

# History of Medical Informatics in Croatia

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**SUMMARY.** Medical informatics (MI) in Croatia started to develop in late sixties of the past century, not much later of the period, when the roots of this discipline were planted all over the world by various working groups and associations engaged in research and development of computer applications in medicine and health care. First MI projects in Croatia were dealing with data processing for not health insured persons, health statistics in the field of outpatient healthcare and occupational health, and the computerization of the Croatian registry of cancer. A little bit earlier Croatia started with education of MI subjects for postgraduate medical students. The development of MI in Croatia to the end of 20th century is presented. At the beginning of the 21st century Croatia initiated the integrated health information system, starting with family medicine as the leading part of the primary health care. Hospitals have not been included in this system yet, developing their information systems by their own resources. Most of applications include MI standards like HL7 and those of ISO and CEN. A four decades long tradition of MI education is described, starting in the beginning of seventies of the past century both at the undergraduate and graduate levels. The postgraduate education of MI specialists, organized in the eighties, is at present suspended, but partially available in the form of several MI courses in other postgraduate and doctoral university programs. The first organization of medical informaticians in Croatia was established 1983 in the form of a Section for MI at the Croatian Medical Association, and in 1989 the independent Croatian Society for MI (CSMI) was formed. CSMI is an association of people involved in MI activities, like disseminating information in the field of MI in the country, promoting high standards in MI ap-

plications, and engaged in research, education and international cooperation in MI. CSMI especially organizes MI conferences and meetings, promotes MI education and its popularization, encourages MI standardization, and struggles for medical informatics dignity and dignity of people involved in medical informatics.

**Keywords:** medical informatics, history, Croatia

## 1. BEGINNINGS OF MEDICAL INFORMATICS IN CROATIA

In the middle of sixties of the past century the quantity of data and information in the Croatian healthcare system reached such a high level, that introduction of sophisticated information and communication technologies (ICT) was widely demanded. From those, most benefits were expected, as elsewhere, by the use of computers, the efficient machines for information processing (IP, in the early days also frequently called automated data processing - ADP). This was just a period of forming various working groups and associations engaged in research and development of computer applications in medicine and health care all over the world, planting the roots of the new emerging field – medical informatics. Consequently, when discussing the beginnings of medical informatics (MI) in Croatia, we have to refer to the first applications of computers in Croatian healthcare. As new technologies and scientific fields can be implemented only by corresponding education, so first teaching on medi-

cal computing at Croatian universities should also be included into the review of the beginnings of MI in Croatia.

Among the first MI projects in Croatia there was the use of IP in the healthcare of the City of Zagreb on processing data of people not having health insurance (1), the processing of health-statistical data in the field of outpatient healthcare and occupational health in the Medical Center Varaždin (2), initiated in 1968, and the computerization of the Croatian register of cancer (3), initiated 1967, in collaboration with international institutions, and continued at home in 1969.

The teaching of MI subjects in Croatia started in 1966 at the School of Medicine, University of Zagreb, organized by the Andrija Stampar School of Public Health for postgraduate students (4). This was, in fact, the first teaching of MI in former Yugoslavia (as Croatia was at that time one of the six republics of this former state). It was extended to all medical students, both undergraduate and postgraduate, when in 1970 the School of Medicine in Zagreb introduced compulsory appreciation courses in MI (4), in order to prepare future physicians and medical specialists for their work with new ICT technologies.

## 2. DEVELOPMENT OF MEDICAL INFORMATICS IN CROATIA

After these first MI projects in Croatian healthcare system, it is im-



**Figure 1.** Panelists on MI Education at the EFMI MI Berlin 1979 Congress

portant to note that further development was supported by the Croatian Secretariat (ministry) of National Health and Social Welfare, helping appearance and development of other MI projects in Croatia. A big support for the development of such projects was the establishment of two computing centers with remarkable computing installations: the Electronic Computing Center of the City of Zagreb (ECCZ, 1970) and the University Computing Center in Zagreb (1971). The ECCZ started from its very beginning to support healthcare projects of the City of Zagreb, as the Croatian metropolis has a number of important health institutions. The University Computing Centre, with its computer terminal network at all Croatian university centers (Osijek, Rijeka, Split, Zagreb), allowed medical students at other Croatian universities, but also other health professionals in Croatia, to use computers for education and research.

In a review written in the early seventies of the past century (5) it is noted that the ECCZ started an early project of IP for outpatient (primary care) institutions, a rare undertaking in these times when most projects were developed for hospitals. This project was started in the Health Centre Remetinec (City of Zagreb) as a model for other outpatient institutions. A more recent review (6) lists a number of such early projects: a model for IP of hospital-

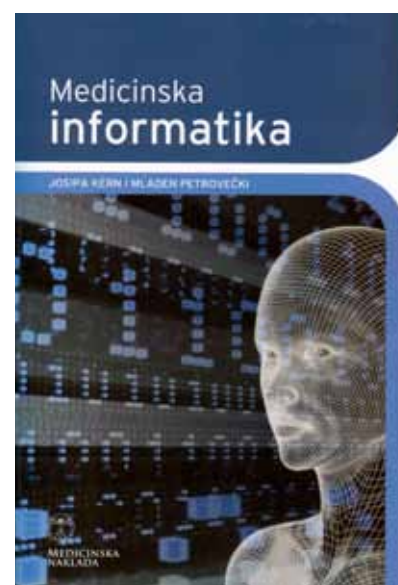
ized patients in the Holy Spirit General Hospital in Zagreb; chronic disease registers created for cancer, psychosis, and alcoholism along with hospital registers and trial registries for patients suffering from tuberculosis and diabetes; periodic health statistic reports covering morbidity, mortality and health service.

In particular clinical disciplines in Croatia, there were significant attempts to follow the dynamic development of MI in clinical applications, both in diagnostics and therapy. In several hospitals computers were early applied for the calculation of radiation doses, applications in nuclear medicine, electroencephalography and computed tomography (the first CT installation in Croatia was installed 1975 in Zagreb), and tissue typisation (as a prerequisite for the development of transplantation medicine). In many hospital departments applications were developed for medical documentation processing in psychiatry, diabetology, otorhinolaryngology, maxillofacial surgery, gynecology and other clinical disciplines.

The development of health information systems in several countries in the mid-sixties of past century induced also such projects in Croatia at the beginning of seventies. The "Integrated Health Information System" project for the healthcare system of the city of Zagreb (7) was the first systematic approach to comprehensive application of ICT. In the

late eighties a similar approach was adopted in the development of the County of Istria information system for primary health care (8, 9).

In the nineties of past century new projects in the field of health information systems appeared, based on new ICT technologies – local computer networks, personal computers and internet. Several applications were developed, serving needs of special health facilities, like general practitioners offices (Zadar, 1995) and institutions for the prevention and rehabilitation of diseases (Polyclinic for Prevention of Cardiovascular Diseases and Rehabilitation in Zagreb). In the field of image and signal processing, as well as computer assisted modeling, several research groups developed applications in orthopedics (10), electroencephalography, dental medicine and other fields. First projects in telemedicine were introduced, starting with telepathology (11), allergology (12), tele-radiology (13). They were reviewed (14) and followed in late nineties by a telemedicine project in isolated areas, with a number of Adriatic Sea islands chosen as test sites for first trials (beginning in 1998) (15).



**Figure 2.** New textbook/manual „Medical Informatics“ (in Croatian), Medicinska naklada, Zagreb 2009

The first decade of the 21<sup>st</sup> century brought a new impetus in the field of health information systems. After decades of attempts to build systems of higher level of integration, the Cro-

atian Ministry of Health decided to develop an integrated national health information system in Croatia. The key drivers behind this decision were previous experience with MI applications and a growing understanding of the importance of health/medical information for making appropriate decisions in healthcare. This system has to be centralized (due to the rather small country's population of less than 5 million people) and should cover whole primary health care (the "gate keeper" in the Croatian healthcare system), as well as hospitals (the main generator of expenses in healthcare). Security and standardization are important requirements for the system. Up to now the primary healthcare part of the project could be implemented (16, 17), but the hospital part is still waiting for broader progress, although pilot projects were implemented in several Croatian hospitals (Holy Spirit General Hospital and Clinical Hospital Dubrava in Zagreb, Clinical Hospital Center in Rijeka, Clinical Hospital in Split) (18). Some interesting new approaches, based on web technology, have been recently reported for the General Hospital in Varaždin (19). The rapid development of MI applications in clinical disciplines found its reflections also in Croatian hospitals and outpatient clinics, introducing new ICT which is now widely used both in clinical practice and research.

In the last decade much attention was paid to the already mentioned standardization in MI, especially provoked by the lack of interoperability among different systems intended to be linked into integrated (networked) health information systems. Consequently, following the international development in this field, a national Technical Committee for Medical Informatics (TO 215), working in scope of the Croatian Standards Institute, was established at the beginning of 2001, collaborating with international technical committees for MI (ISO TC215, CEN TC2513). Somewhat later, in the autumn 2001, the establishment of a second organization responsible for standards was initiated, the HL7 Croatia Affiliate (HL7 - Health

Level Seven, a MI communication standard). HL7 Croatia is active since autumn 2002 as an international affiliate in the affiliate network of 32 members established all over the world (20, 21).

In a Croatian editorial published several years ago (6) it is stated that the Croatian health system appears to be ready for informatization, requiring present and future health care providers with appropriate medical informatics education, having proper computer equipment at their workplaces and an opportunity to participate in the development and/or improvement of the health information system. As one of the EU health strategy priorities is the improvement of health information and knowledge, it means that integrated health information systems are required, i.e. systems able to provide key information on health and the healthcare system to the politicians, health professionals and public in general. The whole history of MI development in Croatia tells us that one can expect successful further development and a full use of the Croatian integrated national health information system.

### 3. MEDICAL INFORMATICS EDUCATION IN CROATIA

After the introduction of first MI compulsory courses at the School of Medicine in Zagreb in 1970, other medical schools in Croatia followed this trend. The Medical School of the University in Rijeka introduced such education in 1977. As the medical schools in Osijek and Split were in the beginning linked to the School of Medicine in Zagreb, so the first MI education in Split (the medical study was opened in 1974) started in 1976, and in Osijek (the medical study was opened in 1979) in 1981. In Croatian nursing schools MI education was also introduced in early eighties of the past century. The Zagreb University School of Dentistry introduced MI as an elective course in 2005, but the postgraduate MI education at this school started much more earlier (in the middle of eighties). As noted earlier, all medical postgraduate studies had MI courses in their curricula. Consequently, medical and

health professionals in Croatia obtained MI education in the form of appreciation courses for almost three decades and were well prepared for the future challenges of the Croatian computerized healthcare. The early beginning of MI education at Croatian medical schools aroused attention elsewhere, including its spreading to other parts of former Yugoslavia and discussions on its first experiences, problems and prospects at international conferences (4, 22).

After more than one decade of broad MI education at the appreciation level, and with several successful research and development projects, trained MI specialists were needed. Following these demands, the School of Medicine, together with the School of Electrical Engineering and the School of Science, all of the University of Zagreb, started a program of postgraduate education in MI in 1984. The program was called "Health Information Systems". More than 120 students enrolled and about 30% finished the program by a M.S. thesis. Most of the students were physicians, but there were also pharmacists, mathematicians, economists, librarian and engineers working in healthcare.

At present the specialized postgraduate program in MI at the University of Zagreb is suspended. However, there are several MI courses in other postgraduate and doctoral programs. These include: Methods in MI, Knowledge discovery in medical domains, Statistical analysis of free text, Health information system management, Simulation modeling, Public health information systems, Bio-signal processing, and Medical image processing.

All medical schools, schools of dental medicine and schools of nursing in Croatia have chairs of MI, some linked with medical statistics, led by professors of MI. Several young people are engaged in teaching and research, ensuring good prospects for future development of MI at the universities and professional schools.

At the beginning teaching materials for MI were in the form of handouts with lectures and tests in written form. The first Croatian textbook



intended for MI teaching was published in 1976, entitled "Fundamentals of Informatics" (23). The next edition was enlarged and changed the title to "Health Informatics" (editions in 1986, 1987 and 1989). In 1997 a new textbook was published under the title "Medical Informatics" (24). A big innovation in Croatian MI publishing, both for educational and scientific/professional purposes, is the recent new book entitled again "Medical Informatics", but this time a work of 42 Croatian authors – university teachers (8 professors, 1 lecturer and 6 assistants from all four Croatian medical schools, 2 professors from other university institutions), scientists and professionals from health institutions and firms engaged in MI projects (25). It is officially recognized as a university textbook in all medical schools in Croatia, but has also characteristics of a MI manual, suitable for other medical practitioners and health professionals interested in MI.

#### 4. CROATIAN SOCIETY FOR MEDICAL INFORMATICS AND INTERNATIONAL COLLABORATION OF CROATIAN MEDICAL INFORMATICIANS

First initiative to form a MI society in Croatia was launched after the MIE 1978 Congress of EFMI in Cambridge, where Croatian participants were present as a group for the first time. This was also the opportunity to establish links to international organizations EFMI and IMIA. At a conference in Zagreb in 1979, named "Social System of Informing in Yugoslavia'79" the necessity to establish a professional organization of medical informaticians was recognized. An initiative board has been formed, proposing formation of a federation of MI societies in all Yugoslav republics (26). But it was too early for most of the other parts of former Yugoslavia for this, even for Croatia where most of MI professionals were active.

A first organization of medical informaticians in Croatia was established 1983 in the form of a Section for MI at the Croatian Medical Association. The members could be professionals of various profiles, phy-

sicians as well as other people with academic education. From the very beginning it was planned, when the circumstances will allow establishing of an independent MI society which could facilitate membership to EFMI and IMIA.

As Zagreb developed during forthcoming years

to the strongest MI center in former Yugoslavia, a series of "Conferences on Informatics in Healthcare" started there, attracting medical informaticians from the whole country and helping in preparations to establish MI societies and their federation which could become member of EFMI and IMIA (27). After more than one year of preparations, the Croatian Society for Medical Informatics (CSMI) was founded on February 16, 1989 (28). It is worth to note that shortly after the foundation of CSMI a successful Alps-Adria conference has been organized in May 1989 in Zagreb, with participants from Austria, Croatia, Germany and Italy.

At the end of 1989, four national societies/sections from Yugoslavia (MI societies from Bosnia and Herzegovina, Croatia and Slovenia, as well as the MI section of the Serbian Medical Society) formed the Yugoslav Association for Medical Informatics (YAMI), with the site in Zagreb (29). YAMI became member of EFMI and IMIA at the MIE 1990 Congress in Glasgow, but was dissolved at the end of 1991 after Yugoslavia fell apart in middle of that year. Consequently, the national so-



**Figure 3.** Participants of the Alps-Adria conference in Zagreb (1989); from left: M. Madjaric, Gj. Dezelic, V. Lovrek, (all from Croatia), R. Greiller (Germany), G. Gell (Austria)

cieties mentioned above became eligible to join EFMI and IMIA independently. CSMI became member of both associations during the MEDINFO Congress in Geneva in September 1992.

According to its Statutes CSMI's basic objectives are to advance dissemination of information in the field of MI in Croatia, to promote high standards in MI applications, and to promote research, education and international cooperation in MI. CSMI especially organizes MI conferences and meetings, promotes MI education and its popularization, encourages MI standardization, and struggles for medical informatics dignity and dignity of people involved in medical informatics.

CSMI started with organization of its national symposia in two-year intervals. The first was held in Zagreb in 1993, and the series continued as follows: Zagreb (1995); Split,



**Figure 4.** YAMI's delegation at EFMI MIE 1990 Congress in Glasgow (dinner after becoming member of EFMI and IMIA); from left: M. Madjaric, S. Vuletic, J. Kern (all from Croatia), I. Masic (Bosnia and Herzegovina), V. Lovrek, Gj Dezelic (both from Croatia), R. Vukasinovic (Serbia)

with a teleconference in Zagreb organized in collaboration with the Croatian Academic Computer Network CARNet (1997); Symposium organized as a teleconference, in collaboration with CARNet, in Osijek, Rijeka, Split and Zagreb (1999); Pula, in connection with the international MEDICON Conference (2001); Zagreb (2003); Rijeka (2005); Brijuni Island, in connection with the EFMI STC (2007); Osijek (2009). Prior to the beginning of each symposium, proceedings were prepared containing reviewed contributions, predominantly in the form of full papers. CSMI was also a co-organizer of conferences with other institutions. Worth mentioning is the conference "Health Technology Assessment of Modern Technologies in Healthcare" (2002) co-organized with the Croatian Ministry of

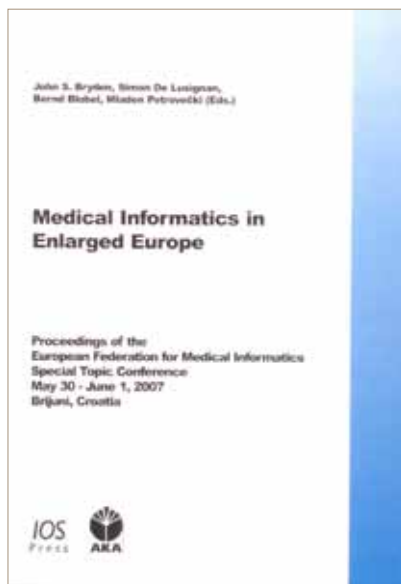


Figure 5. Proceedings of Brijuni EFMI STC 2007

Health, European WHO Copenhagen Office, Andrija Stampar School of Public Health in Zagreb, School of Engineering and Computing in Zagreb, and CROMBES.

The EFMI Special Topic Conference in Brijuni Islands (May 30-June 1, 2007) entitled "MI in Enlarged Europe" (30) was a successful event with more than hundred participant from numerous European countries, being a significant contribution to the international affirmation of CSMI.

The publishing activity of CSMI, besides of symposia proceedings,

contains also the Bulletin of CSMI, a biannual periodic publication (starting in 1991), and special editions: the textbook "Medical informatics" (1997), documents on the principles and recommendations to personal data protection (2000), as well as translations of the IMIA's Recommendations on MI education (2001) and Code of Ethics (2003), available at CSMI's internet portal (in operation since 2000) (31). CSMI's officials served also as guest-editors of other Croatian scientific and professional journals (32).

The development of MI standardization in Croatia, described in Chapter 2, was initiated by CSMI in 2001, and the HL7 Croatia International Associate was established as a joint venture if CSMI and the Croatian Medical and Biological Engineering Society (CROMBES) (33).

During all of its activity, CSMI paid much attention to MI education. The already noted publications of the MI textbook and the translation of IMIA recommendations on MI education (34) were important endeavors. Of great importance was a special discussion organized at the 6<sup>th</sup> CSMI Symposium "Medical Informatics 2003" in Zagreb, resulting in an education plan for MI subspecialists needed in the Croatian healthcare system (35, 36).

## 5. PERSPECTIVES FOR MEDICAL INFORMATICS DEVELOPMENT IN CROATIA

The Croatian integrated health

information system, which started with the family medicine, continues its development. The next step will be inclusion of other primary health care units into the system (dentistry, pediatrics, gynecology, laboratories and pharmacy). As the hospital part has not been included into the integrated information system so far, many Croatian hospitals will continue, for the time being, to develop their information systems independently of the so called "integrated initiative", but with the aim to become parts of the integrated health information system in due course.

Medical informatics education will continue to develop at all medical schools, as well as at schools of dentistry and nursing. Special emphasis will be given to data organization, health information systems and their evaluation from the physician point of view, as well as to decision support systems in health care. More attention will be paid to Internet based services like bibliographic data bases and tools for knowledge discovery.

CSMI will continue to co-operate with EFMI and IMIA, with Healthcare IT Managers and standardization organizations (HL7, ISO, CEN, Croatian Standards Institute). Organization of CSMI symposia and participation in international congresses and conferences will continue. Intending to participate in the development of the electronic health record (EHR) at the European scene, CSMI participates in the EU project



Figure 7. Participants at the Brijuni STC 2007





Figure 8. CSMI Publications: Bulletin of CSMI (left), MI Textbook (right)

entitled *Thematic Network on Quality and Certification of EHR systems*, being one of the 21 beneficiaries of the project. As MI professionals in Croatia are still not officially recognized as health (sub)specialists, CSMI will continue with efforts to achieve this goal.

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Figure 9. Proceedings of one of CSMI Symposia: Brijuni Symposium 2007

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