Evidence-based Biomedical Informatics

The Long Way from Pioneer to Science

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Summary

Objectives: An overview of current trends and achievements in building more evidence of using information sciences technologies in biomedical informatics.

Methods: Extensive search using PubMed for published papers in this field in 2012. A selection process organized in three steps: a) identification and first selection of papers; b) international peer-review by at least 4 reviewers for each paper; c) final selection of five papers by the editorial board of the Yearbook based on the international reviewing results and a balanced coverage of the topics.

Results: Synopsis of the articles selected for the IMIA Yearbook 2012 and an invited opinion paper written by leading scientists in this field.

Conclusion: Evidence based health informatics is an important and ubiquitous trend in biomedical informatics. However, this research field has to be enhanced even further and, more importantly, achievements have to be put in practice.

Keywords

Evidence, biomedical informatics

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Introduction

Biomedical informatics is creating disruptive changes in the healthcare landscape. The word "eHealth" is more and more discussed as it becomes impossible to imagine healthcare without the type of technologies that have pervasively and progressively invaded all aspects of healthcare: public health, prevention, care, governance, benchmarking, research; all stakeholders from fundamental research to clinicians, from care providers to citizens; from governing bodies to federal agencies; and that has extended out of the medical field to result in consumerism and societal impacts. Biomedical informatics and information technologies are seen in many countries as the major tools to leverage and support the renewal of the healthcare system.

And, surprisingly, evidence remains poor. Regulation is disputed and still marginal. Certification is almost inexistent.

While "Medical Informatics - The field of information science concerned with the analysis and dissemination of medical data through the application of computers to various aspects of health care and medicine" is defined in the MeSH terms of PubMed since 1987 [1], a search with (Evidence-Based Practice[mesh] and "medical informatics"[mesh]) retrieves a little bit more than 4,000 references in May 2013. This probably does not reflect the whole corpus of literature and a better query would lead to other figures, but the key point would not change: it is a young science that has emerged in the last 10 years.

The survey paper from Allison B. McCoy et al. accompanying this section proposes a large overview of the evidence that can be used as a foundation in assigning health information technologies into three large pillars: 1) clinical informatics systems and interventions for providers, including clinical information systems and decision support; and health information exchange; 2) consumer health informatics systems, including personal health records and web-based and mobile HIT; and 3) methods and governance for clinical informatics.

The invited joint submission of the IMIA and EFMI working groups on evaluation by Michael Rigby et al. highlights the major work provided by these working groups to enhance and leverage methodological approaches in evidence-based health informatics and standards for reporting such evaluation in the literature.

Building evidence in our field is no longer an option. It is a necessity and an obligation. It is a necessity in order to promote the field, to provide convincing elements to decision makers, and to build good new products. It is an obligation because the influence of HIT on medicine is growing, affecting care providers, impacting patient outcomes, changing lifestyle. For example, it is no longer acceptable that the evidence required for assessing a drug is not required for the tools that will influence the usage of this drug. This point is well addressed by the contribution of the IMIA WG on Safety by Elizabeth M. Borycki et al. entitled "Usability Methods for Ensuring Health Information System Safety: Evidence-Based Approaches". This paper emphasizes the challenge of the lack of system usability and potential safety hazards. Governmental initiatives are being worked on in several places, such as in Europe with the EU Medical Device Directive (MDD) [2] defining software for the diagnosis, treatment, monitoring, or alleviation of diseases and injuries as a medical device and in the

United States with the "Health IT Regulatory Framework" [3]. These initiatives are still ongoing, and there is a lot of uncertainties on how to apply them, however there is clear movement which will lead to a strong regulatory framework in the future.

Hopefully, strong methodology, as already used in numerous other fields, will be adopted in biomedical informatics to bring better evidence. This includes biostatistical contributions, such as power of studies and generalizability of results; it includes better design such as randomized controlled interventions and finally real outcomes and impact measures.

Appendix: Content Summaries of Selected Best Papers for the IMIA Yearbook 2013, Section Evidence-based Health Informatics[1]

Five papers have been selected during the review process which initially evaluated 624 references indexed in PubMed in 2012. Three of them address the very important problem of computerized order entry (CPOE) and clinical decision support systems (CDSS). The first two focus on relevance of CDSS in CPOE while the third is giving insights on the perception of this CDSS by clinicians. Focusing on CDSS and CPOE has been purposely done, taken into account the direct impact on patient care and patient safety that these systems have, and the increasingly frequent adoption of CPOE all over the world. Decision support in CPOE is a flagship of CDSS in the electronic health record (EHR). One paper is devoted to methodological aspects of evaluating alerts and responses. The last selected paper is devoted to EHR benchmarking and performance monitoring. These are limited fields of evidence-based bioinformatics, but they appear to the reviewers as having very important and immediate impacts, and thus deserving more attention in this edition of the Yearbook.

[1] 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.

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2013 in the sections 'Evidence-based Health Informatics'. The articles are listed in alphabetical order of the first author's surname.

Section Evidence-based Health Informatics
▪ Eppenga WL, Derijks HJ, Conemans JM, Hermens WA, Wensing M, De Smet PA. Comparison of a basic and an advanced pharmacotherapy-related clinical decision support system in a hospital care setting in the Netherlands. J Am Med Inform Assoc 2012 Jan-Feb; 19(1):66-71.
▪ Fritz D, Ceschi A, Curkovic I, Huber M, Egbring M, Kullak-Ublick GA, Russmann S. Comparative evaluation of three clinical decision support systems: prospective screening for medication errors in 100 medical inpatients. Eur J Clin Pharmacol 2012 Aug; 68(8):1209-19.
▪ Jung M, Hoerbst A, Hackl WO, Kirrane F, Borbolla D, Jaspers MW, Oertle M, Koutkias V, Ferret L, Massari P, Lawton K, Riedmann D, Darmoni S, Maglaveras N, Lovis C, Ammenwerth E. Attitude of physicians towards automatic alerting in computerized physician order entry systems. A comparative international survey. Methods Inf Med 2013; 52(2):99-108.
▪ McCoy AB, Waitman LR, Lewis JB, Wright JA, Choma DP, Miller RA, Peterson JF. A framework for evaluating the appropriateness of clinical decision support alerts and responses. J Am Med Inform Assoc 2012 May-Jun; 19(3):346-52.
▪ Parsons A, McCullough C, Wang J, Shih S. Validity of electronic health record-derived quality measurement for performance monitoring. J Am Med Inform Assoc 2012 Jul-Aug; 19(4):604-9.

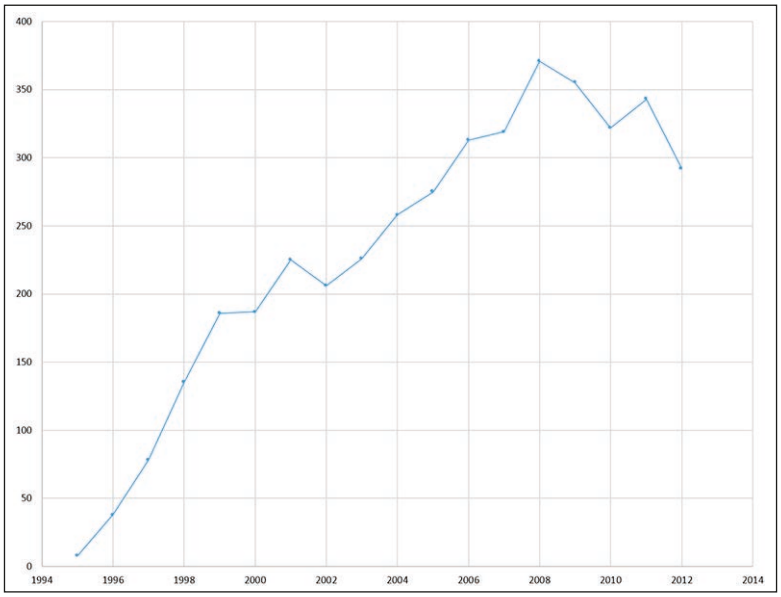

Fig. 1 Evolution of papers Evidence-based Biomedical Informatics in Pubmed

Eppenga WL, Derijks HJ, Conemans JM, Hermens WA, Wensing M, De Smet PA

Comparison of a basic and an advanced pharmacotherapy-related clinical decision support system in a hospital care setting in the Netherlands

J Am Med Inform Assoc 2012 Jan-Feb; 19(1):66-71

This paper addresses the very important aspect of positive predictive value (PPV) on drug decision-support in CPOE. The authors report the PPV of two commercially available systems providing CDS. The first one reports CDS during order entry based on a drug database while the second uses also other context-specific information, mostly laboratory, regarding the patient to further refine the CDSS. Both systems use the same drug database. During 5 randomly chosen consecutive days, all prescribed drugs in this 800 bed teaching hospital

in The Netherlands (4,023 orders for 619 patients) were independently assessed in each system by two pharmacists, and a third in case of disagreement. These orders generated 2,607 and 2,256 alerts with a positive predictive value of 5.8% for the drug database alone and 17% with the extended source of information. Stratification showed significant differences for alert categories: drug-drug interaction (9.9% vs 14.8%; $p<0.05$), drug-age interaction (2.9% vs 73.3%; $p<0.05$), and dosing (5.6% vs 16.9%; $p<0.05$).

There are some limitations to this study. For example, little extended sources of data were available for the so-called "advanced" system.

Nevertheless, this paper emphasizes that the positive predictive value of CDSS's is very low. Most probably, a diagnostic test with a 17% positive predictive value would not get to the market. Not only is 17% a low value, but it is probably one of the reasons why the alert fatigue phenomenon is becoming a major problem in CDSS [4]. This point is also discussed by the authors.

Fritz D, Ceschi A, Curkovic I, Huber M, Egbring M, Kullak-Ublick GA, Russmann S

Comparative evaluation of three clinical decision support systems: prospective screening for medication errors in 100 medical inpatients

Eur J Clin Pharmacol 2012 Aug; 68(8):1209-19

The authors prospectively evaluated the clinical relevance and the sensitivity for drug decision support of three commercially available CDSS's designed for pharmacological use. This study was done using 100 consecutive patients admitted in two general internal medicine wards in a tertiary Swiss teaching hospital. A total of 832 drug prescriptions were analysed. For each patient, clinical pharmacologists performed a review including chart and record review. The list of relevant alerts was then provided to the clinicians caring for the patients who were ultimately responsible to decide if a change in the prescription was required. The authors recorded when changes occurred and whether these changes were related to alerts.

The authors provide very detailed results, organized according to the type of decision support: Drug interactions, dosing and adverse drug reactions. The mean and median numbers of concomitant substances prescribed to each patient were 8.9 and 8 and an increase in the number of concomitant drugs was also associated with an increase of identified interactions. Overall, the proportion of clinically relevant alerts among all alerts (positive predictive value) was 5.7%, 8.0%, and 7.6%, and the sensitivity to detect relevant alerts was 9.1%, 87.9%, and 75.8% respectively for each system tested. Overall, half of the recommendations provided by the clinical pharmacologists to clinicians have been followed by a medication change.

This study has some limitations, such as the absence of a formal assessment of the relevance of CDSS's and the relatively small sample size. However, the authors also found PPV below 10%, and sensitivity at 87% for the best system.

Therefore, the authors propose that normal decision support should only be available on demand for the users, and that only a limited list of alerts shall be automatically computer-triggered. This list should be internally managed focusing on clinical relevance, outcomes, and consequences management.

Jung M, Hoerbst A, Hackl WO, Kirrane F, Borbolla D, Jaspers MW, Oertle M, Koutkias V, Ferret L, Massari P, Lawton K, Riedmann D, Darmoni S, Maglaveras N, Lovis C, Ammenwerth E

Attitude of physicians towards automatic alerting in computerized physician order entry systems. A comparative international survey

Methods Inf Med 2013; 52(2):99-108. Epub 2012 Nov 27

Jung et al. performed the largest international survey evaluating the perception and adoption of clinicians towards CPOE that has been published to date. This cross-sectional quantitative and qualitative questionnaire survey covers 11 hospitals from nine countries from across Europe and 1,018 physicians responded of a total of 2,600 invited. In the 7 hospitals with a CPOE system, physicians had worked, on average, between 3 –7 years with the CPOE system. The 4 hospitals without CPOE accounted for 350 participants.

Both quantitative and qualitative results show that the majority of physicians appreciate the benefits of alerting in CPOE systems. However, alerting should be better adapted to the clinical context and be less interruptible to avoid overload of irrelevant alerts. The three hospitals with the best scores use sophisticated, restrictive alerting systems, interrupting users only for the most important and severe warnings, while the three hospitals with the lowest scores only offer automatic and interruptive alerts. The authors emphasize that the problems identified in their survey is caused by the perceived overload of irrelevant alerts, thus leading to alert fatigue and loss of time.

The study has little limitations taken into account its purpose, which was to evaluate the perceived impact and not the objective impact of alerts.

McCoy AB, Waitman LR, Lewis JB, Wright JA, Choma DP, Miller RA, Peterson JF

A framework for evaluating the appropriateness of clinical decision support alerts and responses

J Am Med Inform Assoc 2012 May-Jun; 19(3):346-52

The authors, who have a rich 15 years history of CPOE experience, propose an evaluation framework to assess the relevance and appropriateness of CDSS in CPOE. Their framework is composed of two major pillars, the alert appropriateness and the response appropriateness. The alerting side itself is decomposed into how clinically relevant it is to display an alert and the level of urgency for the provider to respond to the alert. The provider response appropriateness is composed of the adherence to the alert, the response time, the expected response, and the appropriateness of the response.

The evaluation of the system for acute kidney injury showed that it was an effective method for assessing the clinical appropriateness of synchronous interruptive medication alerts and that this framework produced a good picture of the effectiveness of a CDSS.

One of the key attributes of the framework is that relevant clinical context information is required to determine alert appropriateness at the time it is triggered. This feature adds to the complexity of this framework and limits its easy generalizability. Another key feature of this framework is providing a formal quantitative evaluation of CDSS effectiveness and the potential associated unintended adverse consequences.

Parsons A, McCullough C, Wang J, Shih S
Validity of electronic health record-derived quality measurement for performance monitoring
J Am Med Inform Assoc 2012 Jul-Aug; 19(4):604-9

Since 2005, the New York City Primary Care Information Project (PCIP) has assisted over 3,000 care providers to use a commercially available EHR that is promoting prevention to improve the delivery of primary care. The authors report a retrospective electronic chart review of 4,081 electronic patient records across 57 practices from a subset of 82 practices invited to participate. The authors analyzed 11 clinical quality measures to assess where the information was documented in order to compare the presence of the information and its location: Analyzable structured field, or readable unstructured source, such as scanned documents or free text.

The authors report that little more than half of the information for laboratory test results, such as controlled hemoglobin A1c or cholesterol was documented in a structured form (53.4% - 63.0%) and that only half of the patient smoking status information (53.4%) was in a structured field.

The authors discuss the various reasons that can lead to this situation and propose mitigation strategies to improve the quality of the data in EHRs. However, they raise serious concerns on the usability of EHR derived measurements and show that quality measures derived from EHRs have yet to be validated as representative of provider performance or for benchmarking purposes.

References

1. http://www.ncbi.nlm.nih.gov/mesh/68008490 (accessed May 2013)
2. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1993L0042:20071011:en:PDF (accessed May 2013)
3. http://www.fda.gov/MedicalDevices/Productsand-MedicalProcedures/ConnectedHealth/ucm338920.htm (accessed May 2013)
4. Phansalkar S, van der Sijs H, Tucker AD, Desai AA, Bell DS, Teich JM, et al. Drug-drug interactions that should be non-interruptive in order to reduce alert fatigue in electronic health records. J Am Med Inform Assoc 2013 May 1;20(3):489-93.

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