Evolution of Trends in European Medical Informatics

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Review

ABSTRACT

This presentation attempts to analyze the trends in Medical Informatics along half a century, in the European socio-political and technological development context. Based on the major characteristics which seem dominant in some periods, a staging is proposed, with a description of each period – the context, major ideas, views and events. A summary of major features of each period is also added. This paper has an original presentation of the evolution of major trends in medical informatics.

Key words: medical/health informatics, e-health, trends, history, socio-political context, EFMI, EC.

1. INTRODUCTION

A comprehensive presentation of history of medical informatics requires a systematic and multiaxial approach, to provide not only a list of events, journals, organizations or people, but also to analyze the characteristics of each epoch, to reveal the trends and to recall both successes and failures. The evolution of ideas and trends in medical informatics had some specific features which deserve a special attention. By offering such a dynamic view, the “history” becomes a tool (1) for a realistic estimation of the impact of medical informatics on various domains - healthcare, computer science, industry and education. Such an approach was used in the Foreword to MEDINFO 86 of the Scientific Program Committee (2), analyzing the trends for a short period of time (3 years), within six major directions.

2. MATERIAL AND METHODS

One of the best ways to analyze the evolution of trends/ideas/concepts in any domain is to search the literature, starting with its early attempts to present the achievements in the specific field. This was also our approach, having an immense number of references: all congresses of medical informatics organized by EFMI (European Federation for Medical Informatics (3), or by IMIA (International Medical Informatics Association (4), as well as the contents of most representative journals (5-9) or book series dedicated to this field: Lecture Notes in Medical Informatics (10) for period 1978-1991, followed by Studies in Health Technology and Informatics (SHTI) (11). Nevertheless, some important books (mainly referring the early stages) were also considered. Even the number of materials consulted was large; the references listed here were limited to most relevant ones.

Another important source of information came from the European Commission (12). Several volumes in series (11) refer to projects carried out within successive research frames financed by EC (13-16). As this article

aims mainly to analyze the evolution of the trends in Medical Informatics in Europe and the author has been involved in the evaluation process or monitoring of several European projects since 2002, a balanced view was the target of the presentation, to match both the vision of EFMI (the author was EFMI's President 2006-2008, member of the Board 2001-2010, member of EFMI Council since 1994) and of EC. The topics of contents of conferences or congresses have been analyzed in several ways: counting the number of articles and pages for each topic/subject (most often a chapter was dedicated to a key-word from a list proposed by the Scientific Program Committee of the conference), tracing the presence of topics through the successive conferences, finding the growing or fading interest in various subjects. Links between various topics were also considered.

Another source about the evolution of trends in biomedical/health informatics was to analyze the very content of the courses presented to the students, either medical students/computer science students or future Healthcare Informatics Professionals (HIPs); all teachers tried to be “up-to-date” to the most important topics of interest of the domain at the particular moment (17-21). We could find here, not only some clear milestones for defining the most representative stages of development of ideas in Medical Informatics, but also some views about potential future development of the domain. A comprehensive view from educational point of view is included in the article of Arie Hasman et al. published in Acta Informatica Medica journal (22).

The present paper intends to systematize the enormous amount of information analyzed. This attempt is not the first one and we can cite here several books and articles on “history of medical informatics” (23-26), seen from various perspectives: technological development, educational needs, research objectives etc. Our attempt is to integrate all those views and extract from them the defining lines of trends, tracing the evolution of major

topics and concepts of medical informatics within its complex environment, with moving targets, rapid technological advent and provocative societal challenges, by trying to identify the most common topics which raised the interest of the scientific community in (European) medical informatics over almost half a century.

The presentation was organized following the classical chronological way for a “historical” approach. From the point of view of evolution of trends, we can distinguish five major stages in the development of medical informatics, which will be presented here.

3. MAJOR STAGES OF MEDICAL INFORMATICS HISTORY

3.1. Early (pre-organizational/pioneering) stage: 1950 - 1975

It might be surprising, but a lot of ideas about future developments have their roots in this period. Visionary scientists have realized the enormous potential behind the “new emerging information technology”. Important technological steps took place, with fast transition through first three computer generations; some authors do even split this phase into five distinctive periods (24). Most related work from this stage had a visible pioneering mark but becoming good introduction for the future work in the specific field, under the generic title “computer applications in ...” (27). A major characteristics of this stage we can note the absence of coherent research plans, the work was performed mainly in isolated groups, not raising yet the interest of healthcare managers. Worth to mention that, the development of software in parallel with hardware drew the attention upon “information processing” as a key issue and IFIP (International Federation for Information Processing, established in 1960 (28) under the auspices of UNESCO), initiated technical committees for various domains, including medical domain (TC4 since 1974). Even it is difficult to distinguish important revolutionary achievements for the medical domain, this period was quite prolific in ideas, opening the doors for significant future work.

To summarize the major characteristics of this period:

- Pioneering work of scientists who envisioned various applications of IT in medicine and healthcare (M&HC);
- Analog computers still considered
- Major work on: signal analysis, laboratory applications
- First attempts on decision support (diagnosis)
- Databases, modeling and simulation of some biological processes

3.2. Medical Informatics - “childhood/youth”: 1975 - 1990

The work done in the preceding two decades traced the contour of the emerging domain, most often called “medical informatics” or “health informatics”. It became clearer and clearer that several medical activities will

use computer applications in the future; hence a certain preparation of present and future medical staff about computer use became obvious. Thus, the applications in major areas of medical informatics were systematized and first educational programs in medical informatics began (17), including advanced programs for healthcare information professionals. A detailed description about the evolution of medical informatics education is presented by Arie Hasman et al. (22).

This is also the period when first national and international professional organizations (associations, societies) were established and specialized conferences started to take place. The object of medical informatics is still mostly perceived as dealing with computer applications in various medical fields. They referred not only clinical applications but also healthcare management, which raised the interest at higher level of healthcare institutions and also the interest of industry – the roots of “e-health as a business”. IT offices/compartments in health ministries or health insurance houses have been created in some countries, elaborating strategies for local, regional or even national healthcare information networks (29), but the progress in this line was still limited to a couple of successful networks by the end of this stage (30).

However, the awareness about the potential of these applications to address major challenges of healthcare, accumulated along this period, led to inclusion of ehealth/medical informatics topics in the research programs of the European Commission at end of this period. Several projects were financed by the EC under the first research frames, led at the beginning by Niels Rossing; for our domain it was the AIM (Advanced Informatics in Medicine) Exploratory Plan (31). An important program of WHO, launched at the beginning of seventies, made also reference to the use of IT for reaching their goals (32).

Most important expectations were from the applications in healthcare system; besides the local health information systems to cover certain regions (counties) mentioned above, a visible interest was paid to the development of clinical/departmental and hospital information systems (33), dragging in also the issue of medical data protection, security and confidentiality (34). The term EHR (Electronic Health/Medical Record) has been introduced also in this period.

For research, the highest attraction was held by artificial intelligence methods (29, 35). The work on clinical decision support started to occupy an important place, including the development of medical expert systems, natural language processing, the work on medical terminology and ontologies, specialized high level software etc (36). Actually, research topics and developments showed a marked diversification: mathematical modeling and computer simulation of biological processes (37), advanced techniques for medical imaging (CT, MRI), biological signal processing and medical data analysis etc. Involvement of industry for the development of specialized equipment became evident, moving some of this work from medical informatics groups to

wards related fields of bioengineering. Actually, the parallel development of medical informatics and bioengineering is a good example of a successful cross-fertilization (38).

A point which has to be mentioned is that Europe was split by an “iron curtain” into West and East, with completely different views, mentalities, laws, etc by common heritage and goals (even not always recognized by the leaders). Communication between the two sides was difficult, facing obstacles which might seem today ridiculous! We should emphasize here that, despite all these obstacles, some people tried to maintain the feeble existing link. And, even this article aimed mainly to trace the trends and not the people, the names of Jana Zvarova and Jan H van Bommel should be mentioned for their efforts to offer the chance of two different worlds to meet (36, 39).

To summarize the major characteristics of this period:

- Founding most national and international organizations, conferences
- Attempts to systematize major areas of medical informatics
- First specialized schools and courses
- Development of methodologies, EHR
- Principles of Clinical and Hospital Information Systems
- Security and medical data protection
- Advanced decision support systems – expert systems

3.3. Consolidation period ~1990--2000

The accumulation of knowledge and experience from the previous phase led to an important, maybe the most important conceptual step in the development of medical informatics: it became quite clear that “computer” as a key word in definition of medical informatics should be replaced by “medical information”; computers proved to be just convenient tools for information processing. Coiera made a nice comparison for this: “Medical informatics is about computers as much as cardiology is about stethoscopes” (40). This conceptual shift had a milestoning impact on defining future trends in medical informatics and this is why we proposed the term “consolidation stage” for this period. The new view was best perceived in medical informatics research and education, but it was less felt by the real/practical environment - the major beneficiary - the healthcare system itself. This difference of perception deserves a deeper insight; we will limit ourselves here to just notice it; some of its consequences will be included in the “Discussions” paragraph.

This stage was rich in outstanding achievements: new attractive infrastructure advance – accessibility of computers, extensive use of PC’s, performant communications and start of internet applications, all together generating a new chapter - telemedicine (41), (the new term “telematics” was coined to reflect the strong synergy between telecommunication and informatics (42, 43).

Basic medical informatics courses have been gener-

alized in most medical schools and several specialized medical/health informatics schools have been created, either at undergraduate or (most often) at master level (22). Doctoral level in medical informatics was also introduced in several European countries.

Technological development of IT&C (Information Technology and Communication), with its penetration into all domains, had an impact on its perception by politicians. Several countries extended the name of their ministries of communication with “information (technology)”. Potential medical applications in public health and in the “ever-lasting healthcare reform” (specific to most countries during last decades), determined the creation or development of IT/ITC compartments in health ministries, to elaborate or develop national/regional strategies for implementation of IT in healthcare/medical activities; quite often, health insurance houses were also dragged into this carousel. Even the results of national strategies for this specific stage were - sometimes - below expectations, the interest in the field of governmental institutions became an important fact to be considered for future developments.

Another fact to be considered, specific for Europe at the beginning of this decade, was the collapse of communist regime in East European countries. Almost all new governments tried to make ties with Western countries, developed various co-operation programs, exchanged specialists, launched projects etc – it was an unprecedentedly concert of actions and voices. Some previous collaboration extended (44). National societies/associations of medical informatics have been established in most East European countries, becoming also members of EFMI. But, while political divide broke, economic divide still persisted. In order to facilitate the participation of East European scientists in European conferences, several ways to support them have been found: bursaries offered by National Library of Medicine for attending MEDINFO 92 in Geneva, a support action covered by EC for attending MIE 96 in Copenhagen (Peter McNair), bursaries from British Computer Society for attending Harrogate Conferences in 1996-1997 (Bernard Richards), fee waivers and bursaries for MIE 2000 in Hannover (Rolf Engelbrecht) etc. (45-48). This wave of sympathy brought an enthusiastic atmosphere and engagement in EFMI activities.

An important role was also played by the “e-health unit” of DG “Information Society” (they had various names) which became a major financing source for European research in medical informatics within frame programs 3 to 5. The calls for projects were carefully prepared, including endeavoring topics, including also fundamental research, often left aside due to the long duration of “return of investment”. The merit of Jean-Claude Healy shall be underlined, who continued his mission even after moving to WHO (49). Several success stories from European projects have been reported (50).

The large palette of applications, with some visible achievements with high potential of extension had also a strong impact on industry; e-health market showed a marked increase.

To summarize the major characteristics of this period:

- Medical Informatics (M.I.) consolidates its position as independent (stand-alone) discipline, with own object and methods
- Departments of M./H.I. in health units (incl. ministries)
- Interest at high level, launching of national/regional strategies for implementation of IT in healthcare
- Hospital Information Systems (HIS) in several hospitals, still mainly for management
- Start substantial funding for e-health research (e.g. Eur. C.)
- More visible importance and complexity of EHR, including confidentiality, data protection, standards etc.
- Development of M.I. education (mandatory discipline in most medical schools)
- Contour of new job: HIP – Health Information Professional
- New chapters: internet applications, telemedicine, virtual reality etc.
- Notable progress in classical topics – data bases and case mix, medical imaging, knowledge processing and ontologies etc.

3.4. Maturity of Medical Informatics - 2000 - 2010

The new millennium started in the enthusiastic atmosphere generated by several good achievements, handy technology, some well defined directions for medical informatics research and almost boundless trust in the potential of medical informatics/e-health to address major challenges of healthcare system. However, even a superficial survey over the work done last decades could show a discrepancy between expectations and reality. Reports showed that a high percentage of projects about implementation of information systems failed, others had deviations, either not reaching the parameters or having delays or exceeding the budget (51). Several studies tried to analyze this in detail, revealing potential factors which could contribute to these modest results (besides mismanagement or incompetence): low user acceptance, lack of interoperability, too rapid technological changes, low political support, lack of coordination between teams etc. The importance of quality assessment became evident; actually such studies have been performed even before, but their relevance has not been properly perceived until now (52).

Even successful projects had a lower impact than expected, being used after the end of the projects mainly by the participants in the consortia. Hence, the calls raised the requirements for well prepared exploitation and dissemination plans (15, 16). Moreover, the enlargement of European Union, with several new members, imposed actions to engage also the political factors. Thus, starting with 2002, EC organized annually the “E-Health High Level Conferences” (12), where delegations from ministries of health of member states were invited. These conferences usually adopted “Declarations”, underlining the engagement of official institu-

tions to support all actions directed to better dissemination and implementation of the results from European projects. Moreover, there were recommendations to attract universities or SMEs from the new member states in the research consortia.

Scientific community realized that the challenges for healthcare systems, including the type of problems around implementation of healthcare information systems, were not specific for Europe, but were general, like many other issues. That is why several actions to extend cooperation beyond Europe took place (53), with a couple of summits EC-USA by the end of the period. An important event of the period was the establishment in 2000 of ERA (European Research Area), which became a reference point for various research programs throughout Europe, including the well-known (first - 2004) “eHealth Action Plan” (54). Several actions have been done also within EFMI frame, leading to some successful common projects (55).

The increase of activities connected to e-health generated also an increase of scientific events (conferences, seminars, exhibitions) of medical informatics. EFMI, which used to organize their quasi-annual MIE conferences (Medical Informatics Europe – in each year when there were no MEDINFO's organized by IMIA), added another annual conference – Special Topic Conference, starting with the STC in 2001 in Bucharest (3).

Concerning the research topics, this stage maintained and developed all major topics from previous periods, emphasizing two aspects: interoperability and integration. Fundamental research was strongly stimulated in the 6th and 7th Frame Programs of EC. Virtual Physiological Human became an important platform (56), offering an excellent tool for vertical integration of biomedical information, for linking the molecular level (genomic data from bioinformatics, including development of nanotechnologies for data acquisition, like lab-on-chip), to cell and organ level (using modeling and simulation tools as well as visualization procedures), up to whole body, or even to public health (57). Most projects included also the horizontal integration – the availability of data from primary care to ambulatory specialized care or hospital.

Assessment of quality of information systems was also a topic of interest; as it is often associated with standards and certification procedures, such work took place within a couple of European projects, referring mainly to certification of EHR (58).

The high mobility of persons also required an improvement of health information exchange, yielding a new chapter - “travel medical informatics” (59, 60).

From a technological point of view one should mention the development of thematic networks (61), use of grid technology (62). It was also the period of general use of internet, and beginning of m-health (mobile phone use) (63) and p-health (use of personal portable devices for health data acquisition) (64).

To summarize the major characteristics of this period:

- Clearer understanding of e-health potential to ad-

dress major challenges of present healthcare;

- Involvement of politicians, extension of regional/national projects;
- E-health as business, emergence of specialized industry (e.g. HIMSS);
- All big IT companies started to pay interest to M&HI applications;
- Patient-centered M.I. - development of EHR/EMR;
- New keywords: integration, interoperability, consumer informatics;
- More visible hidden gaps – difficulties in real implementation of Health Information Systems - several “failures” reported; analysis of “barriers”, modest rate of user acceptance, quality assessment of HIS
- Need of larger scale education & training programs (AMIA 10x10);
- Clear contour of sub disciplines: bioinformatics, neuroinformatics, VPH etc.

3.5. Full integration of Medical informatics in medicine and healthcare - 2010 - 2020

The last period in our staging is the present one, hence we will not insist in a detailed description and we will limit the presentation to emphasizing the new characteristic features.

Maybe the most relevant result of the fretful end of the previous decade was the ascertainment of the strong inter-relation between all factors related to health – life style, environment, culture, social and political factors etc and future e-health projects should integrate these features. This is visible in both “eHealth Governance Initiative (ehgi)” (65) “second eHealth Action Plan (eHAP)” (66). The directions to empowering the patient, well aging, personalized care, interoperability and integration are still in a developing trend.

At national level, most countries would need to re-think and revise their e-health strategies, according to the new trends and requirements, to adopt the developed standards and introduce certification procedures for use of all ITC applications in healthcare.

A new keyword is more and more used in all IT applications - ‘big data’, referring to the huge amount of data collected every day in healthcare (especially from genomic data, but not only from there), which need, of course, appropriate tools for handling and processing (WI4). A suitable infrastructure was developed – cloud computing, which will have a strong impact on various ITC applications in healthcare, including the national healthcare plans and strategies (68).

The trend towards personalized healthcare will probably push forward fundamental research. Author’s view is that any piece of biological/medical information has a “life” made of two parts: an “internal” life, expressed as molecular structure, transmitted as “cellular signaling”, becoming biosignals detectable by laboratory or visualization procedures, thus starting its “external” life, when it is processed and interpreted by physicians; the pattern of all pieces of information represent the health state of an individual. For the present period we are still able to collect just fragments of information, which,

most often can be integrated with sufficient accuracy for medical practice. We expect that theoretical development of models will be developed and complex simulations will be built, able to integrate all kind of individual data, from genomic and cellular to physiomic data at tissue and organ level, for building the “digital patient” (also called “e-patient” in (57). Such individual “virtual clones” will be the basic tools for the future of predictive and preventive medicine.

To summarize the major characteristics of this period:

- Big Data approach;
- Cloud computing;
- Social networks on health;
- Restructuring national e-health strategies:
 - Involvement of politicians, improvement of legislation;
 - Certification of EHR and ITC applications in healthcare;
 - Wide adoption of standards;
- Decreasing gaps, increase user acceptance;
- Certification of educational programs in medical informatics;
- Generalization of EHR / EMR, inclusion in Health Information Systems:
 - Integration of molecular & genetic data;
 - Full interoperability - communication, devices, semantic interoperability;
- Patient empowerment, involvement through PMR (Personal Medical Record);
- Visible steps towards “personalized medicine”, with:
 - Increase patient safety, reduction of medical accidents and errors;
 - Increase preventive medicine, reduction of curative medicine;
 - Use of portable/wearable devices for monitoring, prediction & prevention;
 - Deployment of home monitoring systems and tele-assistance;
- Attention moves towards:
 - Deeper penetration of IT tools in medical research (modeling & simulation, digital patient etc);
 - Advanced decision support systems.

4. DISCUSSION

Writing about the history of a domain or idea is a complex work, requiring a sound documentation through an immense volume of literature and other documents and will always be biased by the personal perception, experience and background of the author. The history of medical informatics has already been approached in various angles, as mentioned above. The view here comes from author’s background in biophysics and informatics, his experience as an expert of EC, as an EFMI Council member and as a professor to both students in medicine and in computer science, including an experience as a director of a governmental institution.

The intent in this paper was to reveal the topics which raised the highest interest along half a century and link

these trends with the specific socio-political and technological context. There are several remarks which should be mentioned here, some of them were discussed during the panel in Prague, and others were added after reading so much literature.

a) The staging proposed by the author has no precise limits. The roots of most characteristic ideas can almost always be found in the preceding period; I have included them in the stage where they proved to arouse a large interest. There are visible developments of some trends even within a stage, making possible to split them into sub-periods.

b) There are some topics which have not been mentioned separately, like nursing informatics, computerics, emergency e-health, e-prescription etc, or just mentioned without any comment, like patient safety, ontologies, personal medical record, health-on-the-net etc.

c) A better understanding of a certain event or feature is gained when one also mentions or describes the context in which it is presented. The inter-relations between context and events are strong and offer the best mean to foresee the future developments.

Finally, some comments about the references. The key words for articles and, especially the subject index in books are supposed to be not only helpful, but almost essential for such a historical undertaking. Unfortunately, even there are clear standards in this direction (Medical Subject Headings MeSH (69), they are not always observed, making "improvements": sometimes the granularity is either too low, but most often too high, making them useless. The common search engines make no distinction between normal text and key words. Moreover, most of the times, the classification is uniaxial. Or, in multidisciplinary domains, like medical informatics, one would prefer to classify an item (article, chapter, book etc) from various points of views: technological, methodology, domain of application etc.

Concerning the references, for papers which are supposed to use a large number of references of various kinds, a classification seems welcome, hence we tried to use here separate lists for articles, books, journals and websites.

Another shortcoming is the limited life of some web addresses. It would be useful to have "archives" managed by the entities (institutions, societies etc) which organized the events, where to store all the documents connected to them. An attempt to collect such documents is a part of the "IMIA History Project", led by Casimir Kulikowski, which has set up a web page (70) and organized an attractive Workshop at MEDINFO 2013 (71).

5. CONCLUSION

An analysis of the evolution of trends in medical informatics is useful not only to mark the major achievements of a specific period, but also to foresee the future developments and to help in designing the strategies. The involvement of high level institutions reflects the importance paid to the field of e-health, which is one of the most active domains, both scientific and industrial.

The potential of the field to address the major challenges of healthcare systems gives medical informatics the role of an engine of future developments in healthcare. The expectations from medical informatics are very high. But, as underlined in this article, good results can only be obtained within a concerted action, to consider the real context, taking into account all stakeholders in the process.

At the end of the paper I will cite a phrase from the keynote speech of Jean-Claude Healy at MIE 2005 (72): "Medicine will change in the next twenty years more than it has changed in the last two hundred years!" and e-health will bring an important contribution to this change.

CONFLICT OF INTEREST: NONE DECLARED.

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