

Biomedical and Health Informatics Education — the IMIA Years

J. Mantas

Health Informatics Laboratory, Department of Nursing, School of Health Sciences, National and Kapodistrian University of Athens, Greece

Summary

Objective: This paper presents the development of medical informatics education during the years from the establishment of the International Medical Informatics Association (IMIA) until today.

Method: A search in the literature was performed using search engines and appropriate keywords as well as a manual selection of papers. The search covered English language papers and was limited to search on papers title and abstract only.

Results: The aggregated papers were analyzed on the basis of the subject area, origin, time span, and curriculum development, and conclusions were drawn.

Conclusions: From the results, it is evident that IMIA has played a major role in comparing and integrating the Biomedical and Health Informatics educational efforts across the different levels of education and the regional distribution of educators and institutions. A large selection of references is presented facilitating future work on the field of education in biomedical and health informatics.

Keywords

Education, medical informatics, health informatics, biomedical informatics, nursing informatics

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1 Introduction

The historical evolution of medical informatics is rather short as compared to that of medicine and it is linked to the historical steps of computer science even though computer science began immediately during and after the Second World War, and first applications of computer science in medicine started about a decade later.

We know from earlier fields of science that no discipline can exist if no formal education is established to support it and elevate it to a scientific field. The International Medical Informatics Association (IMIA) was conceptualised and initiated in the late 1960's and early 1970's and one of its very first duties was to establish a working group in education. In this work, we will try to follow and analyse the progress of Education in the field of Medical Informatics during the days of IMIA. Different names with sometimes varying meanings have been suggested for our field of medical informatics. In this contribution, we will interchangeably use the terms medical informatics, biomedical informatics and health informatics as umbrella terms.

In an earlier published paper [1], we have reported a number of educational contributions through the years. For aggregation purposes, we will reiterate some of the important contributions made by the pioneering work of early researchers and of corresponding organisations and events. In this historical perspective, we understand that most of the early developments were trying to resolve specific issues that were based on the needs of the users on the field.

The first discussion about whether medical informatics is a scientific discipline or not occurred during a panel discussion held during the IMIA working conference

in Heidelberg/Heilbronn where it was concluded that medical informatics is a separate discipline with its own methodology [2]. Computer-aided instruction was used on a larger scale after personal computers (PCs) were introduced that were less costly than the mainframes used before (e.g. in the PLATO (Programmed Logic for Automatic Teaching Operations) project of the University of Illinois [3]). In several medical faculties, academic units for medical informatics were created. These units carried out research projects but they also started educational programs in medical informatics or medical information science as it was then often called, especially in the US. The name 'medical informatics' originated in Europe where it was first used by Francois Grémy and Peter Reichertz [1]. The term informatics was used to distinguish the discipline from computer science as it was called in the US. Later, the terms health informatics and biomedical informatics came into use and in a very structured way, recommendations were developed to facilitate curriculum development [4]. A five-stage evolution of medical informatics has been described by Hasman, Mantas, and Zarubina [1] and is given below.

The Initiation Stage

Francois Grémy established the Technical Committee Four (TC4) of the International Federation of Information Processing (IFIP). Under his leadership, TC4 became independent from IFIP in 1977 and was then called the International Medical Informatics Association (IMIA). In 1974, for the first time, medical informatics education was discussed at a meeting in Lyon (France), organized by the international

working group TC4 [5]. At that time, there were already some educational curricula in medical informatics. As early as 1969, Francois Grémy initiated a curriculum in medical applications of computer techniques at Pitié-Salpêtrière (Paris, France). Another meeting was organized in 1983 in Chamonix (France) [6]. John Anderson at King's College Hospital Medical School reported about his experience with research and education in medical informatics [7]. In the US, pioneering work was already under development in clinical and expert systems like MYCIN by EH Shortliffe. In the Soviet Union, medical informatics as a discipline (called medical cybernetics) began in the late fifties of the twentieth century, and the first medical informatics department was established in Leningrad in 1961. Salamon and Dusserre reported efforts to establish a medical informatics course in France [8]. In Belgium, Roger France introduced a course for medical students in which medical information processing using informatics methodology was taught to facilitate decision making [9]. In the Netherlands, the department of Medical Informatics was created in 1973 at the Free University, in Amsterdam, under the chairmanship of Jan van Bommel [10-13], and a separate four-year program in Medical Informatics was established by the University of Amsterdam in the early nineties [14]. In Germany, in as early as 1972, a medical informatics program was established [15]. This program was a collaboration of the University of Heidelberg and the School of Technology in Heilbronn. The names of Franz Leven, Jochen Möhr, and Reinhold Haux are associated with this program [16-22].

The Guiding Stage

In May 1969, in Germany, a model curriculum for informatics was prepared with support of the then existing societies for mathematics and communication technology (the German Informatics Society was founded later in the fall of 1969). Three types of informatics were defined: theoretical, technical, and practical informatics. About 75% of the curricula were devoted

to these subjects. The remaining 25% were assigned to an application field, like engineering, commerce, mathematics, or medicine [23].

In 1973, Peter Reichertz together with the German Informatics Society and the Association for Medical Documentation, Informatics, and Statistics (GMDS) organized a workshop to define a framework for education in medical informatics. From these educational variations, it can be concluded that medical informatics was considered then as a combination of medicine and informatics. According to Moehr, the inclusion of these topics proved that medical informatics was more than the union of medicine and informatics. One of the most important contributions of the conference was the creation of a vision of a new type of professional, the health informatician, and the specification of an integrated curriculum, which was more than a union of a subset of medicine and informatics. Jochen Moehr reported about this meeting in the IMIA Yearbook of 2004 [24]. In 1991, the Recommendations for Education and Training in Medical Informatics of the GMDS were published [25]. In 1981, a report about a model curriculum for doctoral-level programs in what was called health computing was published in the USA by the Association for Computing Machinery (ACM) [26].

In the Netherlands in 1987, recommendations for education and training in medical informatics were formulated by the Medical Informatics Subcommittee of the Committee for Medicine of the Royal Netherlands Academy of Arts and Sciences under the chairmanship of Jan van Bommel. In the report 'Medical Informatics – Renewal in Medicine' it is noted that professionals in healthcare were increasingly confronted with computer systems [27, 28]. The report of the Panel on the General Professional Education of the Physician and College Preparation for Medicine (GPEP) of the Association of American Medical Colleges entitled 'Physicians for the Twenty-First Century' was used as starting point [29]. These latter recommendations were based on the subgroup report on Medical Information Science Skills, chaired by Nina Matheson and Donald A. B. Lindberg [30].

They observed that only a handful of American medical schools had the personnel and computer resources to provide education in the principles and operations of medical information systems.

To successfully implement the Information for Health programme (IfH) at the local level, the NHS Information Authority developed in 2001 competency profiles that identified skill and knowledge levels for NHS staff. These profiles provided guidance and baseline data for local staff training [31].

It is worth mentioning for historical reasons that in 1988, a course taught within the undergraduate curriculum of the Nursing School of the University of Athens was renamed from Medical Informatics to Health Informatics. It was the first time that we encountered this term, which was accepted at the end of the 1990's and beginning of the 2000's as the appropriate generic term reflecting our field in an official course title.

Contagion Stage

In 1976, the European Federation for Medical Informatics (EFMI) [32-37] was established and in 1979 TC4 of IFIP became an independent organization named IMIA. IFIP-TC4 and later IMIA's working group on education organized a number of working conferences dedicated to education in medical informatics. The first working group conference was held in 1974 in Lyon (France), where how to respond to the need for medical informatics education was discussed [5]. In 1983, a second working group meeting was held in Chamonix (France) [6]. Here several existing programs in medical informatics were discussed. Then next conferences were held in Victoria (Canada) in 1989, in Prague (Czech Republic) in 1990 [38], in Heidelberg/Heilbronn (Germany) in 1992, in Newcastle (Australia) in 1997, in Portland (USA) in 2003, in Athens (Greece) in 2005, and in Buenos Aires (Argentina) in 2008. Later educational meetings were conducted during MEDINFO conferences.

The importance of information systems for healthcare was then recognized by the European Community. The AIM (Advanced Informatics in Medicine) initiative was a

research and development activity of the European Community managed through Directorate General XIII of the European Commission. Since hardly any curricula in health informatics existed, it was concluded that one of the tasks of EDUCTRA (Information Technologies for EDUCation and TRaining) had to be to define guidelines for developing curricula for various groups of professionals. The objective of the guidelines was to provide trainers with a framework according to which they could design their courses. These guidelines were produced and published in 1995 [39-41].

An Erasmus Inter-University Cooperation Programme (also funded by the European Commission) was developed at the MSc level with a focus on education in Health Informatics. The programme funded by Erasmus (from 1989 to 1998) and coordinated by the University of Athens (Greece) [42] was organized in two phases. More than twenty European Universities were exchanging professors and students in the implementation of this intensive Master's programme in Health Informatics. It was the first time that the term "Health Informatics" [43-89] was used in an official academic program and was academically appointed to represent our field. Other programs developed courseware [90]. In 1993, the joint European project EuroMISE (European Education in Medical Informatics, Statistics, and Epidemiology) started under the umbrella of the European Trans-European Mobility Scheme for University Studies (TEMPUS) programme. The idea was to teach the teachers in various fields including health informatics [91]. Furthermore, the IT EDUCTRA project approved in the Fourth Framework programme of the EU in 1995 [92], as well as the NIGHTINGALE project (Nursing Informatics Generic High-level Training In Nursing – General Applications for Learning and Education), again an EU financed project, was approved in 1995 [93]. The project was considered essential for planning and implementing a strategy to train the nursing profession in using and applying healthcare information systems. Various European Conferences on Health Telematics education were also organized [94-96] and a textbook in health informatics for nurses was compiled [97].

Consolidation Stage

From the 90s, the University of Maryland in Baltimore began to enter information collected on health/medical informatics programs worldwide into a database [98]. IMIA's Working Group 1 on Education and Training in Medical Informatics provided guidance on critical issues of policy and purpose. It was then decided to establish a website at the University of Heidelberg. The main goal was to give potential students easy access to a new version of the database [99].

IMIA identified the need to develop international recommendations for health informatics education and elaborated IMIA recommendations taking into account the various existing and mainly national recommendations. IMIA recommendations were published in 1999 and centred on the educational needs of healthcare professionals to acquire knowledge and skills in information processing and information and communication technology as needed and applied in medicine and healthcare [100]. These recommendations were received positively as can be concluded from the many citations. Because of the tremendous progress in and the evolution of our field of health informatics, the contents of these recommendations became partially out-dated. Therefore, a first revision of IMIA recommendations was published in 2010 [4]. The name of the domain area was changed to Biomedical and Health Informatics.

Quality Control

IMIA recommendations define the knowledge and skills necessary for the different types of health informaticians. In many countries, the quality of educational programs is monitored via an accreditation procedure. Independent of national programs, IMIA developed an accreditation procedure as a support for institutions that want to establish the quality of their program in health informatics at an international level [101].

2 Methods

In order to achieve our aim to present the development of medical informatics education during the years from the establishment of IMIA until today, an on-line query was conducted on the following databases: PubMed, Scopus, Google Scholar and ScienceDirect. The search was performed from October to December 2015. We focused on papers whose contents included subject areas, namely Bioinformatics, Biomedical Informatics, Health Informatics, Medical Informatics, Nursing Informatics, as well as related information about International Medical Informatics Association (IMIA). To find scientific contents related to our topic, specific keywords were used like: "Bioinformatics", "Computational Biology", "Biomedical Informatics", "Health Informatics", "Healthcare Informatics", "Medical Informatics", "Nursing Informatics", "Informatics" and "Imia". In addition, in order to locate papers in the areas of "Health Informatics/Healthcare Informatics", "Educational Programs", "Curriculum", "Training", and "Education", additional terms were used such as "Health Information Technology", "Health Information Science", "Health Information Courses", "Biomedical Informatics Programs", "Biomedical Informatics Educational Programs", "Health Informatics Programs", "Health Informatics Educational Programs", "Medical Informatics Programs", "Health Informatics Curriculum", "Health Informatics Curricula", "Medical Informatics Curricula", "Medical Informatics Curriculum", "Biomedical Informatics Curriculum", "Healthcare Informatics Curriculum", "Biomedical Informatics Training", "Continuing Professional Education", "Health Informatics Training", "Medical Informatics Training", "Health Informatics Education", "Biomedical Informatics Education", "Healthcare Informatics Education", "Medical Informatics Education", and "IMIA accreditation" (see Fig. 1). However, the final selection was performed taking into account the title, keywords, and abstract. The overall number of papers selected for further analysis was 177. It should be noted that the intention of the author of this article

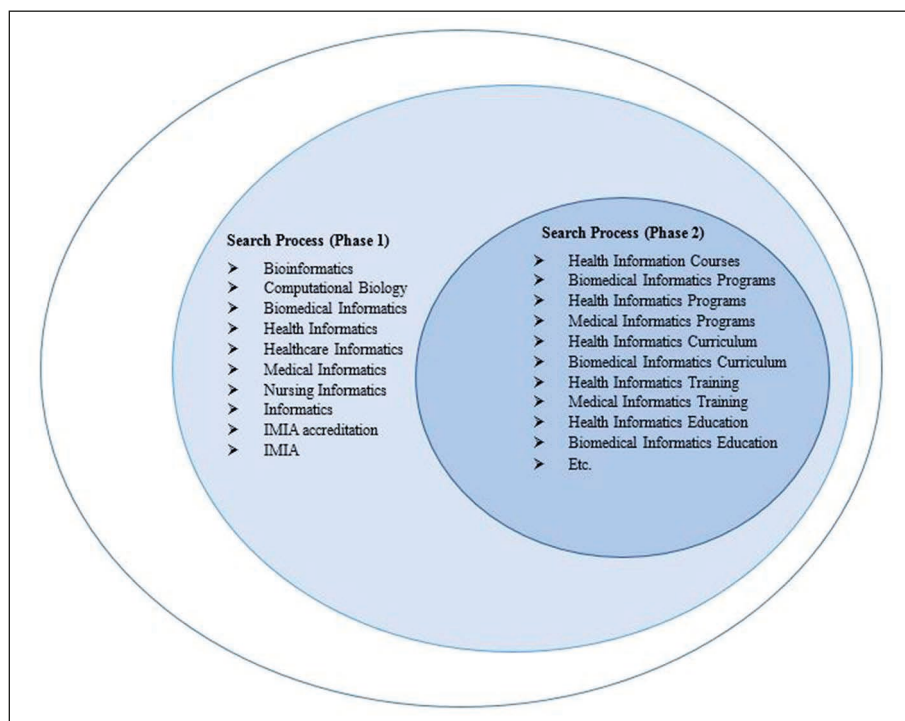


Fig. 1 The search process of papers related to Biomedical Informatics Education

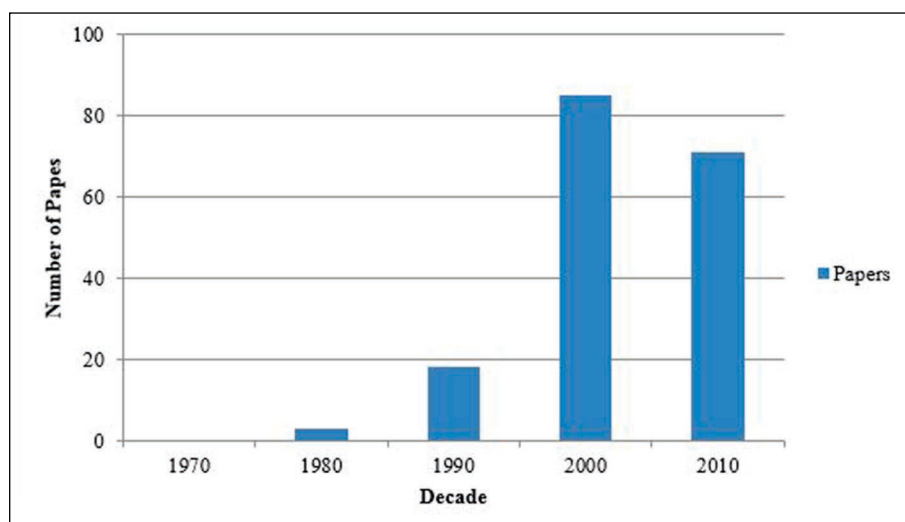


Fig. 2 Number of published papers per decade (n = 177)

was to provide a wide selection of papers to be included in the analysis.

The time period used as a search criterion for this research was from 1967, the early establishment of IMIA, until December 2015. In particular, in the follow up analysis, we wanted to extract descrip-

tive statistics on the contents of the papers and the origin of the publications. Papers with information on academic programs, theme areas, curriculum, evaluation, and accreditation process were located and an analysis of the date of publication was performed.

3 Results

A descriptive analysis was first performed on the yearly (actually, in decades) frequency of the papers, the regional distribution of the origin of the papers, the theme areas, the educational level, the evaluation, and the accreditation.

a Time Span

The distribution per decade of the retained papers appears in Fig. 2. Few papers were published in the early years. The creation of the IMIA working group on education and the frequent annual meetings that were organized mobilized educators and researchers. They published their results in the later and recent years, as seen in the figure. From the Fig. 2, it is clear that a rapid increase in the number of publications occurred after the 1990's coinciding with the direct involvement of the IMIA working group on education facilitating the dissemination of educational activities in biomedical and health informatics.

b Regional Distribution

The analysis of the retained papers according to the origin of the first author shows that North America and Europe played an important role in the advancement and implementation of educational programs in medical informatics throughout the years. However, considering the population of those two continents, one has to emphasize the important progress in recent years of other regions (see Figures 3 and 4).

c Thematic Areas

i Frequency of papers using domain search terms

Table 1 displays the frequency of the papers using domain keywords as search terms in the papers retained for the analysis. The terms "Health Informatics" and "Medical Informatics" are the most frequently met; time-wisely, "Health Informatics" appears later than "Medical Informatics". "Nursing Informatics" [102-134] is the third most frequent term exemplifying the importance that informatics increasingly played in Nurs-

ing in the recent years. On the other hand, “Bioinformatics” [135-136], is frequently used although it appeared in the literature quite later than the other terms.

ii Frequency of papers using educational term keywords

As shown in Table 2, the most frequent papers appear when searched with the

search term “Education” and secondly “Curriculum”. “Education” was expected to be the most frequently met, since it is rather generic. “Curriculum” was often encountered because many efforts on developing curricula were reported in the literature. It should be noted that the keyword IMIA could be found in a few publications because of the previously mentioned educational recommendations

and lately because of historical articles. The IMIA accreditation is mentioned in several articles, as the effort is still minimal.

The above-mentioned generic terms are related not only to the educational field but also to research as a number of research funded programs have focused on the whole spectrum of biomedical informatics (see [137-159]) as described in Fig. 5.

d Curriculum Development

The majority of the papers describe educational programs at all levels of education (undergraduate, graduate, and doctoral). Also a number of publications are focusing on shorter periods of education, such as specialty training programs, distance / e-learning programs, life-long learning, vocational training, and certificate programs (Fig. 7). A few articles provide full documentation of the description of the curriculum, whereas the rest is focused on the curriculum development process. In the early years of medical informatics [160-212], incorporating computer science courses in medical/health sciences curricula was a difficult task. The conservative approach regarding medical curriculum modifications in medical schools was one of the major factors of delaying the adoption of medical informatics courses in medical core curricula. In most papers on educational programs, there is a description of the evaluation process to validate the acceptance of the curriculum and the implementation of the program. The majority of educational programs were adapted to the needs of the local societies and national healthcare systems; the diversity of curricula reflects those diverse needs. Later articles tend to describe a curriculum based on latest educational descriptions. As a result, we have papers with a detailed description of objectives, learning outcomes, and skills. This kind of curriculum description is more structured, easier to be evaluated, maps educational needs, and reflects the professional requirements. IMIA-developed educational recommendations have utilized a structured approach to demonstrate how a biomedical informatics curriculum can be developed at any educational level.

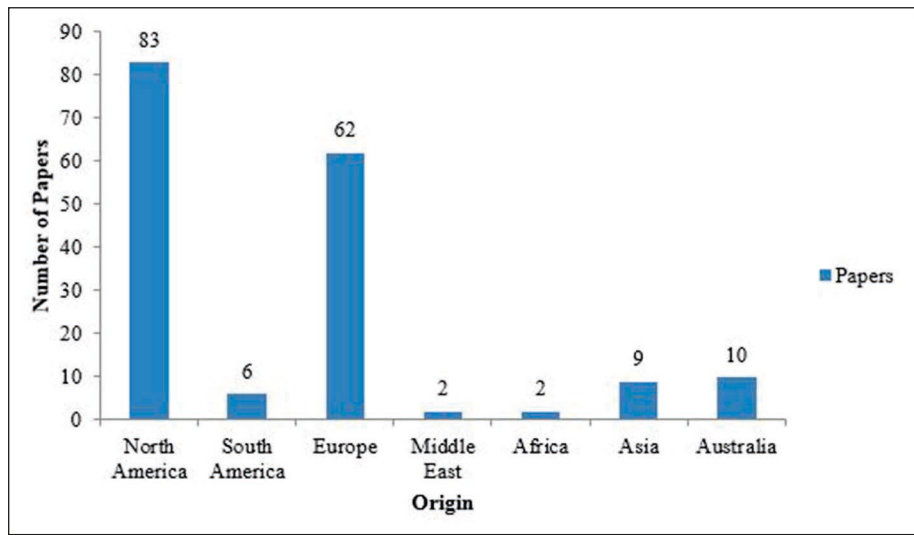


Fig. 3 Number of published papers per origin (n=174, some authors had multiple origins and the corresponding papers were removed)

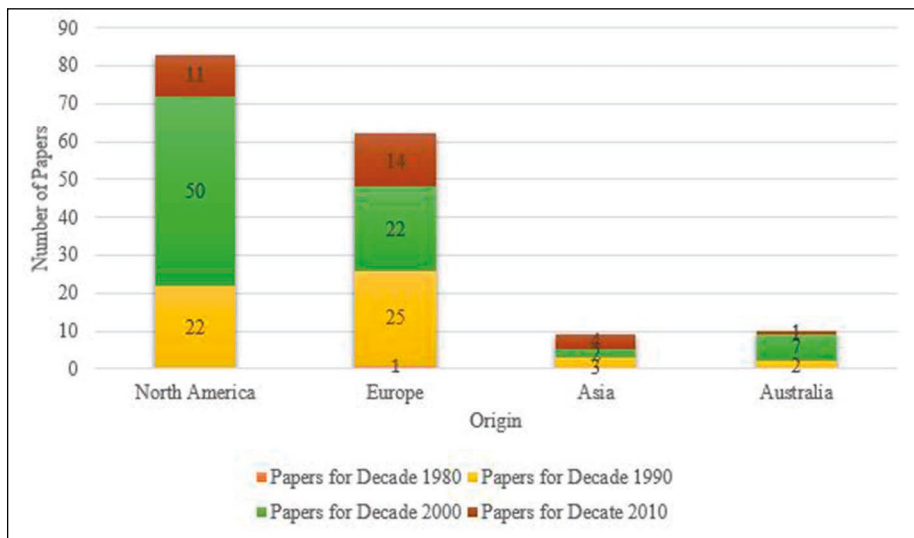


Fig. 4 Number of published papers per origin and decade

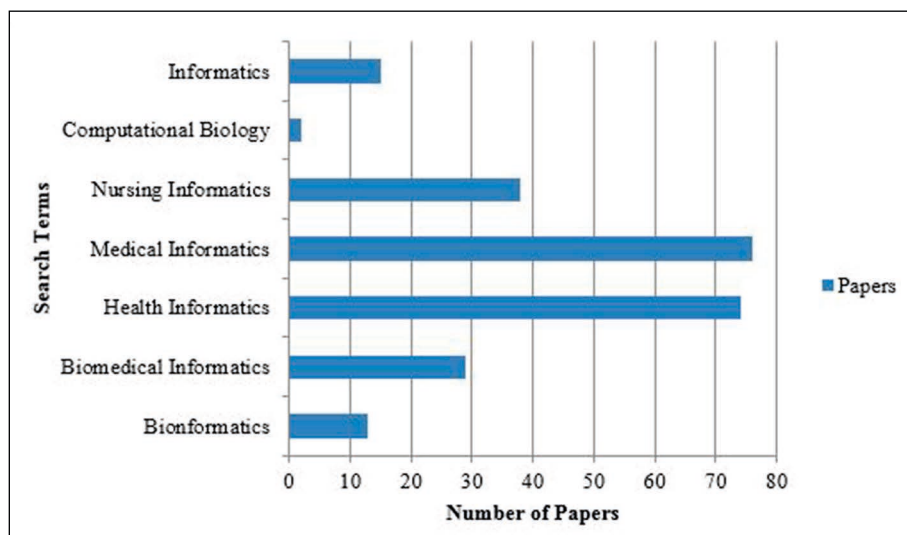


Fig. 5 Number of papers per generic Medical Informatics search term

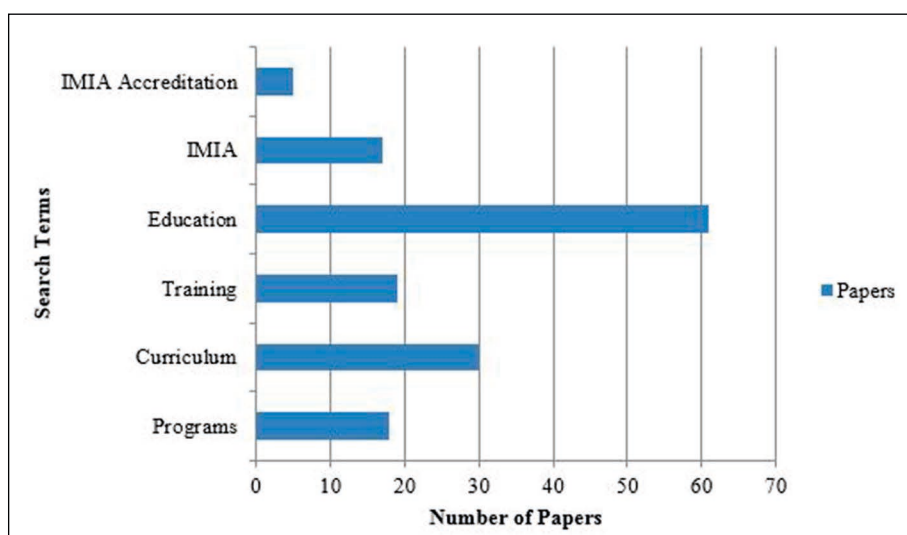


Fig. 6 Number of papers per educational Medical Informatics search term

Table 1 Number of papers per generic Medical Informatics search term (multiple terms may exist per paper).

Search Terms	Number of Papers
Bioinformatics	13
Biomedical Informatics	29
Health Informatics	74
Health Information technology	4
Health information science	1
Health informatics courses	1
Medical Informatics	76
Nursing Informatics	38
Computational Biology	2
Informatics	15

Table 2 Number of papers per educational Medical Informatics search term (multiple terms may exist per paper).

Search Terms	Number of Papers
Programs	18
Biomedical informatics programs	2
Biomedical informatics educational programs	3
Health informatics programs	5
Health informatics educational programs	2
Medical informatics programs	2
Curriculum	30
Health informatics curriculum	2
Health informatics curricula	2
Medical informatics curricula	1
Medical informatics curriculum	5
Biomedical informatics curriculum	2
Healthcare informatics curriculum	2
Training	19
Biomedical Informatics Training	1
Continuing professional education	1
Health informatics training	2
Medical informatics training	2
Education	61
Health informatics education	18
Biomedical informatics education	1
Healthcare informatics education	2
Medical informatics education	13
IMIA (recommendations, history)	17
IMIA Accreditation	5

e Accreditation and Evaluation

In the later years, emphasis focused on both evaluation and accreditation processes. In most countries, a national evaluation committee exists that evaluates in specific periods all educational programs at any level. However, a few organizers of educational programs expressed the need for a more objective outside body to evaluate and accredit programs for international reputation. To this end, IMIA has provided an accreditation

process based on the IMIA Educational Recommendations. Other national associations like the American Medical Informatics Association have moved to the same domain. The evaluation/accreditation process has as its main goal to evaluate a program including a site-visit and to provide suggestions for improvement to the program organizers. These modifications would be monitored by the evaluation committee after a period of three to five years ensuring an international quality control of educational status.

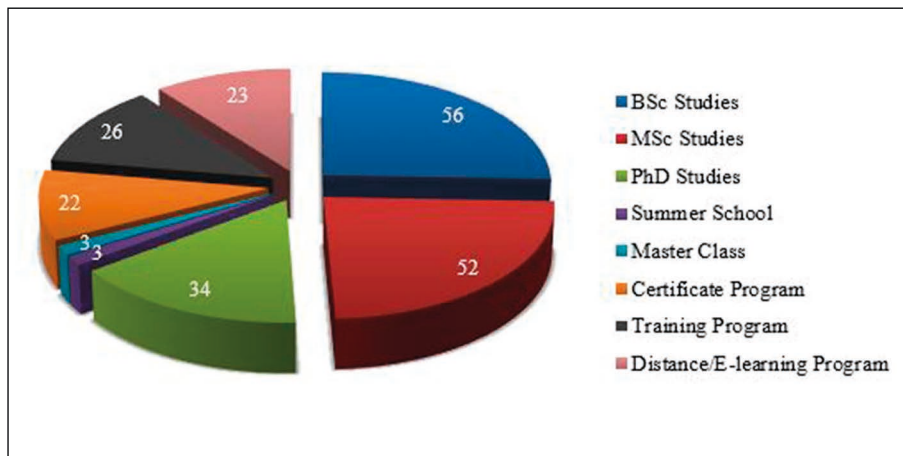


Fig. 7 Number of papers per curriculum

Limitations

This review article has a number of limitations. First, the literature search was limited to English language papers. In the first years of IMIA, other papers written in languages such as French, German, Russian, and Japanese may have had a strong significance in the evolving field. Second, very few papers exist in the years from 1967 to 1987, which may be due to the lack of registration and classification of the articles in the now well-known bibliographical databases; so, the search may be incomplete for those years. Third, the search of papers in Nursing Informatics education may not be complete as other databases are used frequently in Nursing such as CINAHL, which was not used in this current review. Furthermore, for certain questions, access to the full paper was required to extract information, especially in the curriculum section. As access to the full paper was sometimes limited, the extracted information was in some cases incomplete. In summary, this study's limitations include the use of only English language papers and the search on title and abstracts only. Furthermore, we only focused on the literature and did not cover the complete spectrum of contributions of education under IMIA-related societies and groups. Finally, we consider that in certain sections of the review, a further and a more in depth analysis is still required.

4 Conclusions

The paper presents an overview of the Medical Informatics educational activities during the years of IMIA's existence. In the introductory part, a kind of stepwise approach is followed depicting a series of important accomplishments throughout the years. The five stages described are based on a previous publication [1]. The retrieved papers were analyzed in a descriptive way in terms of time distribution, regional origin of the publication, contents in terms of keywords, curriculum description, and evaluation and accreditation processes. Limitations of this research are described.

It is evident that the remarkable local and individual efforts made to develop and establish medical informatics educational courses were put forward - first as part of medical/health sciences curricula and later in specific programs at the postgraduate and undergraduate levels. IMIA acted in the late 1980's as a forum for exchanging experiences and ideas and later as a catalyst to unify and integrate the different initiatives, with the development of educational recommendations as guidelines, which facilitated the development of new programs across the globe and permitted the comparison between different programs. Therefore, IMIA has transformed the "ego-system" (in a good sense) of the early years in an "ecosystem" of educators and institutions truly dedicated to the expansion of biomedical and health informatics education.

The later process of accreditation initiated by IMIA can provide a very powerful tool to the Universities/Institutions seeking for international acknowledgment of their accomplishments and to the IMIA community for expanding in all regions and continents the biomedical and health informatics discipline.

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Correspondence to:

John Mantas
Health Informatics Laboratory
Department of Nursing
School of Health Sciences
National and Kapodistrian University of Athens
Greece
E-mail: jmantas@nurs.uoa.gr