

Health and Clinical Management: Chronic and Acute Challenges

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Summary

Objectives: Summarize some of last year's best research in the field of Health and Clinical Management.

Method: Synopsis of articles selected for the IMIA Yearbook 2012.

Results: Five articles, from international peer-reviewed journals, have been selected in this section.

Conclusions: The selected articles illustrate some of the topics of health and clinical management: from patient safety issues over the possibilities offered by technological devices to building knowledge from data present in electronic patient records.

Keywords

Medical informatics; International Medical Informatics Association; Yearbook; Management; Patient Care Management; Public Health Informatics

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Introduction

Quite understandably, anyone that has suffered illness has wished for a rapid and efficient cure. In order to meet this patients' desire, healthcare providers have sought to increase their knowledge about diseases, their diagnosis and treatment. This can be summarized as a pressure on healthcare to improve its outcomes; a pressure that has existed and will exist for long times and that is addressed primarily by fundamental and clinical research to acquire knowledge. Because of humans' intrinsically limited memory and capacity to deal with large amounts of information, and in order to respond to this knowledge increase, physicians and all other health providers have been progressively forced to specialize in increasingly more specific domains. While this specialization of healthcare actors is an efficient response for those patients suffering a single disease involving a single speciality (e.g. a young and healthy patient that has broken a leg only requires an orthopaedist), it does have its counterparts. With an aging society, an ever increasing number of patients suffer multiple and chronic diseases spanning across many specialities (e.g. diabetic patients with ophthalmologic, nephrologic and cardiovascular complications). Such patients therefore need to receive care that has to be provided by many actors. This finally leads to a dispersion of information about patients' health condition across many institutions and health workers. Because making the best decisions requires to be well informed, solutions must be found to avoid this fragmentation of information in order to improve each

health professional's awareness of all relevant information for his patients [1-4].

The resulting today's healthcare environment is extremely complex: enormous quantity of knowledge that can hardly be handled even by the best specialists, increasing number of patients suffering of chronic and complex diseases for which many professionals need to collaborate together or simply the ever increasing number of diagnostic and therapeutic options are just a few aspects of the complexity.

Now, while this modern healthcare environment is pressured to improve outcomes, which is already challenging enough by itself, recent years have put it under a new and acute stress: reduce, or at least contain, its costs. Because increasing the number of healthcare workers has a direct impact on costs and wouldn't help deal with the complexity of patient care, solutions must be searched for elsewhere. To improve outcomes requires the ability to take advantage of all the most up-to-date knowledge and all the information relevant to a patient's condition and to improve cost efficiency requires an accurate targeting of those patients that will benefit from a healthcare intervention. Due to its capacity to reliably and rapidly process massive quantity of information, evaluate complex equations and conditions and instantly deliver results to numerous recipients, IT has, since many years, proved to be of valuable help in these areas. Existing literature demonstrates that possibilities exist to limit unnecessary visits or interventions by identifying only those patients that require them [5, 6]. Of course, targeting of patients might, on the contrary, be aimed at increasing the number of patients receiving an intervention to improve outcomes [7].

The few challenges presented here are only a very small subset of those that healthcare systems have to deal with today and that, with the constant evolution of science, knowledge and society, new challenges will progressively emerge.

Best Paper Selection

Medline was searched for all articles published last year in the field of health and clinical management. A careful review of all candidates has led to the selection of 5 articles (table 1) that best illustrate the potential of IT in the healthcare environment. A content summary of each paper can be found in the appendix of this synopsis.

The first selected article [8] is an original research on a new usage that can be made of RFID tags. Authors explore the possibility of inferring clinical events, such as contact between healthcare professionals and patients, from proximity sensing. This work is put in the context of nosocomial infections. As healthcare providers have contacts with many patients, they may act as a vector of cross-contamination and therefore participate in threatening patient safety.

The second paper [9] is another example of research in the field of patient-safety improvement. Isolation of patients carrying MRSA is desired as they can potentially cross-contaminate other patients. While testing all inpatients at admission is a costly procedure, testing only patients at high risk of being MRSA-positive requires reliable identification rules to target the “at risk population”. If these rules must be applied by healthcare professionals, they must remain quite easy which hinders their reliability. In order to bypass requires simplicity of rules, the authors have successfully implemented an electronic prediction rule based on data available in a typical hospital EHR within the first day of admission.

The third paper [10] presents a research on the secondary use of data available in patient records to build new knowledge. Although most clinically relevant data is

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2010 in the section ‘Health and Clinical Management’. The articles are listed in alphabetical order of the first author’s surname.

Section
Health and Clinical Management
<ul style="list-style-type: none"> Chang YT, Syed-Abdul S, Tsai CY, Li YC. A novel method for inferring RFID tag reader recordings into clinical events. <i>Int J Med Inform</i> 2011 Dec;80(12):872-80. Robicsek A, Beaumont JL, Wright MO, Thomson RB Jr, Kaul KL, Peterson LR. Electronic prediction rules for methicillin-resistant <i>Staphylococcus aureus</i> colonization. <i>Infect Control Hosp Epidemiol</i> 2011 Jan;32(1):9-19. Roque FS, Jensen PB, Schmock H, Dalgaard M, Andreatta M, Hansen T, Sæby K, Bredkjær S, Juul A, Werge T, Jensen LJ, Brunak S. Using electronic patient records to discover disease correlations and stratify patient cohorts. <i>PLoS Comput Biol</i> 2011;7(8):e1002141. Tatonetti NP, Fernald GH, Altman RB. A novel signal detection algorithm for identifying hidden drug-drug interactions in adverse event reports. <i>J Am Med Inform Assoc</i> 2012 Jan 1;19(1):79-85. Waitman LR, Phillips IE, McCoy AB, Danciu I, Halpenny RM, Nelsen CL, Johnson DC, Storrer JM, Peterson JF. Adopting real-time surveillance dashboards as a component of an enterprisewide medication safety strategy. <i>Jt Comm J Qual Patient Saf</i> 2011;37(7):326-32.

usually captured in a structured way, unstructured data also conveys valuable information. By mining clinical notes, authors have been able to extract “hidden” information that significantly enriched coded data and resulted on finer patient profiles from which unexpected disease co-occurrence. Finally, analysis of these co-occurring diseases allows the construction of gene/protein networks.

The fourth article, by Tatonetti et al. [11], is in the field building knowledge on adverse drug events. While knowledge about drugs, mainly their indications, contra-indications and secondary effects, is mostly studied on isolated drugs, knowledge about drug-drug interactions (DDIs) is still scarce. This research aimed to search for evidence of DDIs in the FDA’s Adverse Event Reporting system. By mining this database, nearly 200 novel DDIs have been discovered and among them an interaction between paroxetine and pravastatin, two among the most widely used drugs in the world.

Finally, the last selected article, by Waitman et al. [12], is another good example of IT’s valuable help in healthcare management. Significant efforts have been made in recent years to reduce adverse drug events: CPOEs with clinical decision support and alerting mechanisms been developed and implemented and coupled to electronic dispensation systems and medication administration records. Despite this effort, preventable

adverse drug events (ADEs) still continue to cause harm to patients. In this paper, authors present a new approach to prevent ADEs: as a complement to CPOE and EHR, define rules to identify patients at risk for an ADE and present these patients on dashboards reviewed by pharmacists.

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Appendix: Content Summaries of Selected Best Papers for the IMIA Yearbook 2012, Section on Health and Clinical Management*

Chang YT, Syed-Abdul S, Tsai CY, Li YC
A novel method for inferring RFID tag reader recordings into clinical events

* The complete papers can be accessed in the Yearbook's full electronic version, provided that the article is freely accessible or that your institution has access to the respective journal.

Int J Med Inform 2011 Dec;80(12):872-80

Avoiding nosocomial infections are one of the many events of concern in respect to patients' safety, particularly with the emergence of multi-resistant microbial agents. Contact between healthcare givers and patients being one of the main causes of cross-infection, there is a demand for a reliable monitoring of patients and health professionals in the hospital setting. In this article, the authors present their work on setting up, evaluating and validating a Contact History Inferential Model through the use of radiofrequency identification tags for proximity sensing. The model was built and evaluated in a Clinical Skill Center and aimed to detect and differentiate close-in, contact and invasive events between caregivers and patients. Based on observations, invasive events were easily distinguishable as their duration and the number of caregivers involved would be greater than for other types of events and nurses would be assisting doctors. To distinguish close-in and contact activities, the authors used an ROC curve to compute the best cut-off value in their setting (21s). The model was then validated in an ICU ward by comparing the automated RFID tag recordings with real-time observation. Results had good sensitivity, specificity and accuracy in detecting and differentiating event types; invasive events being the most accurately detected with a 91% sensitivity and a 98% specificity.

Robicsek A, Beaumont JL, Wright MO, Thomson RB Jr, Kaul KL, Peterson LR

Electronic prediction rules for methicillin-resistant *Staphylococcus aureus* colonization
Infect Control Hosp Epidemiol 2011 Jan;32(1):9-19 Jan;32(1):9-19

Isolation of methicillin-resistant *Staphylococcus aureus* carrying patients is a worldwide hospitals' effort in order to reduce cross-patient contamination. The identification of such patients is costly and resource demanding; it re-

quires the testing of a large proportion of all the patients in order to achieve a reasonable rate of detection and to have an impact. While testing all patients for MRSA colonization is a costlier method, testing only a targeted population requires an efficient rule to identify that target population; furthermore, if the rule is to be applied by caregivers, it must not only be efficient but also simple to evaluate. Unfortunately, the simpler the rule, the lesser is the discrimination between low- and high-risk patients. With the increasing availability of data in hospital information systems, simple prediction rules can be superseded with complex but computer evaluated ones.

Robicsek et al. present their work on deriving prediction rules to identify "at risk patients" based on data available in an EMR within 24 hours of their admission. Up to 27 demographic, admission detail, physiologic, laboratory, medication and medical history variables were identified and used in 5 derived prediction rules of variable complexity. All of these rules have been applied on a validation cohort of patients. All of these rules showed to be more efficient than 2 commonly used prediction rules developed to be applied "manually" (Harbarth and Furuno rules). While all rules were designed to be applied on one third of all patients, the 5 electronic prediction rules lead to the identification of significantly more MRSA positive patients than the two manual prediction rules. These electronic rules also showed an improvement in the overall cost of testing for MRSA.

Roque FS, Jensen PB, Schmock H, Dalgaard M, Andreatta M, Hansen T, Søeby K, Bredkjær S, Juul A, Werge T, Jensen LJ, Brunak S

Using electronic patient records to discover disease correlations and stratify patient cohorts
PLoS Comput Biol 2011;7(8):e1002141

Electronic patient records contain vast amounts of health related data. These

data are both structured and unstructured and are of different types ranging from coded diagnoses, physiological measures, laboratory test results over medication prescriptions and treatment plans to free-text admission, discharge and other notes.

With the consolidation of EPR systems in modern healthcare, this massive amount of information becomes available for researchers. Nevertheless, the documentation of structured data in EPRs, readily available for computer processing, might suffer from biases. For example, diagnoses and morbidity will be entered in a coded manner only when strictly pertaining to a given visit. On the contrary, free-text notes usually do not suffer from this bias and contain a significant amount of additional information.

In the present paper, Roque et al. demonstrate how text and data mining techniques can be used to extract clinical information hidden in text to augment coded data. They used text mining to automatically extract relevant terms from psychiatric patient records free-text notes and mapped these to disease codes in the ICD-10 ontology.

For each patient they constructed a phenotypic profile of all associated ICD10 codes (charted in a structured manner and mined from free-text). This allowed them to cluster patients together based on the similarity of their profiles. The result is a patient stratification based on more complete profiles than the primary diagnosis, which is typically used. They investigated comorbidities by looking for pairs of disease codes co-occurring in patients more often than expected. After manual curation, 93 candidate diagnoses pairs remained flagged as interesting. For a number of these they were able to find genes/proteins known to be associated with the diseases using the OMIM database. The disease-associated proteins allowed them to construct protein networks suspected to be involved in each of the phenotypes.

Tatonetti NP, Fernald GH, Altman RB

A novel signal detection algorithm for identifying hidden drug-drug interactions in adverse event reports

J Am Med Inform Assoc 2012;19(1):79-85

Interactions between drugs (DDIs) are difficult to study. Clinical trials focus on establishing the safety and efficacy of single drugs and typically do not investigate DDIs. While some drug interactions can be predicted through careful evaluation of molecular targets and metabolizing enzymes (e.g., CYP3A4), drugs may also interact with proteins that are not their primary therapeutic target. Thus, few predictive methods for discovering novel DDIs exist.

Spontaneous reporting systems, like the FDA's Adverse Event Reporting System routinely collect ADEs from clinicians, patients and drug companies and thus provide an opportunity to discover unexpected drug interactions. This paper describes the authors work on analysing the reports on ADEs in the FDA's database for discovering new drug-drug interactions. Focus was given on eight distinct severe adverse event classes based on their clinical significance. Of all reports available in the FDA's database, two sets of reports were extracted: the first, the training set, comprised only reports listing exactly one drug and the second, the validation set, included all reports listing exactly two drugs. The probability of occurrence of an adverse event was calculated for each drug based on the "single drug" adverse event reports. This derived probability was then compared to the calculated probability in the "two drugs" adverse event reports and lead to the identification of nearly 200 novel drug-drug interactions. Of these, the interaction between paroxetine and pravastatin, two among the most widely used drugs in the world, was verified in an independent analysis of the Stanford Hospital electronic medical records proving the value of their signal detection algorithm.

Waitman LR, Phillips IE, McCoy AB, Danciu I, Halpenny RM, Nelsen CL, Johnson DC, Starmer JM, Peterson JF

Adopting real-time surveillance dashboards as a component of an enterprisewide medication safety strategy

Jt Comm J Qual Patient Saf 2011;37(7):326-32

Although the use of drugs for treating patients is inevitable in medicine, drugs have been recognized to cause adverse events in a significant number of cases. The medical literature available during the past decades has shown that the magnitude of injury and the cost to society was such that it has led to a call for action. It has also shown that adverse drug events can have their origin anywhere on the path from prescription to administration over dispensing.

Available knowledge about ADEs and the circumstances of their advent has promoted computerization of the medication process. Unfortunately, even with CPOEs coupled to electronic dispensation and administration monitoring systems still allow adverse drug events to occur.

In order to further improve patient safety and healthcare quality, the authors present their study on implementing a real-time surveillance application designed to enable pharmacy review of high-alert medication orders and complement existing computerized provider order entry and integrated clinical decision support systems. The surveillance tool, targeting specific high-risk medications, integrated real-time data from multiple clinical systems and applied logical criteria to highlight potentially high-risk scenarios.

An analysis of the use by pharmacists of the developed application was done for aminoglycosides, warfarin, and anticoagulants (heparin and enoxaparin). It showed that event in the presence of a computerized provider order entry and clinical decision support, such real-time surveillance dashboards can serve as a final safety net to intercept medication errors.