

Medical Informatics in Croatia – a Historical Survey

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Review

ABSTRACT

A historical survey of medical informatics (MI) in Croatia is presented from the beginnings in the late sixties of the 20th century to the present time. Described are MI projects, applications in clinical medicine and public health, start and development of MI research and education, beginnings of international cooperation, establishment of the Croatian Society for MI and its membership to EFMI and IMIA. The current status of computerization of the Croatian healthcare system is sketched as well as the present graduate and postgraduate study MI curricula. The information contained in the paper shows that MI in Croatia developed and still develops along with its advancement elsewhere..

Key words: Medical informatics, Croatia.

1. FROM THE BEGINNINGS TO THE END OF THE 20TH CENTURY

1.1. The beginnings

As in many European countries, medical informatics (MI) began to develop in Croatia in the sixties of the 20th century when medicine was widely recognized as a field in which the use of computers is important and widespread, and will be necessary in the future. This was 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 (1).

Let us remember that in the fifties of the last century, i.e. after the 2nd World War, USA was a leading country in the field of computer science, introducing the first uses of computers in medicine (2). But soon, when Europe recovered from the war disasters, the use of computers in medicine and health care began to advance rapidly, especially in the technologically advanced European countries – France, Germany, Sweden and United Kingdom. This was a result of the entrance of the biggest American computer companies, as for example IBM, Univac, Burroughs, Control Data and Honeywell, into European markets with their computer systems, and the beginning of their investments into European computer industry, in which among the known European computer manufacturers were English ICL, French Bull (bought by the American General Electric in 1964 and sold to Honeywell in 1970) and German Siemens. As most of the US companies were already involved in the realization of medical computing projects, this had, of course, its reflection on MI development in Europe, especially in the field of medical and health in-

formation systems. The names of some of the first European hospital information systems from the sixties—in Sweden the Danderyd Hospital and Karolinska Hospital Systems in Stockholm, in Great Britain the Kings Hospital System in London, in Germany the Medizinische System Hannover, are still in our memories.

This development resulted in the formation of a new scientific discipline named in 1967 by François Grémy “medical informatics” (2, 3). The new name began to spread all over world, especially after the foundation of the European Federation for Medical Informatics (EFMI, 1977) and the International Medical Informatics Association (IMIA, 1979).

In the time of the development of first medical computing projects in the USA and European West, i.e. in the fifties of the 20th century, in Croatia 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. As elsewhere, most benefits were expected by the use of computers because of their efficiency in information processing. Croatia, in these days a federal republic in the former Yugoslav Federation, had a rather developed healthcare system as a result of the tradition in the public health philosophy and ideas of Andrija Stampar (4). As the healthcare system in a substantial part deals with collecting, storing and processing of data, by several independent studies performed in those days it has been shown that the costs in the information sector amount to at least one-third of total costs in the healthcare system (5). So e.g. Morris F. Collen reported that 25-40% of hospital costs are connected with data handling (6), but in other sources it is estimated that the costs might be even higher. So it became apparent that the Cro-

atian healthcare system should be based on the use of modern ICT, especially by the use of computers.

But in that period it was not easy to introduce computers into Croatian healthcare practice. The installation of computers in the whole country was slow, first computers were installed in state statistical institutions, some of the banks and leading research institutes, as well as in newly established computing centres, serving various users (in whole Yugoslavia in 1962 there were installed 30 computers, and to the end of 1968 the number increased three times, cf. ref. 7). It became clear that new technologies and scientific fields can be implemented in healthcare only by corresponding education of professionals engaged in this field. In such circumstances the Andrija Stampar School of Public Health (bearing the name of its founder since 1959 and being a part of the School of Medicine in Zagreb), already engaged in organizing postgraduate courses for health professionals working in public health (physicians, health economists, etc.) introduced MI fundamentals into their curricula. This was done by the initiative of the director of the School Prof. Branko Kesic, Stampar's successor, a visionary realizing early the importance of computers for medicine and health care, noting the appearance of the growing crisis in processing healthcare data and expecting that these tools could help in this situation.

First lectures on MI were given in the academic year 1966/67 as a part of the subject "Introduction to Scientific Work", held in part by Branko Kesic and by Gjuro Dezelic, who was the first of the teaching staff of the School of Medicine in Zagreb having opportunity to work with a large-scale computer, learning programming in order to perform calculations for his scientific research during the postdoctoral training in the USA. But from the very beginning the aim of this initial education of health professionals in MI (still under the name "medical computing", as Grémy proposed the name for this medical discipline just in the same time in 1967) was to extend it as soon as possible to medical students, in order to prepare them for their future professional work characterized by the use of rapidly developing ICT. It is important to mention that at that time this approach in medical education was extraordinary rare. For example, first report on teaching computers to medical students came from USA in 1965 (8), and further reports of similar attempts were published only a few years later. In addition, these first curricula were concerned only with the narrow area of computer programming, and not with other aspects of MI, so important for future health professionals.

All that was still before the Todd Commission Report on medical education in Great Britain (9) stressed the urgent necessity for medical students to be trained in MI, stating that "computers, with all their implications in terms of equipment, procedures and ways of thinking, will play too large a part in the work of all doctors in the future to be left entirely to the expert (*in computing – author's comment*); every doctor should at least learn to understand their basic principles and potentialities."

Soon after these first publications on MI education, and experiencing positive acceptance in teaching MI

to postgraduate students, the Andrija Stampar School of Public Health, as a part of the School of Medicine in Zagreb and supported by the Association of Healthcare Institutions of Croatia, proposed to the end of 1969 introduction of special compulsory appreciation courses in MI at the undergraduate and postgraduate levels for all medical students. The School of Medicine in Zagreb accepted it and teaching for undergraduates and clinical postgraduates started in the summer semester of the academic year 1970/71 (10). When in 1972 the University Computing Centre (SRCE) was opened in Zagreb, operating a modern time-sharing UNIVAC 1110 system, a Terminal station, equipped with conversation terminals, was opened at the Andrija Stampar School of Public Health. This Terminal station, apart from its importance for medical research, served as the first MI Laboratory for practical work with computers in the MI education of medical students and healthcare personnel in Croatia. As the terminal network of SRCE spread to other Croatian universities (in Osijek, Rijeka and Split, being in the same time major health centres in Croatia), this gave a strong impetus to the development of MI teaching, as well as to the scientific and professional development of MI in Croatia.

In late sixties of the past century first MI projects in Croatia's healthcare are noted, mainly concerned with problems in public health. The gathered experience was reported at the First Symposium on Applying Computers in Healthcare (Zagreb, April 21-23, 1971) and later published in the symposium proceedings as reports on (1) the use of automatic data processing in the healthcare of the City of Zagreb (processing of data from people not being health insured), (2) the processing of health-statistical data in the field of outpatient healthcare and occupational health in the Medical Center Varazdin, and (3) the computerization of the Croatian Cancer Registry (initiated 1967 in the Croatian National Institute of Public Health in collaboration with international institutions, and continued at home in 1969) (1).

In a recent panel discussion on the history of MI in Europe (at the Special Topics Conference of the European Federation for MI, Prague, 2013) there have been two presentations finding it appropriate to divide the whole MI history into five periods (stages). Talking about the evolution of concepts in MI George Mihalas denoted the period until the middle of seventies of the past century as the "Early Stage" in MI concepts evolution (11), and in their presentation of the history of MI education Arie Hasman and John Mantas named it the "initiation stage" (12). These two terms, similar in their meaning, denote well the first period of the development of MI as a new field in biomedical sciences.

1.2. Further development of MI in Croatia, its appearance on the international scene and the establishment of the CSMI

Development of MI projects

Further development of MI in Croatia, still in its early stage, was mainly related to the administrative and financial applications in healthcare institutions (especially in larger hospitals, such as the University Hos-

pitals in Zagreb) and Croatian health insurance funds. Among the important projects which are introduced in the field of medical documentation it is worth to mention the beginning of computer data processing in the Health Center Remetinec (Novi Zagreb) in 1970, in collaboration with the Computing Centre of the City of Zagreb and continued as a routine after 1973. Following the previously mentioned first successfully computerized health registry – the Croatian Cancer Registry, the Croatian National Institute of Public Health started with computer processing of data in its second registry – the Croatian Psychoses Registry (founded in 1961). Two other computerized health registries followed: the Croatian Registry of Cured Alcoholics (1974) at the University Hospital “Sisters of Mercy” in Zagreb, and the Registry of Diabetes (now National Diabetes Registry CroDiab) at the University Clinic for Diabetes, endocrinology and Metabolic Diseases “Vuk Vrhovac” in Zagreb.

Remembering the introduction and development of these early MI projects it is worth to note the support that came from the Croatian state health authorities, realizing that application of modern ICT in health care is one of the important components in its modernization and future development. This was an important impetus for future development of MI in Croatia.

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 whole healthcare system of the City of Zagreb, was conceived still in 1974 as a comprehensive application of ICT in that field. Its conceptual design started several years later (in the beginning of eighties) (13), but could not be implemented as planned because of the financial problems during the eighties and the later decay of the ex-Yugoslavia at the beginning of nineties. In the late eighties a similar approach was adopted in the Istria County for the needs of primary healthcare (PHC) (14), with the extension to apply the rapidly spreading microcomputer hardware affordable for PHC teams working in territorially distributed offices and to satisfy their information needs by the use of Lawrence Weed’s POMR (Problem Oriented Medical Record) approach (15, 16).

Among the first hospital information systems in Croatia one can note the beginning of the implementation of such system at the Clinical Hospital Centre in Zagreb in the eighties (17), oriented under conditions of limited hardware resources to develop a basic data set at the level of an integrated hospital information system covering several hospitals (18).

MI applications in clinical medicine

As in many clinical disciplines in Croatia in those years significant efforts were made to follow the development of medical science in the world, so the application of diagnostic and therapeutic methods based on electronic computers started early. Besides the methods for the calculation of radiation doses in radiotherapy applied in several Croatian hospitals, applications in nuclear medicine and electroencephalography have been

developed, and the computed tomography has been applied in Zagreb very early (1975). A Centre for Tissue Typisation, supporting kidney transplantation, was established 1973 at the University Hospital Centre in Zagreb, and started with computer applications from its very beginnings. The use of medical records designed for computer processing started in psychiatry, diabetology, otolaryngology, maxillofacial surgery, gynaecology and other clinical disciplines. ICT based diagnostic and therapeutic instrumentation (e.g. in the clinical laboratory, intensive care, electrocardiography, etc.) was introduced in daily medical work also in the seventies of the last century.

Start and development of MI research

First published results on MI research in Croatia originate from the Andrija Stampar School of Public Health. After the opening of the Terminal station at the School many biomedical researchers in Croatia wanted to perform their statistical data analysis, so necessary in their work, using the big mainframe in SRCE. At that time such analysis was performed by using computer programs in batch processing mode, with software packages specifically intended for biomedical research (e. g. MEDCOMP from the University of Cincinnati [1963], BMD – from UCLA [1971] and SPSS from Stanford University [1973]). As these packages at that time did not allow the user to work on-line and to create their own strategies of data analysis during this work, a special conversational statistical data analysis language as well as a special interactive statistical package for biomedical research, CSTAT, were developed (19, 20). This was welcomed by the users, because it allowed a narrower contact with their own data and creation of new strategies for their statistical analysis, an approach possible today when using personal computers.

In the beginning of eighties the Croatian funds for scientific work started financing first two MI projects. Let us mention their titles: “Production and flow of information in the health care system” (1981-1985) and “Creating algorithms and models of information flow on the operational level in the healthcare system” (1981-1983). These projects resulted in a number of papers: two on the health information systems, four on databases and one on the role of microcomputer technology in health applications (the IBM PC Model 5150 was released in 1981!) (the citations of these papers can be found in ref. 21). Another project was started in the field of modelling and computer simulation of infectious diseases in the population, with the development of software for continuous simulation with graphics modules, partly in collaboration with the Institute of Medical Cybernetics, University of Vienna. The method of continuous simulation was also applied to other health problems, especially to investigate the dynamics and control of non-communicable diseases in the population, and to study the creation and monitoring genetic diseases. The results of these computer simulation studies were published in nine papers (21).

The project of continuing education in PHC (1985-1988) in collaboration with the Japan International Co-

operation Agency (JICA) has gathered researchers from Croatia and Japan in the development of new methods for computer assisted instruction (CAI) in medicine, and this joint work resulted in four papers (21).

Two last projects in the eighties were “Information aspects and ICT basis of health assessment” (1986-1990), and the interdisciplinary project “Connecting the space and health data to assess the health status of the population” (1986-1990). In the framework of these projects four papers have been published on information systems, three on databases in PHC, two on linkage of space, households and inhabitants, and one on genealogies handling by computers (21).

To the end of the eighties, inspired by the rapid development of the medical decision-making software and computer-based expert systems, first ideas appeared to start with research in this field. At that time in the Andrija Stampar School of Public Health several research projects disposed with computerized databases, so it appeared suitable to exploit these data for such purposes. It was favourable that during the eighties at the University of Ljubljana a suitable software system was developed (named ASSISTANT) allowing automatic learning of rules by which physicians make their decisions. In collaboration with the Slovenian colleagues it was possible to acquire the software, so the first pilot study could be carried out on data in the field of perinatology and rheumatology (22), as an introduction for future medical decision-making research in the next decade.

All projects described in this subchapter were led by professors at the Andrija Stampar School of Public Health, which is a part of the School of Medicine in Zagreb. The first two MI projects described in this subchapter were led by Gjuro Dezelic, professor of MI, and Silvije Vuletic, professor of medical statistics. The project on computer simulation was led by Gj. Dezelic in close cooperation with Prof. Branko Cvjetanovic, a leading Croatian epidemiologist, professor at the School and WHO expert. The project on continuing education in PHC was led jointly by Gj. Dezelic and Takao Akatsuka, professor of information engineering at Yamagata University, Yonezawa, Japan. The project on health assessment was led by Gj. Dezelic, and the interdisciplinary project on connecting space and health data was led by Nada Dezelic, professor of health ecology. Most of the papers cited in this subchapter were published in the proceedings of international conferences (in total 12 papers, 6 of them at EFMI MIE congresses and 3 at IMIA MEDINFO congresses), in the proceedings of domestic conferences there were 9 papers, and the rest was published in journals.

Development in MI education

After the introduction of first MI compulsory courses at the School of Medicine in Zagreb in the academic year 1970/71, other medical schools in Croatia followed this trend. The School of Medicine of the University of 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 the second part of eighties personal computers were gradually introduced into MI laboratories, allowing students to broaden their practical work. In Croatian nursing schools MI education was also introduced in early eighties of the past century. The Zagreb University School of Dental Medicine introduced MI in its postgraduate education 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 ex-Yugoslavia and discussions on its first experiences, problems and prospects at international conferences (10, 23).

After more than one decade of 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 Faculty of Electrical Engineering and Computing and the Faculty 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” and lasted about two decades. 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, librarians and engineers working in healthcare (1).

At the beginning the 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 and accepted by the Zagreb University Publishing board as an official text, was published in 1976 and entitled “Fundamentals of Informatics” (24). The next three enlarged and revised editions under the changed title “Health Informatics” were published in 1986, 1987 and 1989. To the end of the eighties, the teaching materials needed for practical work in MI education were also prepared in the form of handouts, until the first MI laboratory manual was published as a book in 1990 (25).

It is worth mentioning that during the eighties an intensive cooperation in MI teaching has been established by the Andrija Stampar School of Public Health with the Medical School in Sarajevo, in the neighbouring Bosnia and Herzegovina, where Gjuro Dezelic taught MI to their postgraduate students from 1984 to 1990, until Izet Masic, after gaining his PhD, succeeded him in teaching and expanded the MI education in his country to the undergraduate level.

Beginnings of international cooperation and establishment of CSMI

First international contacts of Croatian MI professionals happened already at the first of the EFMI congresses—Medical Informatics Europe MIE 1978 in Cam-

bridge. At this venue Gjuro Dezelic had a chance to contact with leading persons of EFMI, and they invited him to participate at the EFMI Council meetings as an informal observer representing Yugoslavia, in which Croatia was one of the six federal republics. As EFMI then consisted of 11 member countries, the Council was interested to get new members and national representatives. In September 1979, at the Congress MIE Berlin, IMIA held its General Conference, so Dezelic could also participate as an observer. As EFMI and IMIA accepted as regular members only MI societies of individual countries, being members of the World Health Organization, in Ex-Yugoslavia it was necessary to found such societies in particular republics, and then to establish their federal association eligible for membership. As the number of MI professionals in particular parts of Yugoslavia was uneven, and most of them were in Croatia, it took a rather long time until the full membership in EFMI and IMIA could be achieved.

In the meantime, after the successful panel of the Croatian Medical Association entitled "Health Information Systems and Health Informatics Activity in the Development of Modern Medicine and Healthcare" in April 1983 in Zagreb (attended by more than hundred participants), the first association of Croatian MI professionals has been established – the Medical Informatics Section of the Croatian Medical Association, with Marija Strnad elected as chair. The members of the Section were physicians and other professionals interested in MI. Already at this panel it was concluded that, when circumstances permit, to establish in Croatia an autonomous MI society, similarly as in other countries, as an incentive to join EFMI and IMIA.

As MI became a topic of increased interest in the medical community in Croatia, the Croatian Association of Healthcare Institutions, an organizer of traditional international exhibitions "Medicine and Technology" held each May in Zagreb, initiated in 1986 the first of "Meetings of Informatics in Healthcare" (MIH) as a successful accompanying event. At the 2nd MIH in May 1987 the Association founded its Committee for Health Informatics, with Gj Dezelic serving as chairman. The Committee was specially engaged to organize MI conferences with participants from other parts of Ex-Yugoslavia and abroad (especially MI experts from the so-called "Alpe-Adria Region" [A-A Region], consisting of geographically relevant parts in Austria, Germany, Italy and Ex-Yugoslavia). At this MIH the Committee was entrusted with the mandate of representing Yugoslav MI professionals in EFMI and IMIA, until an association at the federal level was formed. In the same time Gjuro Dezelic, as the chairman of the Committee, became the status of the official observer from Yugoslavia in EFMI and IMIA.

At the 3rd MIH in May 1988 it was agreed that in particular Yugoslav republics, able to gather enough members, autonomous MI societies should be formed. As a result of this agreement the Croatian Society for Medical Informatics (CSMI) was established on February 16, 1989, succeeding the previously mentioned Committee

for Health Informatics. Also to the end of 1988 MI societies were established both in Bosnia and Herzegovina (BiH) and Slovenia, and Serbia formed the MI section of the Serbian Medical Association. In that way the prerequisites to establish the Yugoslav Association for Medical Informatics (YAMI) were fulfilled.

Simultaneously in August 1988, at the EFMI Congress MIE 88 in Oslo, several participants from A-A Region agreed to meet yearly by turns in Graz, Trieste and Zagreb. According to that in May 1989, at the occasion of the 4th MIH in Zagreb, the first "Alpe-Adria Round Table Discussion" was organized, and the topics were "Presentation of MI activities in the A-A Region" and "Possibilities of the MI collaboration in the A-A Region" (the organizers on behalf of their countries were Günther Gell [Graz, Styria, Austria], Silvio Sponza [Trieste, Friuli-Venezia Giulia, Italy] and Gjuro Dezelic [Zagreb, Croatia, Yugoslavia]; from other parts of the A-A Region main representatives at the meeting were Reinold Greiller [Munich, Bavaria, Germany] and Stefan Adamic [Ljubljana, Slovenia, Yugoslavia]). A month later, in June 1989, the representatives of MI societies of BiH, Croatia and Slovenia, as well as of the MI section of Serbia, gathered in Osijek (Croatia) to attend the founding assembly of YAMI. At this assembly it was decided to locate YAMI's seat in Zagreb, with Gjuro Dezelic elected as president of YAMI, and Izet Masic (BiH), Rajko Vukasinovic (Serbia) and Stefan Adamic (Slovenia) as YAMI's Board members. Additional Board members were YAMI's secretary Visnja Lovrek and treasurer Josipa Kern, both members of CSMI. The road to join EFMI and IMIA was open.

2. MEDICAL INFORMATICS IN CROATIA IN THE LAST DECADE OF THE 20TH CENTURY

2.1. CSMI becomes member of EFMI and IMIA

The prospects for further successful advancement of MI in Croatia were good. Research was advancing well by pursuing many of the problems of the time and orienting itself to contemporary themes. The development of information systems in healthcare began, and MI education produced a new generation of people interested to work in MI. As an indicator of this it can be noted that CSMI had more than hundred members soon after its foundation in 1989. The regulation of its official links with EFMI and IMIA through YAMI was awaited, but the procedure was long. Although YAMI was founded in the middle of 1989, its registration by the federal authorities of Ex-Yugoslavia was fulfilled at the end of that year, so the official application for admission to EFMI and IMIA could be submitted only at the beginning of 1990. Although the boards of both international organizations quickly accepted YAMI's application, one had to wait until August to formalize its membership at MIE 1990 in Glasgow.

Soon after founding, YAMI organized its first MI congress in December 1990 in Belgrade. At YAMI's first general assembly held at this occasion, it was decided to submit to IMIA the candidacy of CSMI for the MEDINFO congress in 1995 in Zagreb. So the plans for

future activities both of CSMI and YAMI were ambitious.

At the same time the Commission of the European Communities (the forerunner of the European Commission), in the endeavour to support common understanding and cooperation in research and basic technological developments in Europe, at the end of 1989 “undertook a number of programmes with the aim of advancing informatics and telecommunications in important application fields. One of these programmes is concerned with medicine and health care. It is called AIM, Advanced Informatics in Medicine.” The AIM action supported in the beginning 42 projects, and a special EFMI’s working group was mandated to submit project proposals of its members (26). As CSMI members participated for years at MIE congresses, this was a good possibility for them to participate also in European projects, either by proposing own projects, or to collaborate in AIM meetings. Everything seemed favourable for Croatian MI researchers, especially for the younger generation trained in MI, expecting to increase their international presence in Europe. But future events disturbed these prospects.

Yugoslavia has entered a period of political turmoil, which led to its dissolution. A little more than two years after the founding of CSMI, in mid-1991 began the aggressive war against Croatia (the main aggression ceased at the beginning of January 1992, but the war ended in August 1995). It caused many victims and great destruction, and many members of CSMI were engaged in defending the country and fighting for its freedom and independence. This of course influenced the work and development of CSMI. But difficulties occurred also in international cooperation. As examples let us mention two cases: (1) Due to the war threats, members of CSMI could not travel to Graz to attend the second meeting “AA 91–Alpe Adria–Informatica Medica” in early October 1991, but could be represented by their fellow Miroslav Madjaric (working at that time with Professor Gell); at this meeting participants from four countries–Günther Gell from Graz, Attila Naszlady from Budapest, Mateja Kozuh-Novak from Ljubljana and Miroslav Madjaric from Zagreb–issued a Resolution to the responsible governments “to stop fighting in Croatia and to induce a peaceful solution on the basis of democracy, freedom and respect for human rights”; and (2) Gjuro Dezelic could not travel to deliver his invited lecture at the “Conference on Training Strategies for Health Information Systems” organized by the Council of Europe and EFMI in Strasbourg, which was scheduled for October 31st, 1991 at 10:40 hours; this happened because at the beginning of that month the Commission of the European Communities, after the start of the war in Ex-Yugoslavia, decided to forbid all invitations of participants from that country to European conferences, as well as to cancel those in progress; at this conference Dezelic had to participate also as a member of the Programme Committee.

The war against Croatia, which followed after a short 10-days war against Slovenia at the end of June, led to

the dissolution YAMI. In September 1991 the Slovenian and Croatian MI societies withdrew from YAMI, and the MI Society of BiH followed a few months later. After January 15th, 1992, when the Republic of Croatia was diplomatically recognized by the European Community member countries and most other Western countries, CSMI already on January 20th submitted its application for membership to EFMI and IMIA. Both organisations accepted CSMI’s application at their first formal meetings, and at the MEDINFO 1992 in Geneva CSMI became member of IMIA (on September 5th) and EFMI (on September 6th).

The candidacy of CSMI for the MEDINFO 1995 Congress in Zagreb, announced in 1990, was from the very beginning fully supported by the Croatian ministers of health and science as well as by the lord-mayor of Zagreb, but due to the post-war economic problems in the country CSMI could not continue any more to apply for the organization of this big world MI gathering in Croatia.

2.2. Advancement of MI research in Croatia, beginning of CSMI biennial symposia and start of the CSMI Bulletin

After Croatia gained international recognition and became a member of the United Nations in May 1992, the opportunities for MI research began to normalize. CSMI could finally revive initial plans, stipulated at its founding, to organize national MI symposia. It was decided to organize them biennially, and the first was scheduled for October 21-22, 1993 in Zagreb. Since then, CSMI MI symposia are organized each two years until today. From the very beginning the proceedings to all symposia (published under the title “Medical Informatics”) were prepared in advance and available to participants, and this habit important for the success of these scientific gatherings is kept until the present time. The main editors of the symposia proceedings, being a good indicator of MI topics investigated by Croatian MI professionals in this period, were from the beginning Josipa Kern and Mira Hercigonja-Szekeres, with several other CSMI members joining occasionally as co-editors.

The number of submissions at symposia in the nineties of the 20th century was about thirty, mostly in the form of full papers (in average 27), and a significant number of authors wrote their texts in English. The 3rd Symposium in 1997 in Split introduced as a novelty a video conference between Split and Zagreb, provided in cooperation with CARNET – the Croatian Academic and Research Network. The success with video-conferencing has enabled to organize the 4th Symposium in 1999 entirely as a video conference between the four major medical centres in Croatia: Zagreb–Osijek–Rijeka–Split. The submissions covered various MI topics: (1) information systems (IS) in hospitals, (2) IS in primary health-care and public health, (3) software and databases, (4) data security and classification, (5) standardization in MI, (6) signal and image processing, (7) telemedicine, (8) medical decision support systems, (9) modelling and simulation, (10) education in MI (there was a total of 107

full papers [32 in English, other in Croatian] in the 4 volumes of proceedings from 1993 to 1999; the numbers in particular topics were as follows: [1] 22, [2] 24, [3] 9, [4] 5, [5] 5, [6] 14, [7] 6, [8] 8, [9] 4 and [10] 9 papers), showing a rather broad range of subjects, some of them quite contemporary, which were investigated by Croatian MI professionals in these days. As the 1st symposium in 1993 was held shortly after the end of war, an extraordinary topic was introduced – MI in emergency conditions. Here an interesting work was presented by Neven Henigsberg and co-authors describing an information system connecting 32 healthcare institutions, based on digital data exchange by using packet-radios (the then available wireless technology), able to communicate large quantity of data collected during disasters (in the pertinent case in besieged areas) and stored in databases, when existing communication infrastructure is disabled.

In parallel to the introduction of MI symposia in 1992 CSMI started to publish its periodical named "*Bilten HDMI*" (CSMI Bulletin, ISSN 1330-0253). The first editor-in-chief was Josipa Kern, followed in 1996 by Silvije Vuletic, who edited it until 2004. In the same period a change occurred also in the person of the CSMI representative in the EFMI Council and IMIA General Assembly. The CSMI president Gjuro Dezelic, who had the observer status of his country in these bodies since 1978, and continued to serve as the official representative since 1990, after joining the Croatian diplomacy could not fulfil this duty any more asked for a successor, so the CSMI vice-president Josipa Kern overtook the duties of the CSMI representative to EFMI and IMIA in 1994. After the beginning of work in the field of medical decision-making and expert systems at the end of the eighties of the 20th century, despite unfavourable post-war economic conditions in the country, two new research projects were started: (1) "Heuristic decision support systems in healthcare" (led from 1991 to the end of 1992 by Gjuro Dezelic, and from 1993 to 1994 by Josipa Kern), and (2) "Information technologies and decision-making in healthcare" (led from 1996 to 1999 by Josipa Kern). The results were published in more than twenty papers, including a PhD thesis and several Master's theses. The methods applied were: inductive learning, neural networks, pattern recognition and text analysis (21).

2.3. Development of MI projects

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 modelling, several research groups developed applications in orthopaedics, electroencephalography, dental medicine

and other fields. First projects in telemedicine were introduced, starting with telepathology, alergology and teleradiology. They were reviewed (27) 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) (28).

Several new registries were established in the Croatian Institute of Public Health: Registry of health professionals (in 1991), Registry of persons treated for psychoactive drugs (in 1983) with regular annual reports on the epidemiology of addiction (started in 1999), Registry of persons with HIV/AIDS (established in 1985).

2.4. Further development of MI education

In the beginning of nineties, the MI laboratory at the School of Public Health has been equipped with a number of personal computers networked to a workstation of the Croatian Academic and Research Network (CARNet), the first Internet Service Provider (ISP) in Croatia (established in 1992). Except that medical students were now able to extensively use common software for text processing, spreadsheets, databases and statistical computing, they were also able to start using Internet and communicate via e-mail. This enabled them to become familiar with examples of the computer applications in doctor's offices, information on drugs, computer-assisted instruction etc. They could start searching Medline databases and read electronic magazines. The postgraduate students were able to start studying special topics, like simulation modelling, methods of inductive learning, decision making by data mining and by free text analysis. In the year 1999, in collaboration with CARNet, the MI university teachers at all four Croatian medical schools—in Osijek (Vesna Ilakovac), Rijeka (Mladen Petrovecki), Split (Marijan Erceg) and Zagreb (Josipa Kern, Jadranka Bozikov)—organized a teleconference on telemedicine for students of medical schools, a project which provoked much interest among Croatian medical students.

In 1997 a fully revised edition of Dezelic's MI textbook appeared under the title "Medical Informatics", published by CSMI, and a new chapter on medical decision-making was added (written by J. Kern) as a result of the increased interest for this special MI field among students (29). In this textbook MI is clearly defined as an interdisciplinary "scientific discipline that deals with the theory and practice of information processes, i.e. with data processing in the broadest sense", as well as it "deals with the procedures for handling of medical data, information and knowledge needed to solve medical problems and for decision-making in healthcare".

3. DEVELOPMENT IN THE 21ST CENTURY

3.1. Development of MI projects—Current status of computerization of the Croatian healthcare system

Since the beginning of the 21st century the Ministry of Health is committed to developing a national health information system in Croatia. The key drivers behind this decision were previous experience with computerized applications and health information systems development, coupled with a growing understanding of the

importance of health information for making appropriate decisions in health care. Health information is used to treat individual patients or population groups, to plan health care and estimate health problems requiring intervention, as well as to ensure better use of resources.

In 2001 a group of experts, consisting of health professionals, MI professionals, and jurists was established to start a new project—an integrated national health information system (INHIS). The requirements for this system were that it should be centralized and cover primary health care (PHC, the ‘gate keeper’ in the Croatian healthcare system), as well as hospitals (the main generator of expenses in health care). The need for centralization derives from the fact that Croatia has a rather small population (< 5 million people), and the Croatian Public Health Institute and the Croatian Health Insurance Institute both require reports on health and health service status as well as surveillance of costs. Security and standardization were *sine qua non* requirements for the integrated health information system (30).

The first phase of the pilot project was based in general practitioner’s (GP) offices which agreed to participate, and several hospitals (clinical and general hospitals). After the successful evaluation of the pilot results the hospital part of the project was halted, but the primary healthcare component continued to develop (31, 32). The PHC project was designed at two levels: central (kernel of the system) and local (individual GP offices). The kernel was run by one vendor, and the local applications were given to several vendors. At the same time a process for certifying local applications was established. The outcome of this process was that several vendors were certified to develop and install their applications in GP offices. All the GP offices holding contracts with the Croatian Health Insurance Institute were obliged to install one of the certified software systems by the end of 2008. By the end of 2007 about 50% had started the real work by using these applications. The most recent information (end of 2012) indicates that the implementation of these systems was successful. An evaluation procedure (“are the health professionals satisfied with”) was completed (33). Recently, development of an integral evaluation instrument for the PHC information system has been under way (34).

Croatia is mindful of the importance of a regulatory framework for the computerization of its healthcare system and several relevant laws have been passed, one of which is the Personal Data Protection Law (35). In addition, an Agency for Personal Data Protection has been established to ensure compliance with this law. Other important legislation covers issues such as the relationship between electronic and paper documents, digital signatures, and standardization.

The ethical aspect of personal data protection is covered by the Code of Ethics for Health Information Professionals, passed by IMIA (36) and translated by CSMI (37). Although the hospital part of the INHIS project was halted, hospital directorates have continued to develop and implement particular ICT applications in their hospitals (38, 39, 40, 41).

In the Croatian Institute of Public Health a new registry was established. It is the Registry of persons with disabilities, established in 2002.

Wanting to direct the process of computerization in Croatia, the Croatian Academy of Medical Sciences (CAMS) established the Committee for e-Health (previously: the Committee on Telemedicine), with a mission to engage all stakeholders in the implementation/improvement of the INHIS in Croatia. The members of the Committee for e-Health are members of CAMS and CSMI. It issued the Declaration on e-Health, organized a debate among the members of both organizations, and finally published it at the CAMS’s website (42). The settings of this Declaration entered into the “National Health Care Strategy” issued by the Croatian Ministry of Health. Also, it became a basis for development of the strategic document on e-Health in Croatia.

In the period 2007-2010 the project ACTION Grid (International Cooperative Action on Grid Computing and Biomedical Informatics between the European Union, Latin America, the Western Balkan and North Africa) (43) was established as the initiatives to create a common health information infrastructure in Europe, and extending it to other regions. The Facultad de Informatica, Universidad Politecnica de Madrid (Spain) was the coordinator of the project (Victor Maojo). The University of Zagreb, School of Medicine was a partner institution with Josipa Kern as the project leader from the Croatian side. The aim was to enhance cooperation between research centres, universities, hospitals, small and medium-sized enterprises, public entities and others, and expand the impact of European achievements in grid and biomedical informatics to researchers, educators, and health practitioners world-wide (44, 45, 46, 47, 48).

3.2. Current development in MI education

The e-Croatia Education Program started in the early years of the 21st century with the introduction of information science into the national curriculum at all levels—from elementary schools through to universities. The development of an appropriate ICT infrastructure was the first step. This involved building of computer classrooms and creating broadband access to the Internet via ADSL from 600 libraries, 700 primary schools, all secondary schools and higher education institutions (49).

IMIA recommends that all health professionals should be acquainted with ICT and be able to use technology responsibly in their daily work. All health professionals should be educated in MI, as well as nursing informatics should be a part of the medical/nursing curriculum. Recently there are four medical schools at Croatian universities, and several nursing schools at baccalaureate level. All the university MI education programs are similar, using the same MI textbooks. However, the position in the medical/nursing curriculum is not the same.

Having several computer laboratories at the School of Medicine in Zagreb, students and teachers began to introduce e-learning into several subjects (pathology, brain

research, physiology, etc.). However, MI and medical statistics are the subjects which make the greatest use of ICT, not just as an educational tool, but also as a way of solving information problems in medicine and health-care. Recently, all courses at the School of Medicine in Zagreb have developed e-lectures, put their teaching material to local Intranet, and realized communication with students by using their internal system maintained by the School's Office for e-learning, and supervised by using the authentication and authorization infrastructure (AAI) of research and high education system implemented in the Republic of Croatia (50).

In 2009 a new comprehensive MI textbook was published, again under the title "Medical Informatics". This was a big innovation in Croatian MI publishing, as it serves both for educational and scientific/professional purposes. It is 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 (51). 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. Recently, this textbook serves also as a basis for the elective course "Biomedical Informatics" at the Faculty of Electrical Engineering and Computing, University of Zagreb.

The current MI professors at Croatian medical schools and applied health studies are Josipa Kern and Jadranka Bozиков (University of Zagreb), Mladen Petrovecki, Lidija Bilic-Zulle and Gordana Brumini (University of Rijeka), Vesna Ilakovac (University of Osijek), Zoran Djogas (University of Split) and Mira Hercigonja Szekeres (Applied Health Studies Zagreb).

3.3. Graduate study curricula for medical and nursing students in Croatia

As an example of MI teaching at Croatian universities, the MI curricula at the School of Medicine in Zagreb will be described.

The MI curriculum for medical students begins with basic ICT skills as an elective course at the beginning of the study. MI for students of the fifth year includes topics relevant to acquaint the students with the concept and tasks of medical informatics as an interdisciplinary profession that deals with the theory and practice of information processes in medicine, health care and research.

The nursing informatics curriculum starts in the second year of the graduate study in nursing (52). The course begins with basic ICT skills and continues with the concepts and tasks of nursing informatics and its role in the nursing process, health care and research.

Both curricula are delivered through lectures, seminars and practical work in computer labs.

3.4. Postgraduate study curriculum

At present the specialized postgraduate MI program

at the School of Medicine in 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 modelling, Public health information systems, Bio-signal processing, and Medical image processing.

A new initiative in postgraduate education is the project at the University of Zagreb named "Curriculum Development for Interdisciplinary Postgraduate Specialist Study in Medical Informatics (MEDINFO)". It started in August 2013 as a 18 months joint project of the Faculty of Organization and Informatics in Varazdin (project leader vice-dean Diana Simic) and the Andrija Stampar School of Public Health, School of Medicine in Zagreb (director Jadranka Bozиков). This project is included into the *Croatian Qualifications Framework* of the Multi-annual Operational Program "Human Resource Development" as a grant within the External Actions of the European Union, and is performed in collaboration with CSMI, the Croatian Chamber of Economy and the Ericsson Nicola Tesla Company in Zagreb during 18 months.

4. ACTIVITIES OF CSMI

The first president of CSMI Gjuro Dezelic was on duty to the year 2004. The next presidents were: Josipa Kern (2004-2008, the vice-president until 2004), Mladen Petrovecki (2008-2009) and Vesna Ilakovac (2009 until today). In year 2004 the past president Gjuro Dezelic was elected honorary president of CSMI. The CSMI representatives to EFMI and IMIA were: Gjuro Dezelic (until 1994), Josipa Kern (1994-2010) and Mira Hercigonja-Szekeres (2010 until today).

Two IMIA documents were translated to Croatian by CSMI and are available at the CSMI Website (53): (1) IMIA Code of Ethics for Health Information Professionals, and (2) IMIA Recommendations on Education in Biomedical and Health Informatics. A document relating to the protection of health information produced by the CSMI Working Group for Data Protection is also available at this website.

In light of the difficulties encountered when building networks and by the lack of interoperability between different systems, the need for standards in MI was recognized as a major challenge. Consequently, at its 4th Symposium in 1999 CSMI initiated the establishment of a local Technical Committee for Medical Informatics (TC 215) at the Croatian Institute for Standards (54, 55). The Committee was established in 2000 with Josipa Kern as its first president. The HL7 Croatia International Affiliate, initiated and established by CSMI and the Croatian Medical and Biological Engineering Society (CROMBES), is the second Croatian organization responsible also for standards in health and medical informatics. This affiliate was established in September 2002. The first president of HL7 Croatia was Gjuro Dezelic (2002-2008), followed by Stanko Tonkovic (2008-2011), and now by Miroslav Koncar (2011 until

today) (56). At the HL7 Croatia Assembly, held on September 22, 2011 Gjurio Dezelic was elected honorary president of HL7 Croatia.

To maintain progress in developing health information systems in Croatia and to inform the rest of Europe about it, CSMI and EFMI organized an international meeting (EFMI Special Topic Conference) titled "Medical Informatics in Enlarged Europe" in 2007 in Croatia on the Brijuni Islands (John Bryden, president of the Scientific Committee). Four EFMI working groups were represented (Primary Care Informatics, Electronic Health Record, Security, Safety and Ethics, and Nursing Informatics) and organized sessions with participation of local, regional and European speakers (57). The keynote lectures were devoted to globalization, progress and challenges of MI (Francis Roger France) and to trends in bio-medical research in Europe (Octavian Purcarea, George Mihalas). The Croatian invited speaker was Diana Simic, as the representative of the e-Croatia Agency. In its cooperation with associations having similar goals and activities, CSMI closely started collaboration with the Slovenian Medical Informatics Association (SIMIA) and HL7 Croatia in organizing ISHEP workshops and conferences (58) (in 2010, 2011 and 2013).

In the promotion of use of high quality electronic health record (EHR) systems in Europe the project "Thematic network on quality and certification of EHR systems" (EHR-QTN) started in 2009, with EuroRec Institute as the coordinator of a permanent network of National ProRec centres in Europe. This project was initiated by the EuroRec Institute (Jos Devlies). CSMI was one of partners in the project, with Vesna Ilakovac as the Croatian representative in it. As the result of these activities the Croatian ProRec Center was formed in November 2013 during the ISHEP conference in Dubrovnik.

CONFLICT OF INTEREST: NONE DECLARED.

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