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Research and Education

Medical informatics in Amsterdam: Research and Education

1 Introduction

The department of Medical Informatics at the Academic Medical Center–University of Amsterdam (AMC-UvA) was established in 1995 in order to strengthen the research, educational, and service-oriented activities in the academic hospital and faculty of Medicine within the AMC. Our department carries out research projects, all sharing the purpose of supporting, directing and evaluating patient care by capturing, aggregating and analyzing patient and health care data. We conduct both applied and basic research ranging from implementation and operation of clinical information systems and (inter)national health information registries to the development and evaluation of medical terminology systems and the improvement of informatics-related techniques for analyzing patient data to generate medical knowledge. Moreover, we have been and still are highly involved in the graduate program of Medical Information Sciences within the faculty of Medicine. We are partners within the IΦE, an International Partnership on Health Informatics Education. In the remainder of this paper, we will first give an overview of the main research themes and projects of our department. Thereafter, the Medical Information Sciences curriculum will be described and our plans for innovating the curriculum. Finally, we will elaborate on our partnership within the IΦE.

2 Research themes and projects

The AMC-UvA's patient care is strongly focussed on the 'evidence-based medicine' paradigm. In this context, our department contributes to choices in patient care, based on documented effectiveness and efficiency of medical practice and quality of care provided. In our applied research projects, we focus on the development, implementation and utilization of clinical information systems and (inter)national health information registries to support analysis and evaluation of care delivered and to support clinical research.

An example of such a clinical information system is PLEKsys, which has been developed in close collaboration with the 'Late Effects Study Group' (consisting of the Pediatric Oncology department and the department of Medical Oncology at the AMC), and the Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital. As the 'Late Effects Study Group' was interested in screening and following childhood cancer survivors and in establishing a pediatric oncology registry on late cancer treatment sequelae, we were asked to develop a computer based registry system to support this screening process and clinical research. PLEKsys offers tools for computerized documentation of the data, for generating (graphical) overviews of data for individual patient management and overviews of patient cohorts, a 'customized search editor' to define user defined searches and a tool to export data to a statistical software package (1).

The use of already existing clinical information systems for quality of care purposes is another research theme. Based on clinical guidelines, performance indicators are developed. Availability and quality of required patient data are evaluated and possibilities for improvement are proposed. This strategy has been followed in order to assess medical practice for meningitis patients (2). A proposal for improvement of diagnosis documentation has been implemented and evaluated in routine practice (3).

Our department is involved in the development and utilization of 5 (inter)national health information registries. We provide the information architecture and (part of the) organiza-

tional infrastructure for the acquisition, storage, analysis and presentation of patient care data with the main aim of analyzing effectiveness and efficiency of the care delivered and to feed back the results to health care professionals in the field.

A national pediatric oncology follow-up registry on late treatment sequelae of Dutch survivors of childhood cancer is under development: LATe Effects Registry (LATER). The information system PLEKsys, that we developed for use by the 'Late effects Study Group' within the AMC, will be installed by all Dutch pediatric oncology centers after expansion and configuration to individual needs of the health team workers at these sites. In addition, a national database will be installed to support the clinical research on late cancer treatment effects. The final goal is to evaluate long term risks of cancer treatments in order to adapt treatment protocols for new patients and to plan treatments for patients who now suffer from negative effects of their earlier cancer treatment (1).

The BHN registry is a Dutch registry of all cardiac and cardio-surgical interventions (coronary artery bypass graft or balloon angioplasty) performed in the Netherlands, developed in close cooperation with the department of Clinical Epidemiology and Biostatistics of the AMC. The main goals of the BHN registry are to optimize utilization of patient care resources and the planning of interventions, to analyze the quality of care and to evaluate the value of new medical devices and techniques used for cardio-surgical interventions (4). Within this project, the possible merits of Internet-based communication facilities for the exchange of patient data between sites are being explored.

In close collaboration with the Interuniversitary Cardiologic Institute of the Netherlands (ICIN), we are now developing a registry for surveillance of adult patients with congenital heart diseases: CONCOR. The main aim is to gain insight in long term comorbidity and mortality of the different congenital heart diseases related to their intervention modalities.

The European Renal Association-European dialysis and Transplant Association Registry (ERA-EDTA registry) covers data from more than 3500 renal units spread over 43 countries with a total population of 716 million people. From 2000 onwards, our department is running this registry in the AMC. The ERA-EDTA registry covers data on mortality and treatment of patients on renal replacement therapy, i.e. dialysis and renal transplantation (5). Major challenges are to develop a uniform terminology and coding system for primary renal disease, comorbidity and causes of death, to facilitate international comparison of patient population features and mortality.

The National Intensive Care Evaluation project (NICE)'s main goal is to maintain a national quality assessment and assurance program for intensive care in the Netherlands by evaluating the effectiveness and efficiency of Intensive Care Units (ICUs) on a systematic and continuous basis. This national database contains data by which Dutch ICUs are evaluated and compared according to mortality and length of stay (6).

We develop and utilize these (inter)national health registries for two reasons: to assist health care providers by bringing research findings to the point of care and to feed our more fundamental medical informatics research. To acquire insight in the efficiency and efficacy of the care delivered, large amounts of data collected during daily patient care are required. In this respect, we focus on research aspects such as: 1) which data are needed to assess medical practice 2) how the quality and completeness of the data can be assessed and ensured, 3) how data should be structured, modeled, classified and aggregated for exploration purposes, 4) which information technology architectures can be used and 5) how data privacy and system security can be enhanced. More fundamental research aspects pertain to 6) developing and evaluating medical terminology frameworks and 7) evaluating and improving techniques for discovery and extraction of clinical information to enhance medical decisions. For example, as part of the NICE project, a terminology system for ICUs diagnoses, DICE, was developed for two purposes: to support intensive care physicians in registering ICUs diagnoses in a structured way and to stratify patient categories for research and auditing purposes. DICE will be integrated into the patient data monitoring systems of the various ICUs (7).

3 The medical information sciences curriculum

In the late eighties, in the AMC, the need for medical informatics education within the medical curriculum was felt when medical students developed interest in information technology in medicine. Their interest in this field was partly accommodated after the development and implementation of a medical informatics major program within the medical curriculum. In 1987, the course was adapted with a stronger orientation on information science. This shift in focus of the program towards information science was due to the need being felt for medical information specialists by the faculty of Medicine. The specialists should be able to create links between practical medi-

cine and the world of information engineering and information technology. It also became clear that a dedicated curriculum in medical information sciences was required as medical students did not have sufficient opportunity to develop the practical skills and knowledge that constitute the scope of the field of medical information sciences. Subsequently, the course was changed into a three-year specialization program following the first year of the medicine curriculum. Due to the large enrollment of students in this program, in 1990 the AMC inaugurated a new full-fledged 4-year M.Sc. program in medical information sciences. From that moment on, the curriculum can be characterized as a dedicated graduate program in health and medical informatics (8). This new medical information sciences program was, and still is, unique in the Netherlands, even though the University of Utrecht has a been offering a medical technical informatics curriculum since 1995. Also within Europe, the Universities of Heidelberg/Heilbronn offer a well-established complete program in medical informatics (9). In the first implementation of our medical information sciences program, two majors were offered. The clinical major focussed on medical technology while the information systems major focussed on the development, implementation and evaluation of information systems in medicine. In 1992, the board of directors of the AMC decided to limit the curriculum to a compound medical information sciences course accentuating the significance of information processing in medical practice and health care. This revised curriculum was introduced in 1994.

3.1 Program rationale and goals

The medical information sciences curriculum of the AMC-UvA aims at imparting students knowledge of, and insight into the issues of delivering health care and services, medical science and methodology, and knowledge and proficiency in informatics so that they can contribute to medical research, evidence-based medicine, treatment and prevention of illnesses and operational management (10). Our program mission adheres to the main objective of medical informatics as specified by Haux (11), i.e.: "to assure and to improve the quality of health care as well as the quality of research and education in medicine and in the health sciences." The final goal of our curriculum is to turn out well-trained graduates in medical information sciences, who are well prepared for professional careers in medical information technology and sciences. The rationale of the curriculum reflects the fact that it is a program of study within a medical faculty. Topics in medical information sciences are best taught and learned in the context of health science, allowing both concepts from medicine and computer science to be integrated. Therefore, a synthesis of medical science and clinical practice with information- and computer science is pursued. Consequently, the role, place and significance of information and information processing in medicine is stressed and supported by information technology. Formalized methods for acquiring and processing, organizing and managing the huge amount of data, information and knowledge to optimize medical and health care decisions embody the main part of the themes within the curriculum. Close knowledge of methods and ways of thinking common to decision analysis and (bio)statistics also constitute an important part of the curriculum.

3.2 Curriculum development and structure

In developing the curriculum and in fulfilling the goals set, the faculty was guided by the Program Steering Committee which is represented by each of the main disciplines Medical Biology, Clinical Medicine, Epidemiology, Computer Science and Informatics. The structure provided leadership and guidance to ensure that the developing program would represent an interdisciplinary approach to biomedical and medical information sciences as well as informatics education. Four domains were considered essential for accomplishing the program goals described earlier. They formed the basis for the curriculum development. These four domains are reflected in four 'pillars', each of which comprise clusters of educational objectives. The four pillars each represent a main scientific area: Medical Biology, Clinical Medicine and Health Care, Information Technology and Information Theory.

Table 1 summarizes the main educational objectives of each pillar. Medical Biology provides an understanding of the fundamentals of human medicine and methods of research. Clinical Medicine and Health Care cover the organization of the health care system and public health, medical research methodology, (bio)statistics, etiology of diseases and fundamentals of information processing in health care. Information Technology assures an adequate level of understanding of, and practical skill in, principles of computer science, information management and technology. Information Theory provides an understanding of epistemology and information theory, medical decision making, concepts and structures of medical data and information systems design. Each main educational objective is elaborated through operationalized objectives. Each operationalized objective is then detailed in subjects belonging to that objective. These subjects are spread over 18 thematically-oriented modules.

Table 1: Main educational objectives for each domain of scientific area within the Amsterdam medical information sciences curriculum.

Pillar 1: Medical Biology

- Knowledge and insight concerning the structure and function of the human body and the methods of research leading to this knowledge and insights.
- Knowledge and understanding of cytopathology and pathophysiology.

Pillar 2: Clinical Medicine and Health Care

- Knowledge and understanding of etiology, the signs and effects of disorders of the major organ functions, the course of diseases and prophylaxis at the individual patient level so that questions on these subjects can be understood and solved.
- Knowledge and understanding of the processes associated with medical practice, and the skills to effectively contribute to solving problems related to medical practice and decision-making.
- Understanding and application of skills in medical research methods, acquisition, processing, analysis and storage of data, publication of results, as well as understanding of the ethical and legal aspects of clinical research.
- Knowledge of the structure, organization and financing of health services and of the relevant processes involved.
- Knowledge and understanding of the methods and principles in the field of public health.

Pillar 3: Information Technology

- Knowledge of software and hardware for the acquisition, analysis and presentation of medical data, and skills applying this knowledge.
- Knowledge and understanding of the methodologies of computer sciences in order to find solutions for medical problems.
- Knowledge of health-care related information and communication technology, and understanding of their applicability.

Pillar 4: Information theory

- Knowledge and understanding of the basic concepts of epistemology and information theory related to medical practice.
- Knowledge and understanding of the decision-making and control processes in medical practice and health care, and the capability of analyzing and modeling these independently.
- Understanding of the concepts and structures of medical data.
- Knowledge and understanding of methods of information planning and system development, and the capability of selecting the appropriate methods for specific application in medical practice and health care.
- Knowledge of complex information systems used in health services.

3.3 Curriculum organization

The AMC curriculum of medical information sciences spans four years, of which the first year comprises the 'propedeuse' which is comparable to a B.Sc. degree while the last three years make up the 'doctoral' period which leads to a M.Sc. degree in medical information sciences. The first 3 years of the curriculum are structured into modules which are self-contained course units. Each module includes elements from several pillars with strong emphasis on one particular pillar. A total of 18 modules encompass the first 3 years of study (6 modules per year). The last year is mainly devoted to research: students must fulfill a research trainee-ship which is accredited by a written thesis, oral presentation and oral exam.

3.4 Methods of instruction

So-called 'student-centered' instructional approaches are considered well-suited for helping students in acquiring knowledge and verbal skills, and in expanding the ability to negotiate, collaborate and communicate. Academic achievement, study satisfaction and self-esteem may be enhanced by peer interaction, cooperative education, active problem solving, and group work (12-14). Interactive teaching and small group training are therefore heavily employed in the study program. While regular lectures account for 25% of the instruction, interactive lecturing, tutorial groups and practicals account for 75% of the program. Through this interactive approach, we intend to provide a stimulating learning environment for students enrolled in the curriculum. In interactive lecturing, the lecture content is taught in a problem-oriented way. In most modules, a real case study is used as a starting point to elaborate on a specific subject matter. The students are required to actively participate by working on the real case study in small groups, by posing questions and discussing the different solutions each group comes up with. In addition to these interactive group lectures, students are required to attend so-called 'tutorial groups'. During these tutorials, the assignments which students elaborated on during self-study are covered by the entire group. These tutorial groups must be prepared in such a way that the student is able to present and explain his/her solutions and is capable of reflecting on solutions other group members may submit. The idea behind the tutorial groups is that students will acquire missing knowledge or remedy

misconceptions by reflecting on the various solutions presented. During the computer practicals, students must conduct practical work in order to acquire programming skills, and gain experience with the design and implementation of information systems. Practicals are also devoted to the students' gain in proficiency in project management, planning, collaboration and independent problem solving.

3.5 Faculty and students

3.5.1 Faculty

The curriculum of medical information sciences is run by AMC professors. Over 15 departments take part in the program, though the involvement of the various departments varies from guest lecturing to teaching a considerable part of the program. Our department of medical informatics covers 30% of the overall involvement in the first 3 years and the full 100% in the 4th year of the study program by organizing and mentoring all research traineeships. Staff members of the department of medical informatics serve both the educational institute for medical information sciences, responsible for the implementation of the study program, and the educational committee, which is in charge of monitoring new developments in the field of medical informatics and related employment matters.

3.5.2 Students

Student enrollment in the medical information sciences program currently numbers 100 overall and is gradually increasing over the years. In 2000, there were 43 male and 57 female students. Most students (85%) enter the study program directly after high school. They are admitted to the program only if they graduated from high school and had majors in mathematics, physics and chemistry. In addition to high school graduates, 10% of the program's students have previous (foreign) degrees or diplomas while 15% have over 3 years of relevant work experience. The average age of students entering the program is 22 years.. About 40% of the new students had an initial preference to study medicine, but failed to enter the medical school. Of these 40%, a total of 10% enter medical school in the second or third year, 8% start another M.Sc. Program and 22% remain within the medical information sciences program.

4 Curriculum innovation

In the Netherlands, every four years the union of collaborating universities installs external bodies of acknowledged experts to assure the quality of all Dutch university courses. These external bodies review and evaluate all courses focusing on student expectations and on new directions and opportunities within the discipline and the society. The results may be used to initiate innovations in (the organization of) the curriculum. Overall, the most recent findings of the external body that assessed our curriculum of medical information sciences were very positive: the curriculum was considered to be of high academic quality, innovative in instruction strategies and geared to the labor market. However, some fine tuning of the curriculum was recommended. First, in order to keep up with the demand of well-trained personnel in medical information sciences/informatics, and for graduates to be able to compete with other graduates of more informatics-oriented disciplines in the future, it was advised to shift the study load from the medical biology pillar to the information technology and information theory pillars. In addition, curriculum recommendations suggested emphasizing: professional perspectives for students, (organization of) the patient care process, working methods of health care workers and operational management within health care. Correspondingly, as emphasis in health care is changing towards life-long patient care and evidence-based medicine, the scientific staff felt the need to shift the focus of our curriculum somewhat to related areas of medical informatics: viz the automation of the patient record, the implementation of outcome and quality-related databases and the usage of advanced techniques for analyzing and evaluating these databases.

In innovating our curriculum, we take these trends into account and integrate these themes into the new curriculum, which we hope to have fully implemented in 2002. For example, the first year of training now includes an introduction of medical informatics issues related to the electronic patient record. The rationale behind introducing the electronic patient record as a major theme in the first year is that students will be confronted with the full scope of information processing issues in health care and thus acquire a clear picture of career profiles in the field. After all, the electronic patient record is deemed as the data source for direct patient care support, for clinical research and hence for generating and evaluating clinical guidelines, for analyzing and evaluating the quality of care in light of these guidelines, and for optimizing operational management of patient care.

To support patient care directly, implementation of the electronic patient record requires insight in the (organization of the) care process, the work procedures and decision making processes of health care professionals and their information needs. To support clinical research and to analyze and evaluate the care given, requires standardization of terminology and standard data structures. Optimizing operational management requires insight in the institutional organization of health care. More technical issues related to the electronic patient record such as networking, telecommunication and security are also introduced. In

accomplishing these goals, the *Handbook of Medical Informatics* is used as teaching material in this introductory course on medical informatics (15). In addition, we evaluate whether our program still meets recent international recommendations on medical informatics training (15-17). We intent to concurrently familiarize our first year students with all these aspects of medical informatics and elaborate these themes more deeply in the remainder of the curriculum. With this revised curriculum, we hope to educate future graduates in the field of medical informatics even better than today.

5 International partnership in health and informatics education: IΦE

To prepare students for leading positions in medical information and communication technology, the faculty felt the need to establish international relations with other universities involved in medical and health informatics education. Approximately 4 years ago, the UvA and the University of Heidelberg/University of Applied Sciences - Heilbronn, which jointly offer and maintain one of the oldest programs in the field of medical informatics, decided to co-operate in the field of medical informatics education. This co-operation has grown into an International Partnership in Health Informatics Education (IΦE) consisting of 5 universities. These 5 universities offer dedicated M.Sc. Degree programs in Medical and Health informatics (9-10, 18-21). The main goals of this partnership are: 1) to support and encourage the exchange of talented students, 2) to support and stimulate the exchange of teachers and the sharing of courseware, 3) to establish joint international master classes for talented students (22). In this context, master classes are defined as 'seminars for talented students in medical informatics developed by professionals, well known for their knowledge, skill and experience in the field'.

We began the student exchange at M.Sc. Level by having excellent 4th year students fulfill part of their traineeship with one of the partners, by the exchange of instructors between the universities of Heidelberg/Heilbronn and Amsterdam and by organizing international master classes that were attended by talented students and staff members of all affiliated institutes. Prospects of further co-operation in education under investigation are: exchange of PhD students, the joint development and use of courseware, expansion of the master classes to a formalized international training scheme for graduating students.

The final aims of the IΦE partnership are to strengthen education and renew the medical informatics field on an international scale by realizing an information and communication technology network and infrastructure, for sharing courseware and distance learning and perhaps even links to other resources.

6 Conclusion

We have given an overview of the research themes and projects of our Department of Medical Informatics and the medical information sciences curriculum of the AMC. As stated earlier, our research concerns both applied and fundamental research projects in the medical informatics field. The rationale for conducting applied research projects is twofold. First, to bring our research findings directly to the point of care. Most of our studies are thus conducted with clinical partners within or outside the AMC. Second, we seize on these applied research projects to feed our more fundamental research projects focussed on the further development, evaluation and improvement of medical informatics related techniques and methods.

We are responsible for nearly 50% of the education in the medical information sciences curriculum and serve on the educational institute and educational committee. The curriculum is under revision; the revised version will be fully implemented in 2002. It is anticipated that our renewed curriculum will result our future graduates being even better qualified to respond to the information management requirements in health care.

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