness and user-friendliness. Their remarks were used to further improve the user interface. In *Figure 4* the preliminary design of the user interface is displayed, before it was refined through the prototyping method. The appendix contains a screenshot of the final version of the user interface of the analyser component.

In designing, Nielsen's broadly applied usability heuristics served as guidelines (Nielsen, 1994). In essence, the aim was to create an aesthetically pleasing, uncluttered interface that allowed users to effectively and efficiently perform the pharmacotherapeutic analysis according to the STRIP method (*aesthetic and minimalist design*). The purpose of the method is to create a newly refined list of a patient's diseases and diagnoses. Since this is a core aspect of the application, the main panel

containing the new list is always in view. This also holds for the current patient's personalia and relevant measurements, which are displayed in the top row. The steps of the STRIP method (e.g. checking for undertreatment, over-prescribing, clinical interactions etc.) are shown on the far right, with the currently selected step coloured differently from the others (*visibility of system status*). The generated advices are shown together with their causes and textual explanations. All possible actions users can take (e.g. adding or removing drugs) are shown only when they can actually be performed; consequently, all available options are immediately visible (*recognition rather than recall*). Throughout the interface, concepts and terms that are either common medical knowledge (e.g. *episodes* for diagnosed diseases) or have a solid basis as computer concepts (e.g. *recycle bin* to store discontinued drugs) are used (*match between system and the real world*, *consistency and standards*).
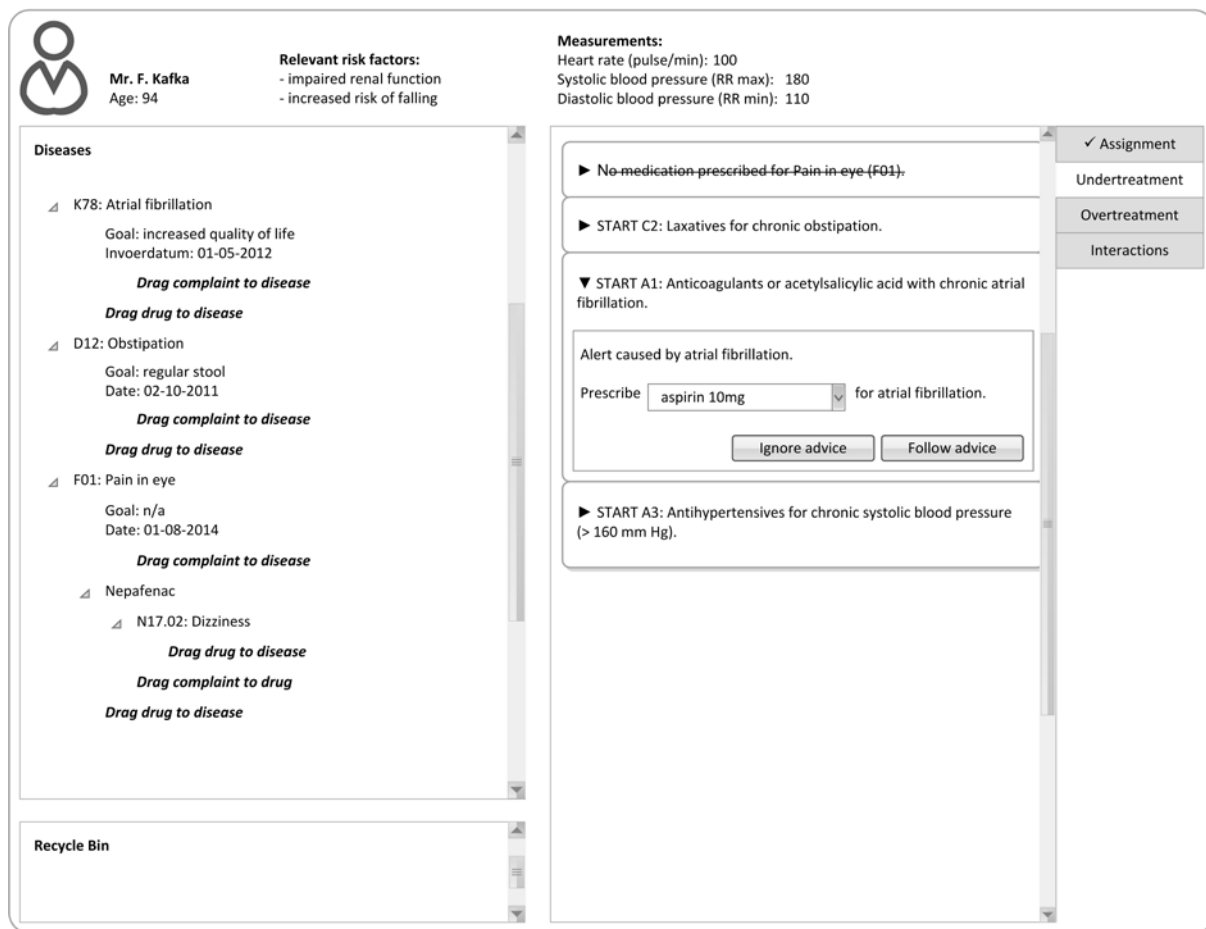

Figure 4: Initial wireframe user interface design.

The STRIP workflow consists of six steps, which were translated into six advice-supported panels in the interface. While users are guided from one step to the next with a *Next*-button, they do not have to follow this designated order. They can review earlier steps in later phases, or skip unnecessary checks for uncomplicated cases (*flexibility and efficiency of use*). Assigning drugs to diagnosed diseases is a core principle of the STRIP method; in the application this feature was extended by allowing users to further assign side effects to drugs that cause them. This approach results in a structured health record showing the relations between diseases, complaints, and drugs. The assignment of drugs to diseases has been implemented through a drag 'n drop mechanism.

The system is designed in such a way that technical errors are hidden from the user. Users can always recover from their own mistakes through a single action, such as dragging back a drug that was accidentally placed in the recycle bin to its original position (*error prevention, help users recognize,*

diagnose, and recover from errors). Each panel contains a context-aware help-button which shortly tells the user what is expected of him or her in the current step. An instructional video explaining the use of the application is available on-demand (*help and documentation*). This demonstration video can be viewed here: http://videodemo.stripa.eu/english/ (Meulendijk M. , 2014).

2.4 Semantic Interoperability

Essential to the usefulness and time efficiency of any application relying on external data, is its ability to communicate with third-party applications. In the primary care sector sharing data is notoriously difficult because of its sensitive nature and multitude of (often incompatible) information systems. While a more direct and safe approach is being researched, STRIPA currently uses an old but proven health exchange format known as MEDOVD (Nictiz, 2008); it is accessed by users through the *Importer* and *Exporter* classes in Figure 2. MEDOVD is a *de facto* standard based on the EDIFACT format that can be locally exported and imported by physicians, and which is supported by all Dutch CPOE systems (Mensink, 2013). It can contain complete health records and is flexible enough to include different classification systems.

While international classification standards for drugs and diseases exist, most countries have implemented their own modified versions, or even completely disconnected ontologies; the Netherlands is no exception. A Dutch extension of the ICPC ontology for diseases is widely used in primary care, as well as custom national standards for dosage and measurements. In STRIPA, objects (such as drugs and diseases) have been designed in such a way that they can contain values from multiple classification systems. As cardinalities between these ontologies are not necessarily one-to-one, objects can contain several values of some classification systems. For example, diseases may have a single ICPC value, but multiple entries of the more specific ICD10 classification (World Health Organization, 1994). STRIPA's rule engine relies on coded objects, and rules incorporate either the most common or the most specific system of classification. To enable the use of different ontologies as input for the application, conversion rules have been implemented to convert values from one classification system to their equivalents in another.

3 Evaluation & Contribution

At the moment of writing, multiple studies investigating STRIPA's effectiveness and efficiency are being conducted. The results of these studies have not yet been published, but early analyses show that caretakers perform significantly better when optimizing medical records with help by STRIPA than through their usual care practice: 55% of their unsupported decisions are correct, versus 76% of their choices made with the decision support system. Subjective comments of users in this experimental study included unfamiliarity with the interface ("I wanted to bisect [the dosage for] digoxin, but couldn't.") and concerns about the output quality ("The system failed to recognize the impaired renal function […] resulting in a suboptimal drug balance."). The current prototype does increase the time practitioners require to perform medication reviews. Among the primary concerns of the developers are ways to decrease the time needed to complete analyses, by improving the relevance of the generated advices and through a more complete integration with existing information systems.

In this paper the authors strived to demonstrate how an elegantly implemented decision support system could contribute to more effective and efficient medication reviews in primary care. The preliminary results of an experimental study give reason for optimism. This leads the authors to believe that one process-oriented decision support system, built around a context-aware rule engine, operated through an intuitive user interface, is able to contribute to improving drug prescription practices. A product-ready version of the STRIP Assistant is planned for release in 2015, making the tool available for primary care practitioners in the Netherlands. Further research will focus on performing more extensive analyses of the studies into STRIPA's effectiveness and efficiency.

References

Apache Software Foundation. (2014). *Apache Shiro | Java Security Framework*. Retrieved from http://shiro.apache.org/

Björkman, I., Fastbom, J., Schmidt, I., & Bernsten, C. (2002). Drug-drug interactions in the elderly. *The Annals of Pharmacotherapy, 36*(11), 1675-81.

Boonstra, A., Boddy, D., & Fischbacher, M. (2004). The limited acceptance of an electronic prescription system by general practitioners: reasons and practical implications. *New technology, work and employment, 19*(2), 128-144.

Chismar, W., & Wiley-Patton, S. (2003). Does the Extended Technology Acceptance Model Apply to Physicians. *HICSS '03 Proceedings of the 36th Annual Hawaii International Conference on System Sciences (HICSS'03)* (p. 160.1). Washington: IEEE Computer Society.

Claxton, A., Cramer, J., & Pierce, C. (2001). A systematic review of the association between dose regimens and medication adherence. *Clinical Therapeutics, 23*(8), 1296-310.

De Groot, D., De Vries, M., Joling, K., Van Campen, J. P., Hugtenburg, J., Van Marum, R., . . . Van Hout, H. (2014). Specifying ICD9, ICPC and ATC codes for the STOPP/START criteria: a multidisciplinary consensus panel. *Age and ageing*.

Dutch College of General Practitioners. (2012). *Multidisciplinary guideline Polypharmacy and elderly ('Multidisciplinaire richtlijn Polyfarmacie bij ouderen' in Dutch).* Guideline, Utrecht.

Frazier, S. C. (2005). Health outcomes and polypharmacy in elderly individuals; an integrated literature review. *Journal of Gerontological Nursing, 31*(9), 4-11.

Kesselheim, A., Cresswell, K., Phansalkar, S., Bates, D., & Sheikh, A. (2011). Clinical decision support systems could be modified to reduce 'alert fatigue' while still minimizing the risk of litigation. *Health Affairs, 30*(12), 2310-2317.

Ketikidis, P., Dimitrovski, T., Lazuras, L., & Bath, P. A. (2012). Acceptance of health information technology in health professionals: An application of the revised technology acceptance model. *Health Informatics Journal, 18*(2), 124-134.

Kuyuma, M., Endo, H., & Umegaki, H. (2000). Factors influencing nonadherence with medication regimens in the elderly. *Nippon Ronen Igakkai Zasshi, 37*, 363-70.

Leendertse, A., Egberts, A., van den Bemt, P., & Stoker, L. (2008). Frequency of and Risk Factors for Preventable Medication-Related Hospital Admissions in the Netherlands. *Archives of Internal Medicine, 168*(17), 1890-1896.

McInnes, D., Saltman, D., & Kidd, M. (2006). General practitioners' use of computers for prescribing and electronic health records: results from a national survey. *Medical journal of Australia, 185*(2), 88-91.

Mensink, G. (2013). Veilig elektronisch verhuizen - een tussenstand (Safely transfering electronically - an intermediate score, in Dutch). *SynthesHis, 1*(12), 4-14.

Meulendijk, M. (2014). *STRIPA Video Demo.* Retrieved from STRIP Assistant: http://videodemo.stripa.eu/english/

Meulendijk, M., Meulendijks, E., Jansen, P., Numans, M., & Spruit, M. (2014). What concerns users of medical apps? Exploring non-functional requirements of medical mobile applications. *Proceedings of the European Conference on Information Systems (ECIS) 2014.* Tel Aviv, Israel.

Meulendijk, M., Spruit, M., Drenth-van Maanen, A., Numans, M., Brinkkemper, S., & Jansen, P. (2013). General practitioners' attitudes towards decision-supported prescribing: an analysis of the Dutch primary care sector. *Health Informatics Journal, 19*(4), 247-263.

Nictiz. (2008). *Patiënt Overdracht Bericht (Patient Transfer Message, in Dutch).* Den Haag.

Nielsen, J. (1994). Heuristic evaluation. In J. Nielsen, & R. Mack, *Usability Inspection Methods.* New York: John Wiley & Sons.

Pevnick, J., Asch, S., Adams, J., Mattke, S., Patel, M., Ettner, S., & Bell, D. (2010). Adoption and use of stand-alone electronic prescribing in a health plan-sponsored initiative. *The American journal of managed care, 16*(3), 182-191.

Red Hat Inc. (2014). *Drools - Business Rules Management System (Java™, Open Source).* Retrieved from http://www.drools.org/

Sayers, Y., Armstrong, P., & Hanley, K. (2009). Prescribing errors in general practice: A prospective study. *European Journal of General Practice, 15*(2), 81-83.

Shi, S., Mörike, K., & Klotz, U. (2008). The clinical implications of ageing for rational drug therapy. *European Journal of Clinical Pharmacology, 64*(2), 183-99.

Sloane, P., Gruber-Baldini, A., Zimmerman, S., Roth, M., Watson, L., Boustani, M., . . . Hebel, J. (2004). Medication Undertreatment in Assisted Living Settings. *Archives of Internal Medicine, 164*(18), 2031-2037.

Steinman, M., Landefeld, C., Rosenthal, G., Berthenthal, D., Sen, S., & Kaboli, P. (2006). Polypharmacy and prescribing quality in older people. *Journal of the American Geriatrics Society, 54*(10), 1516-23.

Stichting Farmaceutische Kengetallen. (2005, August 12). Polyfarmacie ('Polypharmacy' in Dutch). *Pharmaceutisch Weekblad, 140*(32).

Van der Lugt, J., & Klapwijk, S. (2008, December). Overzicht in beeld ('Overview in focus' in Dutch). *SynthesHIS, 7*(4).

Van Schaik, P., Flynn, D., Van Wersch, A., Douglass, A., & Cann, P. (2004). The acceptance of a computerised decision-support system in primary care: a preliminary investigation. *Behaviour & information technology, 23*(5), 321-326.

Velo, G., & Minuz, P. (2009). Medication errors: prescribing faults and prescription errors. *British Journal of Clinical Pharmacology, 67*(6), 624–628.

Walker, M., Takayama, L., & Landay, J. (2002). High-fidelity or low-fidelity, paper or computer? Choosing attributes when testing web prototypes. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (pp. 661-665). SAGE Publications.

World Health Organization. (1990). *WHO | The Anatomical Therapeutic Chemical Classification System with Defined Daily Doses (ATC/DDD).* Retrieved from WHO | World Health Organization: http://www.who.int/classifications/atcddd/en/

World Health Organization. (1994). *WHO | International Classification of Diseases (ICD).* Retrieved from WHO | World Health Organization: http://www.who.int/classifications/icd/en/

World Health Organization. (1998). *WHO | International Classification of Primary Care, Second edition (ICPC-2).* Retrieved from WHO | World Health Organization: http://www.who.int/classifications/icd/adaptations/icpc2/en/

Wright, R., Sloane, R., Pieper, C., Ruby-Scelsi, C., Twersky, J., Schmader, K., & Hanlon, J. (2009). Underuse of Indicated Medications Among Physically Frail Older US Veterans at the Time of

Hospital Discharge: Results of a Cross-Sectional Analysis of Data From the Geriatric Evaluation and Management Drug Study. *The American Journal of Geriatric Pharmacotherapy, 7*(5), 271-280.

Yarbrough, A., & Smith, T. (2007). Technology Acceptance among Physicians: A New Take on TAM. *Medical Care Research and Review, 64*(6), 650-672.