A Bio-medical Informatics Perspective on Human Factors
How Human Factors Influence Adoption of Healthcare Information Technology

R. Meyer, Section Editor for the IMIA Yearbook Section on Human Factors
Department of Imaging and Medical Informatics, Geneva University Hospitals, Geneva, Switzerland

Summary

Objectives: to select and summarize excellent research papers published in 2009 in the field of human factors in bio-medical informatics.

Methods: we attempt to derive a synthetic overview of the activity and new trends in this field, from a selection of research papers published in 2009.

Results: it is possible to identify commonalities in this diverse domain: healthcare information technologies (HIT) adoption still occupies a central role in the field with research focused mainly on measuring impact and influence of this adoption.

Conclusion: The HIT community is giving birth to interdisciplinary research and clear methods to optimize implementation and subsequent achievement of managerial objectives. It also tries to synthesize the major findings in workshops, meetings and networks. The best paper selection of articles on human factors shows examples of excellent research on methods concerning original options to assess the importance of healthcare personnel psycho-sociology when confronted to the adoption of new tools and process which still does not prevent failures but will help learning from them.

Keywords

Medical informatics, International Medical Informatics Association, yearbook, human factors

Yearb Med Inform 2010: 21-4

Introduction

Since the 1991Institute of Medicine recommendations [1-2] electronic health records (EHRs) are expected to support patient care, improve quality of care, enhance productivity of healthcare professionals, support research, accommodate future developments and ensure confidentiality. Many studies have given strong evidence of medication errors and adverse drug events reduction following a CPOE implementation [3-5]. However, despite these evidences adoption of Healthcare Information Technologies (Hitech) in hospitals has been slow due to many factors including: the high cost of purchase-implementation-maintenance of systems, the immaturity of software products, the lack of integration between EHR systems, the medical staff resistance, the emergence of new mortality and morbidity causes [6-16]. Studies are showing a gap between medical teams perceived value of EHR systems and their intent to adopt this practice [17]. Most of the teams are reluctant to cross the gap on the perception that Hitech are time-inefficient or a major time-consuming system[6,18-24].

Best Paper Selection

The best paper selection of articles for the section on human presents excellent research on methods used for the analysis of interaction and communi-cation between healthcare agents, between healthcare computer systems and professionals. IMIA Yearbook 2010best papers were selected from the classical healthcare informatics journals as well as form a large number non bio-medical informatics specialized journals in order to perform an as broad as possible worldwide selection. The five papers selected this year clearly address different aspects of the health information technology adoption issues and how this adoption could become successful, or not. One paper by Beuscart-Zephyr and al. focuses on a human factor engineering approach to determine the potential impact on safety and efficiency caused by the implementation of a medication administration work system. Fridell and al. studied in a very interesting manner the influence of a PACS on the radiographer's work leading to unusual conclusions. Two of the papers selected this year, focused on methodologies or advices for success: Peleg and al. merged qualitative research, cognitive science and information systems works to develop a user centered approach aiming to design and evaluate a decision support system, while Goroll and al. established a survey on a collaborative method including 500 physicians in the USA and were able to propose a list of the essential factors to large scale EHR adoption. Finally, Peute and al. made a very informative analysis on a CPOE implementation failure from a socio-technical angle. A brief content summary of the selected best papers can be found below.

Conclusion and Outlook

The optimal use of systems requires an understanding of the interaction between humans and computers. It is here that human cognition comes into play and that cognitive psychology can provide a conceptual framework for a safe approach to systems development [25]. A positive user experience is the *sine qua non* condition to get the job done efficiently, easily and without frustration [26]. In some context this usually makes for a happier customer or a more profitable line of business. In the healthcare context a better human-machine interaction can save lives. The best paper selection for the Yearbook section ‚human factors' can by no means reflect the broadness of a field that is heterogeneous and published in a large collection of journals not only bio-informatics or clinically centered. The selected papers, however, shed light on some special aspects deserving particular attention as they will still concern organizational and methodological questions in the near future. As already stated last year in this section [27], the current health informatics research shows a need for consolidation in terms of integrating human factors in computerized healthcare institutions, as well as in routine health policy management. With more than 5000 peer reviewed works reachable via Medline, human factors engineering is in deep need of coordination and harmonization of the findings in the domain. Compilation throughout networks, meetings and workshop initiative represents the next steps that this domain will have to climb to support worldwide experimented teams as well as newcomers. Four major workshops gathering prominent actors have already been held in Europe and USA and a special issue of the International journal of Medical Informatics has just been released on human factors this April [28]. The growing importance of this field is further demonstrated by the activities of two working groups dedicated to human factors for health informatics at the international level (IMIA WG on Human Factors Engineering for Healthcare Informatics, chair Drs. Peter L. Elkin, and co-chair Marie-Catherine Beuscart-Zéphir) and at the European level (EFMI WG on Human and Organizational Factors of Medical Informatics, chair Jos Aarts and co-chair Marie-Catherine Beuscart-Zéphir).

Acknowledgement

References:

1. Dick RS, Steen EB. The Computer-Based Patient Record: An Essential Technology for Health Care, Revised Edition. Washington, DC: National Academies Press; 1991.
2. Dick RS, Steen EB, Detmer DE. The Computer-Based Patient Record: An Essential Technology for Health Care, Revised Edition. Washington, DC: National Academies Press; 1997.
3. Bates DW, Leape LL, Cullen DJ, Laird N, Petersen LA, Teich JM, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. JAMA 1998; 280(15):1311–6.
4. Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, et al. The impact of computerized physician order entry on medication error prevention. J Am Med Inform Assoc 1999;6(4):313–21.
5. Teich JM, Merchia PR, Schmiz JL, Kuperman GJ, Spurr CD, Bates DW. Effects of computerized physician order entry on prescribing practices. Arch Intern Med 2000;160(18):2741–7.
6. Ash JS, Bates DW. Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion. J Am Med Inform Assoc 2005;12(1):8–12.
7. Initiative, eHealth. Electronic prescribing: Toward maximum value and rapid adoption. Washington, DC: eHealth Initiative. 2004.
8. Schade CP, Sullivan FM, de Lusignan S, Madeley J. e-Prescribing, efûciency, quality: lessons from the computerization of UK family practice. J Am Med Inform Assoc 2006;13(5):470–5.
9. Gans D, Kralewski J, Hammons T, Dowd B. Medical groups' adoption of electronic health records and information systems. Practices are encountering greater-than-expected barriers to adopting an EHR system, but the adoption rate continues to rise. Millwood: s.n., Health Aff 2005;24(5):1323–33.
10. Burt CW, Hing E, Woodwell D. Electronic medical record use by ofûce-based physicians. s.l.: United States: National Center for Health Statistics; 2005.
11. Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. Health Aff 2004;23(4):184–90.
12. Halamka J, Aranow M, Ascenzo C, Bates DW, Berry K, Debor G, et al. E-Prescribing collaboration in Massachusetts: early experiences from regional prescribing projects. J Am Med Inform Assoc 2006;13(3):239 –44.
13. Koppel R, Metlay JP, Cohen A, Abaluck B, Localio AR, Kimmel SE, et al. Role of computerized physician order entry systems in facilitating medication errors. JAMA 2005;293(10):1197–203.
14. Han YY, Carcillo JA, Venkataraman ST, Clark RS, Watson RS, Nguyen TC, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. Pediatrics 2005;116(6):1506–12.
15. Middleton B, Hammond WE, Brennan PF, Cooper GF. Accelerating U.S. EHR adoption: how to get there from here. Recommendations based on the 2004 ACMI retreat. J Am Med Inform Assoc 2005;12(1):13–9.

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2010 in the section 'Human Factors'. The articles are listed in alphabetical order of the first author's surname.

Section Human Factors
■ Beuscart-Zéphir MC, Pelayo S, Bernonville S. Example of a Human Factors Engineering approach to a medication administration work system: Potential impact on patient safety. Int J Med Inform 2009Apr;79(4):43-57.
■ Fridell K, Aspelin P, Edgren L, Lindsko L, Lundberg N. PACS influence the radiographer's work. Radiography 2009;15:121-33.
■ Goroll AH, Simon SR, Tripathi M, Ascenzo C, Bates DW. Community-wide implementation of health information technology: the Massachusetts eHealth Collaborative experience. J Am Med Inform Assoc 2009 Jan-Feb;16(1):132-9. Epub 2008 Oct 24
■ Peleg M, Shachak A, Wang D, Karnieli E. Using multi-perspective methodologies to study users' interactions with the prototype front end of a guideline-based decision support system for diabetic foot care. Int J Med Inform 2009 Jul;78(7):482-93. Epub 2009 Mar 27
■ Peute LW, Aarts J, Bakker PJ, Jaspers MW. Anatomy of a failure: A sociotechnical evaluation of a laboratory physician order entry system implementation. Int J Med Inform 2010 Apr;79(4):e58-70. Epub 2009 Jul 28.

16. Nebeker JR, Hoffman JM, Weir CR. High rates of adverse drug events in a highly computerized hospital. Arch Intern Med 2005;165(10):1111–6.

17. Hollingworth W, Devine EB, Hansen RN, Lawless NM, Comstock BA, Wilson-Norton JL, et al. The impact of e-prescribing on prescriber and staff time in ambulatory care clinics: a time motion study. J Am Med Inform Assoc 2007;14:722-30.

18. Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. JAMA 1993;269(3):379–83.

19. Bates DW, Boyle DL, Teich JM. Impact of computerized physician order entry on physician time. Proc Annu Symp Comput Appl Med Care 1994:996.

20. Shu K, Boyle D, Spurr C, Horsky J, Heiman H, O'Connor P, et al. Comparison of time spent writing orders on paper with computerized physician order entry. Medinfo 2001;10(Pt 2):1207–11.

21. Overhage J M, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices. J Am Med Inform Assoc 2001;(4):361–71.

22. Pizziferri L, Kittler AF, Volk LA, Honour MM, Gupta S, Wang S, et al. Primary care physician time utilization before and after implementation of an electronic health record: a time-motion study. J Biomed Inform 2005;38(3):176–88.

23. Bosman RJ. Impact of computerized information systems on workload in operating room and intensive care unit. Best Practice & Research Clinical Anaesthesiology 2009;23:15–26.

24. Mador RL, Shaw NT. The impact of a Critical Care Information System (CCIS) on time spent charting and in direct patient care by staff in the ICU: A review of the literature. Int J Med Inform 2009; In press.

25. Beuscart-Zephir MC, Elkin P, Pelayo S, Beuscart R. The human factors engineering approach to biomedical informatics projects: state of the art, results, beneûts and challenges. Yearb Med Inform 2007:109-27.

26. Horvath J. User experience & the business of healthcare. Human Factor Inc. white paper; 2010.

27. Meyer R. A Bio-Medical Informatics Perspective on Human Factors. Findings from the Yearbook 2008 Section on Human Factors. Yearb Med Inform 2009:59-62.

28. Beuscart-Zephir MC, Aarts J, Elkin P. Human factors engineering for healthcare IT clinical applications. Int J Med Inform 2010:79(4):223-4.

Correspondence to:
Dr Rodolphe Meyer
University Hospitals of Geneva
Department of medical Informatics
Geneva, Switzerland
Tel: +41 22 305 58 95
Fax: +41 79 676 24 45
E-mail: rodolphe.meyer@sim.hcuge.ch

Appendix: Content Summaries of Selected Best Papers for the IMIA Yearbook 2010, Section Human Factors*

Beuscart-Zéphir MC, Pelayo S, Bernonville S

Example of a human factors engineering approach to a medication administration work system: Potential impact on patient safety

Int J Med Inform 2009 Apr; 79(4):43-57

The authors had two main objectives in this paper. They wanted to describe a Human Factors Engineering (HFE) approach to a medication administration work system, in the context of a hospital medication Computerized Provider Order Entry (CPOE) project. This done they wantedto identify the impacts of this CPOE on both the efficiency and the safety of the medication use process.They used ethnographic methods to support the analysis of the current work system and work situations, coupled with cognitive task analysis methods and documents review. Then they performed heuristic evaluations tests both in-lab and on-site for the evaluation of the CPOE candidate. As a result they identified different work organizations and procedures across the hospital's departments. The most important differences concerned the doctor–nurse communications and cooperation modes and the procedures for preparing and administering the medications. They efficiently identified and distinguished currently unsafe or uncomfortable work situations that could obviously benefit from an IT solution from other work situations incorporating efficient work procedures that might be impaired by the implementation of the CPOE. The results of the usability assessment were translated into require-

ments to support the necessary re-engineering of the IT application.

Fridell K, Aspelin P, Edgren L, Lindsko L, Lundberg N

PACS influence the radiographer's work

Radiography 2009;15:121-33

The aim of this qualitative study was to explore changes in radiographers' work with regard to skills, work practice and technology. This is based on the observation that introduction of new technology in radiology department seems to dissolve boundaries between the professions in the work environment where the technology is introduced. The study used open-ended interviews to explore the radiographers' perceptions of such changes, and to identify problems and solutions pertaining to work practice. The new technology immediately created a vision of improved service to the clinicians. The experience among radiographers was that the production of images increased and as a result the stress in work increased as well.At the start there were visions of new routines, and therefore the radiographers became early adopters to the new technology; in practice the organization was stacked in old routines, as the routines were inflexible and PACS work was pushed into old work routines.Although inflexible, this does not mean that they cannot change, and obviously new routines had been implemented making it possible for the radiographers in finding new ways for collaborating with colleagues.In order to optimize the service the radiographers developed an insight into the need for a more comprehensive change in work using a new PACS technology and digital workflow.

Goroll AH, Simon SR, Tripathi M, Ascenzo C, Bates DW

Community-wide implementation of health information technology: the Massachusetts eHealth Collaborative experience

J Am Med Inform Assoc 2009 Jan-Feb;

16(1):132-9. Epub 2008 Oct 24

This article describes the formation and implementation phases of the Massachusetts eHealth Collaborative (MAeHC), focusing on barriers identified, lessons learned, and policy issues. The MAeHC was formed to improve patient safety and quality of care by promoting the use of health information technology through community-based implementation of electronic health records (EHRs) and health information exchange. The MAeHChas recently implemented EHRs in a diverse set of competitively selected communities, encompassing nearly 500 physicians serving over 500,000 patients. Targeting both EHR implementation and health information exchange they identified numerous challenges and had to develop strategies for overcoming them. They identified the need to develop a business model to support widespread EHR adoption. Contribution of capital for the initial investment is being proposed on a fair share basis, according to expected financial return for individual parties. Development of the MAeHCrepresents one approach to accelerating implementation of HIT, with potential benefits in quality, safety, and efficiency. Although substantial early progress has been realized, the organization is still young, and the benefits still need to be demonstrated. Nonetheless, the barriers encountered and strategies to overcome them should be applicable to others considering similar initiatives.

Peleg M, Shachak A, Wang D, Karnieli E
Using multi-perspective methodologies to study users' interactions with the prototype front end of a guideline-based decision support system for diabetic foot care

Int J Med Inform 2009 Jul;78(7):482-93. Epub 2009 Mar 27

In this paper the authors wanted to develop a guideline-based decision support system (DSS) prototype to help clinicians deal with diabetic patients' foot problems. To reach their goal, they drew on methodologies from qualitative research, cognitive science, and information systems. They estimate that clinical practice guidelines are important instruments for improving the quality of care but in paper form, however, they think that they are not used as effectively as possible. Field observations, structured interviews, and document analyses were used to collect and analyze users' workflow patterns, decision support goals, and preferences regarding interactions with a DSS. The requirements were aligned with sequence diagrams and followed Nielsen's heuristics to develop a DSS prototype. Think-aloud analyses and the technology acceptance model were used to direct the evaluation of users' perceptions of the prototype. This multi-perspective approach was intended to facilitate user-centered design and evaluation. As a result they assess that users had a positive response to the DSS prototype in terms of its clarity of design and ease of use and that they expressed a high intention of using the system in the future.

Peute LW, Aarts J, Bakker PJ, Jaspers MW
Anatomy of a failure: A sociotechnical evaluation of a laboratory physician order entry system implementation

Int J MedInform 2010 Apr;79(4):e58-70. Epub 2009 Jul 28

This article had two main objectives. First, the authors wanted to investigate the human, social and organizational issues surrounding a Computerized Physician Order Entry system for Laboratory ordering (CPOE-L) implementation process. Second, they wanted to provide lessons learned and recommendations on to how to manage challenges of human, social and organizational nature surrounding CPOE-L implementations. To realize their objectivesthey identified by a heuristic analysis of literature on CPOE implementations the themes surrounding CPOE introduction. The resulting set of themes was applied as a reference model for 20 semi-structured interviews conducted during the CPOE-L implementation process with 11 persons involved in the CPOE-L project and in reviewing all CPOE-L related project documentation. Data was additionally gathered by user questionnaires, by user discussion rounds and through an ethnographical study performed at the involved clinical and laboratory departments. In analyzing the interview transcripts, project documentation and data from user questionnaires and discussion rounds a grounded theory approach was applied by the evaluation team to identify problem areas or issues deserving further analysis.As a main result, the understanding of clinical workflow was identified as a key theme pressured by organizational, human and social issues ultimately influencing the entire implementation process in a negative way. Delays in CPOE introduction, system immaturity and under-functionality could all be directly attributed to a superficial understanding of workflow. Consequently, final CPOE integration into clinical and laboratory workflows was inhibited by both end-users as well as department managers and withdrawal of the CPOE-L system became inevitable. This excellent case study demonstrates which human, social and organizational issues relevant to CPOE implementation cumulatively led to a failure outcome of the CPOE-L pilot introduction. A must read for anyone involved in a CPOE implementation.