

A 2014 Medical Informatics Perspective on Clinical Decision Support Systems: Do We Hit The Ceiling of Effectiveness?

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Summary

Objective: To summarize recent research and propose a selection of best papers published in 2013 in the field of computer-based decision support in health care.

Method: Two literature reviews were performed by the two section editors from bibliographic databases with a focus on clinical decision support systems (CDSSs) and computer provider order entry in order to select a list of candidate best papers to be peer-reviewed by external reviewers.

Results: The full review process highlighted three papers, illustrating current trends in the domain of clinical decision support. The first trend is the development of theoretical approaches for CDSSs, and is exemplified by a paper proposing the integration of family histories and pedigrees in a CDSS. The second trend is illustrated by well-designed CDSSs, showing good theoretical performances and acceptance, while failing to show a clinical impact. An example is given with a paper reporting on score-cards aiming to reduce adverse drug events. The third trend is represented by research works that try to understand the limits of CDSS use, for instance by analyzing interactions between general practitioners, patients, and a CDSS.

Conclusions: CDSSs can achieve good theoretical results in terms of sensibility and specificity, as well as a good acceptance, but evaluations often fail to demonstrate a clinical impact. Future research is needed to better understand the causes of this observation and imagine new effective solutions for CDSS implementation.

Keywords

Medical informatics, International Medical Informatics Association, yearbook, decision support systems

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Introduction

The year 2013 has produced a large amount of publications related to decision support as evidenced by the number of papers returned by the literature search (more than 1400). Clinical decision support systems (CDSSs) continue to be developed, calibrated, and evaluated in intervention studies, and their effectiveness is assessed. Many research works tackle the issues of appropriateness and security of drug prescribing. However, recent systematic reviews of CDSS interventions, mostly designed to provide reminders for clinicians, demonstrated modest improvements on processes of care combined with a great variability (e.g. [1, 2]). It appears that at least three trends can be identified from 2013 publications. Firstly, CDSSs generally demonstrate very limited or no effectiveness on clinical outcomes. This seems to be not only consistent with the overall results of prior reviews, but also suggests that keys for the improvement of CDSS impact have not been found yet. An effectiveness ceiling may be reached. Almost consequently, the second noticeable point is that research work focuses on the identification of the barriers to CDSS adoption and their understanding. The third trend is illustrated by less applied works that aim at proposing new theoretical approaches or technologies to develop new CDSSs that could overcome some weaknesses of the existing ones. The three “best papers” selected this year for the decision support section of the Yearbook illustrate these three trends.

About the Paper Selection

A comprehensive literature search was performed with two bibliographic databases, Pubmed/Medline (from NCBI, National Center for Biotechnology Information) and Web of Science® (from Thomson Reuters). The search was targeted on the topics related to clinical decision support and computer provider order entry. References addressing topics of other sections of the Yearbook, such as those related to medical imaging or CDSSs targeting patients as users, were excluded. Performed at the beginning of January 2014, the search returned a total of 1,407 references. Articles were separately reviewed by the two section editors, and were first classified into three categories: kept, discarded, or pending. During the review process, papers were evaluated based on their contribution to one of the following themes: originality of the application domain, new methodology for medical decision support, evaluation of a CDSS, design recommendation for CDSSs, or review on the impact of CDSSs. Then, the two lists of references were merged, yielding 55 references that were classified as “kept” by at least one reviewer or classified as “pending” by both reviewers. The 55 references were reviewed by the two section editors jointly to select a consensual list of 15 candidate best papers. Following the IMIA Yearbook process [3], these 15 papers were peer-reviewed by editors and external reviewers (at least four reviewers per paper). Three papers were finally selected as best papers (Table 1). A content summary of these selected papers can be found in the appendix of this synopsis.

Conclusions and Outlook

The first selected paper, by Gay et al. [4], provides an example of theoretical works to extend CDSS capabilities. Many medical disorders involve genetic factors, for instance mutations in BRCA1 or BRCA2 increase the risk of breast and ovarian cancers. When available, knowledge on mutations may appropriately guide medical decisions. The authors propose a modeling framework to account for genetic information in the context of medical knowledge-based systems. They qualitatively describe family configurations and mutation inheritance patterns. This work however is preliminary and has not been tested in real applications yet. Other theoretical works were also noticeable in 2013. For instance, Wilk et al. [5] formally addressed the problem of multi-morbidity management for which several guidelines/CDSSs may suggest concurrent or conflicting recommendations. For these cases, they propose an interesting mitigation method based on constraint logic programming. Within the scope of this year's special theme for the Yearbook, "Big Data – Smart Health Strategies", approaches that exploit large amounts of existing information to provide answers to clinical questions, like Watson [6, 7], seem to mature, although they still require further scientific assessment. Data available in existing information systems can be used to train CDSSs. For example syndromic algorithms have shown to be efficient for detecting patients in healthcare facilities with potentially transmissible infectious diseases through the use of computerized emergency department data, with good theoretical results in terms of sensibility and specificity [8].

The second selected paper, by Hackl et al. [9], reports on the evaluation of a classical CDSS, which was designed to reduce adverse drug events. The CDSS, named ADE scorecards, collects clinical data in a hospital, applies rules to detect potential adverse effects, and then builds syntheses and graphs to aid clinicians. An evaluation following the design of time series studies has been conducted in 5 hospital departments. The system was well accepted by healthcare professionals, but the evaluation failed to show an impact on clinical outcomes, i.e. the ADE rate. This exemplifies the development of a CDSS that failed to reach its champions' expectations

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2014 in the section 'Decision Support'. The articles are listed in alphabetical order of the first author's surname.

Section
Decision Support
<ul style="list-style-type: none"> ▪ Gay P, Lopez B, Pla A, Saperas J, Pous C. Enabling the use of hereditary information from pedigree tools in medical knowledge-based systems. <i>J Biomed Inform</i> 2013 Aug;46(4):710-20. doi: 10.1016/j.jbi.2013.06.003. ▪ Hackl W, Ammenwerth E, Marcilly R, Chazard E, Luyckx M, Leurs P, Beuscart R. Clinical evaluation of the ADE scorecards as a decision support tool for adverse drug event analysis and medication safety management. <i>Br J Clin Pharmacol</i> 2013 Sep;76 Suppl 1:78-90. ▪ Hayward J, Thomson F, Milne H, Buckingham S, Sheikh A, Fernando B, Cresswell K, Williams R, Pinnock H. 'Too much, too late': mixed methods multi-channel video recording study of computerized decision support systems and GP prescribing. <i>J Am Med Inform Assoc</i> 2013 Jun;20(e1):e76-84.

for effectiveness despite a thoughtful design. Likewise, a randomized controlled study on pressure ulcer prevention conducted in nursing homes with a multifaceted intervention, including a CDSS, showed a positive effect on care processes, but none on patient outcomes [10]. Such results make the relevance of the guideline-based knowledge used to formalize CDSS knowledge bases as well as the quality of the translation of originally narrative guidelines questionable. Séroussi et al. [11] observed with a CDSS on breast cancer management that non-compliance of clinicians' decisions with the system was associated with patient profiles for which supporting evidence was lacking. Another study by Korley et al. [12] illustrates the role of supporting knowledge by comparing the agreement between routine care and three CDSSs on computer tomography indication for mild traumatic brain injuries. The three CDSSs were based on different knowledge sources and within the study behave differently. Boutis et al. [13] conducted a multi-centered study to safely reduce radiology exams in children with acute ankle injuries. Following the recommendations to maximize intervention effectiveness, a multifaceted intervention including a CDSS was first performed to optimize behavioral changes. Then, in the last phase of the study, the CDSS was only used in the intervention group. The interesting result of this paper is that the CDSS was able to sustain the improvements from the prior multifaceted intervention. Similarly, Lin et al. [14] conducted a successful study using a CDSS to determine the appropriateness of imaging tests in case of suspected coronary heart disease. Results demonstrated the ef-

fectiveness of the CDSS with an increase of appropriate tests and a significant decrease of inappropriate tests. However, in the context of the study, the use of the CDSS was mandatory since it was used as a substitute of a private payer's standard protocol. Such organizational constraint in care processes can be considered either as a bias or as a feature that optimizes CDSS effectiveness.

The third selected paper, by Hayward et al. [15], differs from "classical" studies evaluating CDSSs. In this study, the focus is on the interactions between general practitioners, the patient, and a CDSS in the context of routine consultations involving prescribing. Material is obtained from the analysis of video-recorded consultations. Following a task model of the decision-making process for the prescription of a drug, authors observed that current CDSS alerts that criticize the prescription appear "too late", while the prescribing decision has been made and already negotiated with the patient, thus making alert override more likely. The conclusion is that effective decision support for prescribing should occur earlier in the decision process. Though limited in size and scope, this qualitative study allows for a novel interpretation of a review based on a meta-regression analysis of 162 randomized controlled trials of CDSSs by Roshanov et al. [16]. In this review, the authors tried to identify factors discriminating between effective and ineffective CDSSs. Paradoxically, one of the results is that decision support presented as alerts within electronic charting or order entry systems is associated with failure compared to other types of presentation. In view of this observation, the work by Hayward et al. suggests possible explanations. Nevertheless,

many stakeholders still promote reminders and alerts as an effective mean to impact decisions, while acknowledging that the problem of alert overriding by healthcare providers has to be considered, as confirmed by Yeh et al. [17]. According to this approach, Smith et al. [18] proposed a pragmatic approach that accounts for this phenomenon and developed a software prototype that could track and catch missed follow-up of abnormal test results in connection with overridden alerts. CDSS acceptance is a key factor for the dissemination of such tools and their effectiveness. While CDSS acceptance by physicians has been widely studied, Shaffer et al. [19] focused their work on how a patient accepts (or not) that her physician uses a CDSS. Their study showed that a physician referring to a colleague was better perceived by the patient than a physician using a CDSS. Authors conclude that the negative perception is not associated with the need to seek external medical advice but rather with the use of a non-human tool. According to this study, patients' attitudes or beliefs may also represent a barrier to CDSS effectiveness.

Many other works published in 2013 deserve to be highlighted. For instance, Raebel et al. [20] proposed definitions and a standardization of prescription adherence enabling operationalization on electronic data. Such a standard is important for comparison of CDSSs since processes of care are often assessed by their adherence to recommendations and the notion of adherence may have various meanings. Another challenge when designing a decision support system is to extract structured clinical data from electronic health records. The prediction of clinical data from non-clinical claim data and comorbidities is a common solution. Bang et al. [21] showed that the addition of data on prescribed medications can improve these predictions. These results may allow for better clinical input for decision support, but they might also suggest that decision support itself should include information on prescribed drugs. Nursing informatics is a growing field in medical informatics, well represented in the works published in 2013. Several papers relate to nursing informatics and decision support systems targeting nurses. Lee et al. proposed a review of the features characterizing CDSS for nursing practices [22]. Other works include the previously mentioned CDSS for pressure

ulcer prevention [10] or a CDSS for improving ADE screening in nursing homes [23].

In conclusion, clinical decision support is still an active domain of research. However, CDSSs in 2013 seem to reach a plateau with respect to their effectiveness when implemented in real-world settings. One could consider that paradigm shifts are required either in the design, the development, or the implementation of CDSSs. Enhancements could be brought by new decision models, explicit commitments on the validity and evidence of supporting knowledge, improved human-computer interfaces, and new ideas on a better collaboration between computerized decision support artifacts and their users.

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Appendix: Content Summaries of Selected Best Papers for the 2014 IMIA Yearbook, Section Decision Support

Gay P, Lopez B, Pla A, Saperas J, Pous C
Enabling the use of hereditary information from pedigree tools in medical knowledge-based systems

J Biomed Inform 2013 Aug;46(4):710-20

Family history is important information. It needs to be integrated into knowledge-based systems and taken into account by decision support systems when dealing with genetic diseases to permit personalized medicine. The authors first present pedigree file formats, which are commonly used for structuring a family history. Then they propose several indicators that can be computed from those pedigree files. They distinguish statistic-based indicators and structured data-based indicators, the latter being subdivided into individual-level and family-level indicators. They also propose algorithms and rules for exploring family trees, and for splitting a multi-rooted tree into several normal trees.

In addition, the authors propose architecture for integrating pedigree information into a knowledge-based system. The various indicators proposed are computed by a risk calculator, which has been integrated to the eXIT*CBR case-based reasoning system for medical diagnostic. This system allows mixing pedigree information with other medical data such as clinical conditions during case-based reasoning.

The authors present several case studies. The proposed methods and indicators were applied to breast cancer diagnosis data including 347 pedigree files as well as clinical data, showing the feasibility of this approach.

Hackl WO, Ammenwerth E, Marcilly R, Chazard E, Luyckx M, Leurs P, Beuscart R
Clinical evaluation of the ADE scorecards as a decision support tool for adverse drug event analysis and medication safety management
Br J Clin Pharmacol 2013 Sep;76 Suppl 1:78-90

Adverse Drug Events (ADEs) are an important healthcare problem. The authors propose ADE scorecards as a way to increase hospital team awareness of ADEs. These scorecards aim at facilitating the detection of ADEs, but also the understanding of their causes. Scorecards are developed with a user-centered design. The system includes a synthesis listing the possible ADEs detected. For each of them, the system proposes a detailed statistical analysis with patients' characteristics, graphics, and possible causes. A tool for facilitating case-review is also available. Rules for 27 classes of ADE are integrated.

The authors investigate the usage and acceptance of scorecards, in three hospital departments (two other departments acting as a control group). The results show that pharmacists are the most frequent users of scorecards. Eleven health professionals were interviewed. Most of them consider scorecards as useful for both learning and care improvement, through the discovery of new information and the support for decision making.

The authors do not show a significant impact of scorecards' use on the rate of potential ADEs. During a period of one year, about 3,500 ADEs were detected in 21,000 patient stays, but neither the comparison of test departments with control ones, nor the introduction of the system in test departments, had an impact on ADE rates. However, as discussed by the authors, most of similar systems described in the literature were also unable to show a significant reduction of ADEs.

Hayward J, Thomson F, Milne H, Buckingham S, Sheikh A, Fernando B, Cresswell K, Williams R, Pinnock H

'Too much, too late': mixed methods multi-channel video recording study of

computerized decision support systems and GP prescribing

J Am Med Inform Assoc 2013
Jun;20(e1):e76-84

The extensive overriding of alerts generated by CDSSs, even when critical, is acknowledged in the literature. This paper reports on interactions of general practitioners (GPs) with CDSSs in prescribing tasks in the context of routine consultations.

The approach used mixed qualitative and quantitative methods to analyze interactions between general GPs, their patient, and their prescribing software, which included CDSS functions such as alert generation. Authors also focus on consultations, where a new treatment is prescribed (a 'new acute' prescription) since it involves many decision-making processes. They also categorize CDSS-generated alerts according to their potential importance (safety, warning, other). Material results from the coded transcription of video recording of actual consultations combined with synchronous logged computer tasks.

A total of 112 consultations for 8 GPs in the UK were observed. 73 consultations include at least one prescription and a total of 117 alerts were issued by the CDSS, with safety and warning alerts in similar proportions. Only 2% of alerts induce some review and further checking by the GPs, but none led to a modification of the entered prescription. From 43 consultations with a new acute prescription, the qualitative analysis of prescribing tasks, decomposed as "formulating the problem", "negotiating a proposed medication", "reaching agreement on the treatment", and "instructing on using the medication", shows that these tasks are initiated before the computer was used to enter the prescription, and thus before alerts were issued.

Authors' findings are that current CDSS alerts appear "too late", when the prescribing decision has been made and negotiated with the patient. Consequently, alerts do not fit correctly into the consultation workflow and are likely to be ignored by GPs. Though obvious limitations with respect to generalizability, this qualitative study suggests however that effective decision support for prescribing should be brought earlier in the process to prevent alert generation.