Improving care of vulnerable elders through computerized clinical decision support
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Chapter 8

General Discussion
This thesis set out to provide the groundwork for building decision support systems to help general practitioners, hospital physicians, and older patients make better health care decisions. The broad question underlying this work is “How do we provide effective support for clinicians and patients, while avoiding adverse unintended consequences?” In investigating aspects of this central question, the works collected in this thesis have yielded several important findings.

In the second chapter we demonstrated that clinical decision support systems can be modeled as two streams of information flow: one that represents a decision about the patient, and one that represents a decision about the user, and consequently when and how to present the information about the patient to the user. This model can be used to define the topics that should be covered in education about decision support, defined when specifying a proposed decision support system, and reported when describing a system in a research report. It can also be used to suggest hypotheses about the relationship between elements in the model and effectiveness of alerts, and suggest outcomes to measure effectiveness (such as the effect on the user and workflow as well as on the patient).

When we asked our clinical users what information they wanted and why, we learned that they want systems to help them with their responsibilities and prevent errors, and are concerned about systems that interrupt their work. Despite expressing concerns about interruption, when given a choice of type of support, respondents chose an interruptive form of support in a majority of cases. This underscores the need to find innovative solutions to the problems of alert fatigue.Clinicians wanted support when they felt the rule represented minimal care and when they perceived a gap between current adherence to the rule and appropriate adherence to the rule. The most common reasons for wanting support were a sense of responsibility, concern about forgetting to perform the action, and feeling that not performing the action would lead to harm for the patient. The most common reasons for not wanting support were feeling that they would recognize when action was needed and not forget to perform it, concerns about interruption, and feeling that support would be useful for others but not themselves.

One important aspect of ensuring that a system is useful is ensuring that the underlying information is correct; to this end we investigated the specific question of whether proton pump inhibitors are indicated for older patients taking NSAIDs. This is of particular interest in our project, as preventative treatment with proton pump inhibitors is recommended by the ACOVE rules, but is not reimbursed by insurance. We concluded that the current evidence is not definitive, particularly in very old patients, but does suggest that proton pump inhibitors are effective at reducing gastrointestinal complications of NSAIDs, and may be cost-effective if ulcer severity is considered.
The next step is to formalize the clinical knowledge into a specification for a computer system. We found that the methods for formalizing guidelines were not suitable for formalizing a diverse set of clinical rules. We created LERM for the purpose of assessing clinical rules for their amenability to decision support and formalizing them for implementation in a decision support system. We evaluated LERM by applying it to a sample of clinical rules, and found it to be usable and reliable between different users.

In ICOVE, our goal was to provide decision support to patients as well as clinicians. To gain information about the needs of older patients as users, we conducted a survey of community dwelling older adults who use the internet. Of the seniors we surveyed, most respondents used both the internet and paper-based resources when seeking health information, and in general the internet was preferred over paper-based resources. Respondents indicated that they turned to the internet when seeking information about symptoms, prognosis, and treatment options. Most respondents indicated that they ask health professionals when seeking information about prescription medications, side effects, practical care information, and nutrition/exercise advice. A minority of respondents appear to rely mainly on health professionals for all types of information, using neither the internet nor paper-based resources to seek health information. If this dichotomy persists in a broader sample, it implies that providing both internet-based and paper-based resources is reaching the same audience twice, and additional efforts are needed to reach the substantial minority of patients who use neither.

In the final study in this thesis, we performed a pair-randomized controlled trial to investigate the effectiveness of a simple email intervention (“SnelleCor”) in reminding hospital clinicians to send letters to the general practitioner in a timely manner. SnelleCor generated a monthly email reminder sent to each doctor with a list of his patients who were overdue for letters. This non-interruptive intervention resulted in 21% fewer letters that were still overdue at 90 days after the visit in the intervention group compared to the control group. Furthermore, the intervention was well-liked by its users, with a median overall satisfaction score of 6/7.

**Strengths and limitations**

The main limitation of this body of research is that much of it is exploratory; however, the strength of this work is that we are building a solid foundation of evidence on which to move forward. We showed that we do not yet have a solid theoretical foundation on which we can base decision support research, but the two-stream model (2SModel) is a first step in remedying that situation. We have not yet established whether the clinician’s choice of clinical rules will improve acceptance of the advice, although the success of SnelleCor implies that
user involvement in system design can result in successful systems that do not model the prototypical interruptive system suggested by the current evidence from systematic reviews. The survey of seniors who use the internet implies that the internet is an appropriate channel for health information for seniors, but we do not know whether particular information provided via the internet will be used by seniors, nor how to reach seniors who do not seek information via internet. The strength of our approach is that we chose to take the slower route of involving users in the design process, to help ensure that the system which is ultimately built is one that will be useful and usable by its intended audience. However, this also comes with the limitation that what the users want may not be directly aligned with what we anticipated. We quickly learned that in general, doctors did not want to limit support to vulnerable elderly patients for clinical rules where they felt all of their patients could benefit. Thus, the studies in this thesis pertain to all older patients (and in the case of SnelleCor, all patients) rather than just vulnerable elders. The strength of the SnelleCor study is that we used a randomized controlled trial, which provides the strongest evidence for effectiveness. However, the 2SModel demonstrates the limitation in interpreting the evidence from a single clinical trial such as SnelleCor: We know SnelleCor was successful, but why? Even a simple intervention such as this one has many factors which could impact its success. The strength of the 2SModel is that it provides a lens through which, in combination with other studies, we should be able to address these questions in the future.

Relationship to other work

Osheroff tells us that good decision support provides “the right information, to the right person, at the right time, through the right channel, and in the right format” [53], but the mixed results observed in practice [4] imply that it is not always obvious what the “right” choices are. Wright et al. evaluated the clinical rules supported in the Partners Healthcare System, and suggested that the functions of the system could be described in terms of four aspects: triggers, input data, interventions, and offered choices [59]. Berlin and Sim proposed a model suggesting that decision support can be modeled with four main components: a knowledge source, decision support system, and information delivery into a clinical context [46]. When the elements of these two models are represented in terms of Ahituv’s information flow model [44], it becomes clear that two decisions are taking place: one about the information that will be presented, and another about the delivery of that information. Osheroff’s “five rights” pertain to the information generated by the decision support system, and the delivery of the information. Essaihi et al. suggest an “action palette”, which parallels the “offered choices” suggested by Wright et al. [56]. Musen et al. suggested that decision support systems can be divided along five axes: systems that give the user information about the state of the patient (“what is true”, e.g. a diagnosis) vs.
a recommendation ("what to do", e.g. performing a blood test), “passive” systems that require the user to make an effort to access the program vs. “active” systems that provide advice without the user requesting it, “critiquing” systems that critique the user’s decision vs. “consulting” systems that provide advice about a decision without considering the user’s decision as part of their input; the underlying reasoning mechanism (Bayesian reasoning, neural networks, etc.), and the human-computer interaction [1]. The 2SMModel builds upon these axes by implying that systems can be classified by their instantiation of the components of the model. Thus, for example, a “critiquing” system is defined both by the data it uses (the user’s decision) and by the timing of its advice (after the user has made a choice).

The Technology Acceptance Model (TAM) tells us that people will use a system if it is perceived as useful and easy to use [215]. A parallel can be drawn between the TAM and the 2SMModel: the patient axis determines the quality of the advice (thus, its potential usefulness) and the user axis determines the quality of the presentation (thus, whether it is easy to use). However, recent studies have indicated that the most effective systems present interruptive alerts [54] and require practitioners to supply a reason for over-riding advice [4, 57]. Clearly, applying these findings to all decision support interventions would quickly result in a system that was unusable. In our survey, we found that general practitioners already feel they are receiving too many alerts and are concerned about interruption. Stratification of alerts by severity level has been successful in reducing alert fatigue [39, 40]. In our SnelleCor system, we demonstrate that non-interruptive systems can also be effective. In the 2SMModel we hypothesize that the key is a good match between form and the function. Elucidating that relationship is a topic of future research.

LERM is the first formalization method to specifically address clinical rules, but other formalization methods exist for other types of knowledge. In addition to the methods discussed in Chapter 5, more recent work includes the Guide-Lines Into DEcision Support (GLIDES) method [216] and the CLinical quality Indicator Formalization (CLIF) method [217]. GLIDES is intended to formalize narrative guidelines, which typically contain recommendations for patients with one clinical condition, organized into a plan that is followed over time. Step three of GLIDES is to create structured rules, similar to those resulting from step two of LERM. Step four of GLIDES is to apply action types and standard vocabularies. This is similar to step five of LERM, although LERM provides more detailed instructions as to how these should be applied. Thus, the two methods could be used together: GLIDES up to step three, and then LERM to guide the rest of the formalization process. Likewise, the starting point of CLIF is quality indicators structured in numerator/denominator format, and the first step is to map the items in the quality indicator to elements in a terminology. This
is similar to step five of LERM. CLIF then goes on to reformulate the specified quality indicator into an SQL query. If the goal were to transform a clinical rule to an SQL query, LERM could be followed through step 5, and then CLIF applied for the remainder of the transformation.

The authors of the ACOVE-2 intervention suggested that real improvement in adherence to the ACOVE quality indicators would require decision support integrated into an electronic patient record system [30]. Thus, the goal of the ICOVE project is to provide computer-based support for the recommendations implied by ACOVE. The “user-centered design” approach has long been known in software engineering [218], but seems to be rarely employed in the field of medical informatics. This may be due in part to the limited amount of time that clinicians can typically devote to helping build workflow models or test prototypes, as that is time taken away from clinical duties. Nonetheless, the effectiveness and acceptance of the SnelleCor system suggests that this approach can be used successfully, although more studies are needed to tell if this approach consistently yields good results.

Patient preferences are implicitly part of ACOVE. The clinical rules state that treatments are “offered” [12]. Decision support systems can encourage this by simply including “patient declines” among the interaction options available to the clinician, and potentially by offering patient-oriented information that can be used to guide shared decisions. “Informed consent” implies a need for sufficient information, and with the growing complexity of care and demands on the clinicians' time, it is increasingly useful for the patient to have information available from sources other than their care providers.

SnelleCor is the first study to investigate the use of reminders to support writing patient letters. Other systems to support writing of patient letters have implemented systems to automatically generate letter templates using content from the patient record, or multifaceted interventions [214] [197, 213]. It is also one of the few studies investigating the use of email reminders to support documentation tasks. Other studies include an email reminder to improve completion of performance evaluations, which showed an increase from around 50% to nearly 100% [219], and completing documentation for arterial catheterization, which increased by 12% in the intervention group compared to the control group [204]. Email reminders may also have a role beyond documentation tasks. Lester et al. created email reminders to notify doctors of patients with high LDL and no statins, which increased statin prescriptions from 2% in the control group to 15% in the intervention group [220]. Murtaugh et al. sent email reminders to home care nurses prior to the home care visit recommending care for heart failure patients, which demonstrated improvement on several process measures [221].
Implications and future work

Medical informatics is a field with many stakeholders: clinicians, policy makers, patients, system developers, educators, and researchers, among others. The work in this thesis has implications for all of these groups. For clinicians, the most directly applicable findings are those from the review of PPIs to combat the gastrointestinal effects of NSAIDs. Although the findings were not conclusive, they support the practice of coprescription. The message from the 2SModel, LERM, and SnelleCor studies is mainly, “Hang in there, we’re working on it.” Right now, the field is beginning to recognize and characterize the problems that clinicians have experienced, which will in turn allow us to solve them. Likewise, for policy makers, the review of coprescription of PPIs with NSAIDs should stimulate reconsideration of the current payment policy (coprescription of PPIs in older patients is not reimbursed). In the field of decision support, we should work towards establishing a set of functional requirements for decision support within Electronic Patient Record (EPR) systems that facilitate development of usable, shareable decision support systems. This recommendation is not new; what is new is that the 2SModel brings us one step closer to defining what those requirements might be. The 2SModel can be equally applied to patient-oriented decision support. Our survey in seniors in the Netherlands implies that the internet is an appropriate channel for information for older patients. We also suggest that clinical decision support has the potential to both improve the quality of care (in terms of adherence to quality indicators such as ACOVE) and to improve the doctor-patient relationship by reducing cognitive load. For decision support developers, the LERM method is directly applicable for anyone who seeks to implement a system with clinical rules as the knowledge base. The survey of older patients tells us that we can develop internet-based interventions to reach a significant part of the population of seniors. The survey of general practitioners tells us that clinicians value systems that help them manage their responsibilities and prevent errors, and are concerned about interruptive reminders. The SnelleCor study tells us that “thinking outside the pop-up box” can yield useful and usable systems.

For researchers and educators, the 2SModel has direct implications. First, it can be used to organize the subjects that should be taught as part of a complete decision support curriculum. For researchers, it implies that the type of decision we make about the patient can and should influence the way we present that result to the user. Further, we hypothesize that there are consistent relationships between the two that can be elucidated and used to make better systems, and in turn better care. To investigate these relationships, we will need meta-analytic studies reviewing many individual decision support implementations. To this end, we recommend that researchers use the 2SModel as a guide to reporting the structure and function of decision support systems. We postulate that extant
knowledge of medical decision making can be cross-applied to decision support to make more useful and usable systems. On the side of patient-oriented support, our survey of seniors who use the internet opens many questions. Most critically: developing evidence-based usability guidelines for computer-based health information tools for seniors, the specific health information needs of seniors, and, if the finding bears out that seniors who seek health information on paper also use the internet, and those who do not use the internet rely mainly on information from health professionals, then how we should reach these patients with health information. Further research is also needed on the relationship between age, NSAIDs, and PPIs, particularly studies in large populations. The implementation of electronic patient records in large hospitals in the Netherlands will make these types of studies more feasible in the near future. As of the writing of this thesis, the ICOVE studies continue: we are currently implementing decision support for nine rules at the Spaarne Hospital in Hoofddorp, and are awaiting results from an ICOVE decision support system implemented in the general practice setting.

Conclusions

In conclusion, this thesis presents a general model of information flow in decision support systems that can be used to organize factors that should be considered in the design and reporting of systems and that may impact the success of systems in supporting decisions and improving care. We found that in choosing which clinical rules they want supported, clinicians value systems that help them manage their responsibilities and avoid errors, and are concerned about interruption. We addressed the quality of evidence underlying the system by reviewing the evidence for coprescription of proton pump inhibitors with NSAIDs, and found that although the evidence is insufficient, it points towards support of the recommended practice of coprescription. To transfer this knowledge to a clinical decision support system, we developed the LERM method for formalizing clinical rules. To present this information to older patients, we found that the internet appears to be a preferred channel for health information, although further research is needed on how to reach older patients who do not appear to actively seek health information. SnelleCor offers a case study demonstrating that decision support systems can be both well liked and effective, and despite evidence from recent reviews, interruptive systems are not the only recipe for success. We hope that the studies in this thesis will help guide the development of more useful and usable systems for patients and their clinicians.