Medical Informatics and the Quality of Health: New Approaches to Support Patient Care
Findings from the IMIA Yearbook of Medical Informatics 2003

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Summary

Objectives: The Yearbook of Medical Informatics is published annually by the International Medical Informatics Association (IMIA) and contains a selection of excellent papers on medical informatics research which have been recently published (http://www.yearbook.uni-hd.de). The 2003 Yearbook of Medical Informatics took as its theme the role of medical informatics for the quality of health care. In this paper, we will discuss challenges for health care, and the lessons learned from editing IMIA Yearbook 2003.

Results and Conclusions: Modern information processing methodology and information and communication technology have strongly influenced our societies and health care. As a consequence of this, medical informatics as a discipline has taken a leading role in the further development of health care. This involves developing information systems that enhance opportunities for global access to health services and medical knowledge. Informatics methodology and technology will facilitate high quality of care in aging societies, and will decrease the possibilities of health care errors. It will also enable the dissemination of the latest medical and health information on the web to consumers and health care providers alike. The selected papers of the IMIA Yearbook 2003 present clear examples and future challenges, and they highlight how various sub-disciplines of medical informatics can contribute to this.

Keywords

Medical Informatics, IMIA Yearbook, Evaluation, Health Technology Assessment, Quality of Health Care

Medical Informatics and the Quality of Health

Information and communication technology (ICT) offer tremendous opportunities for a better and safer health care (1, 2). But there are also hazards associated with information technologies in health care: modern systems are costly, and their failures may cause negative effects on patients and staff (e.g. 4, 5, 6). Thus, medical informatics is asked by decision makers, users and even patients to be proven safe and beneficial. Therefore, rigorous, generalisable evaluations of ICT applications in health care are necessary and of great importance for decision makers and users.

In general, evaluation can be seen as the systematic assessment of design, development, introduction and usage of information system components, with the aim to learn, to answer relevant questions, and to support decision-making. Evaluation is thus an activity which should be closely connected to all phases of the life-cycle of an information system component. It is not a question of whether to evaluate or not. It is the question of how to evaluate in a way that helps to come to an informatics solution that contributes to better and safer patient care.

In order to address the important question of how medical informatics can con- tribute to the quality of patient care, the Yearbook of Medical Informatics 2003 of the International Medical Informatics Association (IMIA), has taken this question as this year's special topic. This issue of the Yearbook demonstrates the significance of medical informatics by presenting examples of its contributions to the quality of health.

In this paper, we will give an overview on the content of the IMIA Yearbook 2003, and discuss how the selected papers address this interesting question.

The IMIA Yearbook of Medical Informatics 2003

The IMIA Yearbook of Medical Informatics (7, 8) has been published annually since 1992, by the International Medical Informatics Association (IMIA). It contains a selection of recent, excellent and original research papers in the area of medical informatics. The 2003 issue of the Yearbook includes papers selected from the period of April 2001 to March 2002. The selection criteria for inclusion in this Yearbook included topic significance, representativeness and coverage of literature in a given sub-

field, and high quality of presentation and results.

Traditionally, the selected papers are structured according to main sections: Bio-informatics, Computer-supported Education, Health and Clinical Management, Health Information Systems, Knowledge Processing and Decision Support, Patient Records, and Signal Processing. In addition, papers such as reviews covering medical imaging informatics or other topics, synopsis by guest editors, and papers presenting international research and education programs, are written for the Yearbook to complement the selected papers. In the following, we will give a short outline of the content. The detailed table of contents of the IMIA Yearbook 2003 can be found in Table 1.

Preface

This year's preface to the Yearbook "Quality health care requires quality patient data" has been written by Rogers Côté from the University of Sherbrooke, Canada, the founder of SNOMED.

In Memoriam
Professor Jean-Raoul Scherrer

In 2002, one of the leaders of our field, Professor Jean-Raoul Scherrer, passed away. A section of the yearbook, containing 5 papers, is devoted to him in honor of his outstanding contributions to medical informatics.

Information on IMIA

The Yearbook contains detailed information about IMIA and its Member Societies (mainly prepared by Steve Huesing), and about its Working and Special Interest Groups (prepared by Nancy Lorenzi). The activities of IMIA regions are reported with the help of Regional Editors: Arie Hasman for EFMI, Sedick Isaacs for Helina, Jochen Moehr and Charles Safran for the North American IMIA Member Societies, Chun Por Wong for APAMI, and Lin-

Table 1 Table of contents of IMIA Yearbook of Medical Informatics 2003 (this table can also be found in the Internet at http://www.yearbook.uni-hd.de).

Preface	R.A. Côté. Quality health care requires quality patient data.
Editorial	R. Haux and C. Kulikowski.. Quality of Health Care: Informatics Foundations.
In Memoriam Prof. J-R Scherrer	Lun KC, IMIA President. Jean-Raoul Scherrer – intellectual, renaissance man and dear IMIA colleague. Reichert A, EFMI President, Engelbrecht R, EFMI Past President Prof. Jean-Raoul Scherrer, a professional leader. van Bemmel JH. Medical information systems in the age of Jean-Raoul Scherrer. Geissbühler A, Lovis C, Spahni S, Appel RD, Ratib O, Boyer C, Hochstrasser DF, Baud R. A humanist's legacy in medical informatics: visions and accomplishments of Professor Jean-Raoul Scherrer. Scherrer JR. An integrated hospital informationan system in Geneva.
Review Section	Hasman A, Safran C, Takeda H. Quality of health care: informatics foundations. Ball M, Garets DE, Handler TJ. Leveraging IT to improve patient safety. Riva G. Medical applications of virtual environments. Burdea G. Virtual rehabilitation - benefits and challenges.
Research and Education Section	Aarts JECM, Berg M, Huisman E. Health information management education at the Institute of Health Policy and Management of the Erasmus University Medical Center. Geissbühler A, Lovis C, Vallée JP, Spahni S, Baud R. A 2'200-bed laboratory: research and education in medical informatics at Geneva University Hospitals. Maglaveras N. Research and education directions in medical informatics at the Aristotle University of Thessaloniki. McCray AT. Informatics research, development, and training at the Lister Hill National Center for Biomedical Communications. Takeda H. Introduction to the Department of Medical Information Science of Osaka University Hospital.
Challenges in Medical Informatics	Musen MA, van Bemmel JH. Challenges for medical informatics: a discipline coming of age. Talmon JL, Hasman A. Medical informatics as a discipline at the beginning of the 21 st century. Musen MA. Medical informatics: searching for underlying components. Kulikowski CA. The micro-macro spectrum of medical informatics challenges: from molecular medicine to mransforming health care in a globalizing society. Lun KC. Challenges in medical informatics: perspectives of an international medical informatics organization.
Special Section: Quality of Health Care: Informatics Foundations	Bürkle T. Quality of healthcare: the role of informatics. Synopsis. Bates DW, Cohen M, Leape LL, Overhage JM, Shabot MM, Sheridan T. Reducing the frequency of errors in medicine using information technology. Chertow GM, Lee J, Kuperman GJ, Burdick E, Horsky J, Seger DL, Lee R, Mekala A, Song J, Komaroff AL, Bates DW. Guided medication dosing for inpatients with renal insufficiency. Roine R, Ohinmaa A, Hailey D. Assessing telemedicine: a systematic review of the literature. van't Riet A, Berg M, Hiddema F, Sol K. Meeting patients' needs with patient information systems: potential benefits of qualitative research methods. Vassallo DJ, Hoque F, Roberts MF, Patterson V, Swinfen P, Swinfen R. An evaluation of the first year's experience with a low-cost telemedicine link in Bangladesh.
Section 1: Health and Clinical Management	Zhu L. Health and clinical management. Synopsis. Chakravarty S, Shahar Y. Acquisition and analysis of repeating patterns in time-oriented clinical data. Dowding D. Examining the effects that manipulating information given in the change of shift report has on nurses' care planning ability. Horn W, Popow C, Unterasinger L. Support for fast comprehension of ICU data: visualization using metaphor graphics. Knaup P, Wiedemann T, Bachert A, Creutzig U, Haux R, Schilling F. Efficiency and safety of chemotherapy plans for children: CATIPO - a nationwide approach. Redelmeier DA, Shafir E, Aujla PS. The beguiling pursuit of more information.
Section 2: Patient Records	van der Lei J. The changing scenery of patient records. Synopsis. Aubert BA, Hamel G. Adoption of smart cards in the medical sector: the Canadian experience. Hasman A, de Bruijn LM, Arends JW. Evaluation of a method that supports pathology report coding. Kim MI, Johnson KB. Personal health records: evaluation of functionality and utility. Liu Y, Satomura Y. Building a controlled health vocabulary in Japanese.

coln de Assis Moura Jr. for IMIA-LAC. The IMIA representatives provide information on their own national societies. In addition,

the IMIA code of ethics for health informatics professionals which has just been adopted is presented.

Table 1 (Continued)

Section 3: Health Information Systems	de Assis Moura L, Jr. Health information systems. Synopsis. Beuscart-Zéphir MC, Anceaux F, Crinquette V, Renard JM. Integrating users' activity modeling in the design and assessment of hospital electronic patient records: the example of anesthesia. Jordan DA, McKeown KR, Concepcion KJ, Feiner SK, Hatzivassiloglou V. Generation and evaluation of intraoperative inferences for automated health care briefings on patient status after bypass surgery. Masys D, Baker D, Butros A, Cowles KE. Giving patients access to their medical records via the internet: the PCASSO experience. Winter AF, Ammenwerth E, Bott OJ, Brigl B, Buchauer A, Gräber S, Grant A, Häber A, Hasselbring W, Haux R, Heinrich A, Janssen H, Kock I, Penger OS, Prokosch HU, Terstappen A, Winter A. Strategic information management plans: the basis for systematic information management in hospitals.
Section 4: Signal Processing	Tilg B. Biomedical signal processing. Synopsis. Fan L, Evans DH, Naylor AR. Automated embolus identification using a rule-based expert system. Gharieb RR, Cichocki A. Segmentation and tracking of the electro-encephalogram signal using an adaptive recursive bandpass filter. Hu Y, Luk KD, Lu WW, Holmes A, Leong JC. Comparison of time-frequency distribution techniques for analysis of spinal somatosensory evoked potential. Sekihara K, Nagarajan SS, Poeppel D, Marantz A, Miyashita Y. Reconstructing spatio-temporal activities of neural sources using an MEG vector beamformer technique. Zhang XS, Roy RJ, Jensen EW. EEG complexity as a measure of depth of anesthesia for patients.
Section 5: Image Processing	Handels H. Medical Image Processing: New Perspectives in Computer Supported Diagnostics, Computer Aided Surgery and Medical Education and Training. Synopsis. Abbou CC, Hoznek A, Salomon L, Olsson LE, Lobontiu A, Saint F, Cicco A, Antiphon P, Chopin D. Laparoscopic radical prostatectomy with a remote controlled robot. Gering DT, Nabavi A, Kikinis R, Hata N, O'Donnell LJ, Grimson WE, Jolesz FA, Black PM, Wells WM 3rd. An integrated visualization system for surgical planning and guidance using image fusion and an open MR. Papademetris X, Sinusas AJ, Dione DP, Duncan JS. Estimation of 3D left ventricular deformation from echocardiography. Pommert A, Hohne KH, Pflesser B, Richter E, Riemer M, Schiemann T, Schubert R, Schumacher U, Tiede U. Creating a high-resolution spatial/symbolic model of the inner organs based on the Visible Human.
Section 6: Knowledge Processing and Decision Support	Knowledge-based systems: enhancing the quality of care. Synopsis. Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A computerized reminder system to increase the use of preventive care for hospitalized patients. McQuatt A, Sleeman D, Andrews PJ, Corruble V, Jones PA. Discussing anomalous situations using decision trees: a head injury case study. Peleg M, Boxwala AA, Bernstam E, Tu S, Greenes RA, Shortliffe EH. Sharable representation of clinical guidelines in GLIF: relationship to the Arden Syntax. Steiner SH, Cook RJ, Farewell VT. Risk-adjusted monitoring of binary surgical outcomes.
Section 7: Computer- supported Education	Daetwyler C. Computer-supported education. Synopsis. Bernard-Opitz V, Sriram N, Nakhoda-Sapuan S. Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. Luque Ruiz I, López Espinosa E, Cerruela García G, Gómez-Nieto MA. Design and development of computer-aided chemical systems: virtual labs for teaching chemical experiments in undergraduate and graduate courses. Maleck M, Fischer MR, Kammer B, Zeiler C, Mangel E, Schenk F, Pfeifer KJ. Do computers teach better? A media comparison study for case-based teaching in radiology. Plougmann S, Hejlesen OK, Cavan DA. DiasNet - a diabetes advisory system for communication and education via the internet.
Section 8: Bioinformatics	Tanaka H. Computational approach towards challenges in the post-genomic era. Synopsis. Becker MY, Rojas I. A graph layout algorithm for drawing metabolic pathways. Coppel RL. Bioinformatics and the malaria genome: facilitating access and exploitation of sequence information. Reis BY, Butte AS, Kohane IS. Extracting Knowledge from Dynamics in Gene Expression. Sreekumar KR, Aravind L, Koonin EV. Computational analysis of human disease-associated genes and their protein products. Yates A, Chan CCW, Collard RE, George AJT, Stark J. An approach to modelling in immunology.

Reviews

As customary, the 2003 Yearbook includes a number of original review articles, which focus primarily on this year's theme. An article by Arie Hasman, Charles Safran and Hiroshi Takeda on "Quality of health care: informatics foundations" reviews how decision support systems and reminder systems can contribute to the quality of care. "Leveraging IT to improve patient safety" by Marion Ball, David E. Garets and Thomas J. Handler discusses the urgent need to improve patient safety, and how technology (i.e. computer-based patient records and especially physician order entry) can be used for this task. The review of Giuseppe Riva as well as that of Grigore Burdea survey virtual reality approaches to support diagnosis, therapy and rehabilitation.

Education and Research in Medical Informatics

The Yearbook provides an opportunity to highlight an international selection of recent education, training, and research programs in Medical Informatics. In this 2003 edition, authors from Bethesda, Geneva, Osaka, Rotterdam and Thessaloniki summarize their educational and research approaches.

Challenges in Medical Informatics

In April 2002, an IMIA working conference on challenges in medical informatics in the 21st century took place in Madrid. Selected papers by Marc Musen, Jan van Bemmel, Jan Talmon, Arie Hasman, Casimir Kulikowski and Kwok Chan Lun, published as a result of this conference, are reprinted in this section.

Selected papers and synopses

The main part of the Yearbook 2003 consists, as usual, of selected high-quality original papers. This year, 40 papers from 25 international journals were selected from over 20,000 published peer-reviewed papers. After the selection process was complete, guest editors were asked to write synopses summarizing the papers in the different sections.

Medical Informatics and the Quality of Health in the IMIA Yearbook 2003

We now briefly review the contents of each section, focusing on connections to the special topic of the Yearbook 2003.

The synopsis of the special section on "Quality of Health Care: The Role of Informatics", which contains five papers, was written by Thomas Bürkle from the University of Münster (Germany). The section starts with a paper discussing how information technology can avoid or potentiate human errors. Then, three evaluation studies are presented, addressing distinct information technologies, evaluation questions and evaluation methods: a descriptive case study of a telemedical application in Bangladesh, a formative qualitative evaluation of a patient information system, and a quantitative evaluation of the effects of an order entry system on patient outcome. The section closes with a systematic review of evaluation studies of telemedicine, illustrating the as yet limited evidence for the effectiveness and efficiency of these applications.

The section on Health and Clinical Management was commented on by Zhu Ling of Golden Medicine Commodities Network, Beijing (China). Two papers focus on the analysis and visualization of clinical data, while two other papers discuss the effect of information on individual decision making. The fifth paper examines the design and outcome of a chemotherapy planning system and is thus directly related to the special topic of this Yearbook.

The synopsis for the section on Patient Records was written by Johan van der Lei of the University of Rotterdam (Netherlands). It contains 4 papers on rather different topics: on the adoption of smart cards in health care, on building a controlled vocabulary, on accuracy of report coding, and on evaluation of web-based personal health records, addressing the problem of data entry which is tied to those applications, and pointing to the importance of further developments in this promising area.

Lincoln de Assis Moura Jr. of Atech Foundation, Sao Paulo (Brazil), guest edited the section on Health Information Systems which contains four papers: strategic management of information systems as a precondition for high quality information processing, user involvement in the development of an electronic patient record, legal and security issues connected with patients access to their medical records, and design and evaluation of a system for detecting abnormal events. Three of these papers deal with preconditions for high quality information systems, underlining once again the fact that evaluation should start with the design of information systems.

Signal Processing, with five papers, guest edited by Bernhard Tilg from the University for Health Informatics and Technology Tyrol (UMIT, Austria), and Image Processing, including 5 papers, guest edited by Heinz Handels, University of Lübeck (Germany), both show recent trends in the development of methods and tools to support biomedical image and signal processing. The work of these fields, sometimes seen as unrelated to direct patient care, in fact provides important theoretical and practical contributions to diagnostics (e.g., automatic ECG or EEG analysis), therapy (e.g. robotics, surgery guidance systems), and education (e.g., visible human model). IT in those areas can thus directly contribute to the quality of patient care.

The section on Knowledge Processing and Decision Support, containing four papers, was edited by Yuval Shahar of Ben Gurion University, Beer Sheva (Israel). The papers tackle various facets of decision making: practical aspects such as the effects of a reminder system, the use of decision trees in the management of patients, and more theoretical issues such as the representation of clinical guidelines, and a method for monitoring surgical outcome. Decision-support systems seem to have already shown its positive effects on patient care.

Computer-supported education, with four papers, was edited by Christof Daetwyler from Darthmouth College Medical School (USA). Education can comprise education of clinical staff as well as education of patients. The selected papers address both of these areas: the effects of computer-based advice for patients with autism and diabetes, and the design and effects of computer-based learning systems in medical education. The use of such application systems to increase knowledge of both patients and health care professionals could be an important step in improving patient care. Unfortunately, up to now there are only been a few clinical evaluations of such systems.

Finally, the section on Bioinformatics was guest edited by Hiroshi Tanaka of Tokyo Medical and Dental University (Japan). This broad field is addressed by the five selected papers which deal with genome informatics and metabolic pathway analysis, and also with the promises of clinical application of bioinformatics.

Conclusion

This short description of the content of the 40 selected papers emphasizes how the IMIA Yearbook broadly represents medical informatics as a scientific discipline. Medical informatics deals with the patient- and health-related processing of data, of information, and of knowledge. It tackles not only technical, but also individual, organizational and social aspects of informatics. Achievements in all those areas can (directly or indirectly) contribute to the quality of health. Evaluation as an activity closely connected to all phases of the life-cycle of an information system component helps to improve information technology and to gather evidence of patient care support. The selected papers of the IMIA Yearbook 2003 present examples and future challenges for this topic.

Modern information processing methodology and information and communication technology have strongly influenced our societies and their health care. As a consequence of this change, medical informatics as a discipline has taken a leading role in the further development of health care. This involves developing information systems that enhance opportunities for global access to health services and medical knowledge. Informatics methodology and technology will facilitate continuous quality of care in aging societies, and will decrease the possibilities of health care errors.

It enables the dissemination of the latest medical and health information on the web to consumers and health care providers alike. Medical informatics can thus help "to create better health for every world citizen as a path to world peace", as Charles Safran has recently put it.

Outlook

The next IMIA Yearbook, 2004, will appear in March, 2004. The theme of the 2004 Yearbook will focus around the potential of bioinformatics, in conjunction with medical informatics, to contribute to novel diagnostic and therapeutic approaches in molecular medicine. The issue will concentrate on clinical implications of research, with the purpose of documenting accomplishments, and encouraging interdisciplinary approaches to the new field of clinical bioinformatics. Besides this special topic, the 2004 Yearbook will continue its broad coverage of all relevant topics in medical informatics. Up-to-date information about the current and future issues of the IMIA Yearbook is available at http://www.yearbook.uni-hd.de.

References

1. Kohn L, Corrigan J, Donaldson M, editors. To err is Human: Building a Safer Health System. Washington: National Academy Press; 2000.
2. Ball M, Douglas J, Lillis J. Health Informatics: Managing Information to Deliver Value. In: Patel V, Rogers R, Haux R, editors. Proceedings of the 10th World Congress on Medical Informatics (Medinfo 2001). Amsterdam: IOS Press; 2001. p. 305-8.
3. Haux R, Ammenwerth E, Herzog W, Knaup P. Health Care in the Information Society: A Prognosis for the Year 2013. Int J Med Inform 2003; 66:3-12.
4. Bates DW, Cohen M, Leape LL, Overhage JM, Shabot MM, Sheridan T. Reducing the frequency of errors in medicine using information technology. J Am Med Inform Assoc 2001; 8 (4): 299-308.
5. Rotman B, Sullivan A, McDonald T, Brown B, DeSmedt P, Goodnature D, et al. A Randomized Controlled Trial of a Computer-based Physician Workstation in an Outpatient Setting: Implementation Barriers to Outcome Evaluation. J Am Med Inform Assoc 1996; 3 (5): 340-8.
6. Fessler J, Grémy F. Ethical problems in health information systems. Methods Inf Med 2001; 40: 359-61.
7. van Bemmel J, McCray A. Yearbook of Medical Informatics (annual edition). Stuttgart: Schattauer; 1992-2000.
8. Haux R, Kulikowski C. Yearbook of Medical Informatics (annual edition). Stuttgart: Schattauer; since 2001.

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