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Recommended target audience, course content and learning arrangements for teaching health informatics competencies: A scoping review

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Abstract

Background: As healthcare depends on health information technology, there is a growing need for Health Informatics competencies in daily practice. This review aimed to explore how the teaching of education in HI has been arranged. 28 publications, published in English between 2016 and 2020 and obtained from selected bibliographic databases, were reviewed. The data was analyzed using deductive content analysis with the following pre-formulated topics: *target audience, course content and learning arrangements*. The results highlight three key competencies: documentation and communication, management, and understanding of health information technology. It underlines a blended teaching method to improve the competencies of healthcare professionals, graduates, undergraduates, and suggests adding active interactions, multi-professional interactions, and hands-on skills. This study highlights the importance of adapting to changes in healthcare, improving HI competencies in healthcare, and fostering positive digital experiences. It underlined the need for practical training, in theory and

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hands-on sessions, including key competencies in documentation and communication, management and health information systems.

Keywords
Health informatics competencies, course content, learning arrangement, target audience

Introduction

As healthcare services are based on patient data,[1] they cannot exist without health information technology (HIT). HIT supports daily work routines in healthcare, but it may also cause challenges and affect the work differently.[2] How well a system is integrated into the healthcare systems and individual health organizations varies depending on the user's level of satisfaction.[3] Some nurses, for example, may feel that they do not have the competencies or training to use digital tools for work. Currently, during typical educational programs for healthcare professionals, an inadequate level of education in informatics is offered, or in some cases no education in this field is provided.[2,3]

Because of the challenges in healthcare, core competencies in informatics were developed to meet the needs of all healthcare professionals.[4] Educational recommendations that have been developed to support education and competency developments in health informatics (HI).[5] The International Medical Informatics Association (IMIA) recommendations on Education in Biomedical and Health Informatics (BMHI) guide curricula and were developed by the IMIA for all healthcare professionals. The IMIA recommendations define and link the competencies and knowledge needed for all health informaticians and the profession.[6] A certain level of expertise in HI is also essential in the nursing practice. For example, the Technology Informatics Guiding Education Reform (TIGER), was developed to focus on integrating nursing, technology, and informatics into research development, education, and practice.[7]

The health IT Competences Tools and Repository (HITComp) was created as a recommendation for collecting data on the competencies and skills that are essential at various levels of knowledge and for various roles in healthcare. The HITComp Repository is a searchable database developed for everyone interested in HIT and plays a vital role in connecting competencies, education, and competence for all healthcare professionals.[8] Further, the Commission on Accreditation for HI and Information Management Education (CAHIIM) focuses on establishing accreditation standards for the different programs.[6] While HITComp is a tool and repository that can gather information on skills and competencies required in healthcare,[8] CAHIIM is used to accredit educational programs to students aiming for a career in HI and health information management.[9]

Acquiring competencies in HI requires dedicated effort, motivating universities to proactively design and implement courses aimed at facilitating student's in mastering these competencies. While optimal timing for introducing HI competencies to students remains uncertain, this presents an opportunity for universities to cultivate the competencies for students.[10–12] There are discussions about whether to teach HI at the bachelor's and master's levels,[1,10,13] or as a course for postgraduates and healthcare professionals.[11,14] The IMIA recommendations focus on delivering education, training, and high-quality healthcare in BMHI.[6] The proposal suggests incorporating HI into the curriculum for undergraduates at both introductory and advanced levels within the first 2 years of their education. Introducing education on HIS in the later year of the academic program, particularly during the final years.[15]

The IMIA recommendations also divide learners into three different roles. The first role aims to introduce the learners to fundamental topics in BMHI, in other words a beginner's level. Learners in the second role, the BMHI generalists, are learners from a non-BMHI background. The education

for the BMHI generalists requires competencies and knowledge in assisting different biomedical and health informatics aspects and information technology. The third role, the BMHI specialists, are learners with a BMHI background. This role focuses on education where the learners focus on knowledge in their fields and specializations.[15]

A review by Nazeha[16] indicates that competencies and knowledge in HI are relevant for all healthcare professionals and can be implemented into HI education.[16] From a clinical practice perspective, it was shown that knowledge and positive experiences in HI contribute to the safe use of patient data and expertise to avoid errors in healthcare systems.[17] Without training or HI education, healthcare professionals may be less interested and less willing to learn or use HIT due to feelings of incompetency.[18] Positive experiences will encourage a willingness to adopt technology in daily work routines, and the work environment will also be positively affected.[17]

Objective

This review aimed to explore how the teaching of education in HI has been arranged. This study focuses on the content, learning arrangements, and target audience. The research questions for this study are: Who is the target audience for HI education? What is the typical content in HI education? What are the common methods of organizing HI education?

Methods

The scoping review methodology guidelines of the Joanna Briggs Institute (JBI) were used to identify English language publications published between 2016 and January 2020. Table 1 Only publications published within this time frame were searched because of the competency needs generated by recent technology advancements.[19]

The PCC format[19] was used to define the study population (P), concept (C), and context (C) (Figure 1, Table 2). The population was defined as the audience, including teachers, education planners, study advisers, executive teams, and HI-related teams. The concept was defined as educational recommendations, curricula, and degree programs in HI. The context included educational levels such as university education on all levels, basic studies, and advanced studies in HI. The bibliographical database MEDLINE via PubMed, Scopus, and Web of Science were accessed with help from the informatics librarian. Only publications found in these three bibliographic databases were included in the review; gray literature was excluded. All publications were considered.

Table 1. The search strategy.

Data base	Search string
Scopus	(TITLE-ABS-KEY ("health informatics" OR "medical informatics") AND TITLE- ABS-KEY (education* OR curricul* OR program) AND TITLE-ABS-KEY (recommendation* OR proposition* OR endorse*))
PubMed	((("health informatics" OR "medical informatics")) AND (education OR curricul* OR program*)) AND (recommendation* OR proposition* OR endorse*)
Web of Science (From web of Science core Collection)	TOPIC: (("health informatics" OR "medical informatics") AND (education* OR curricul* OR program) AND (recommendation* OR proposition* OR endorse*))

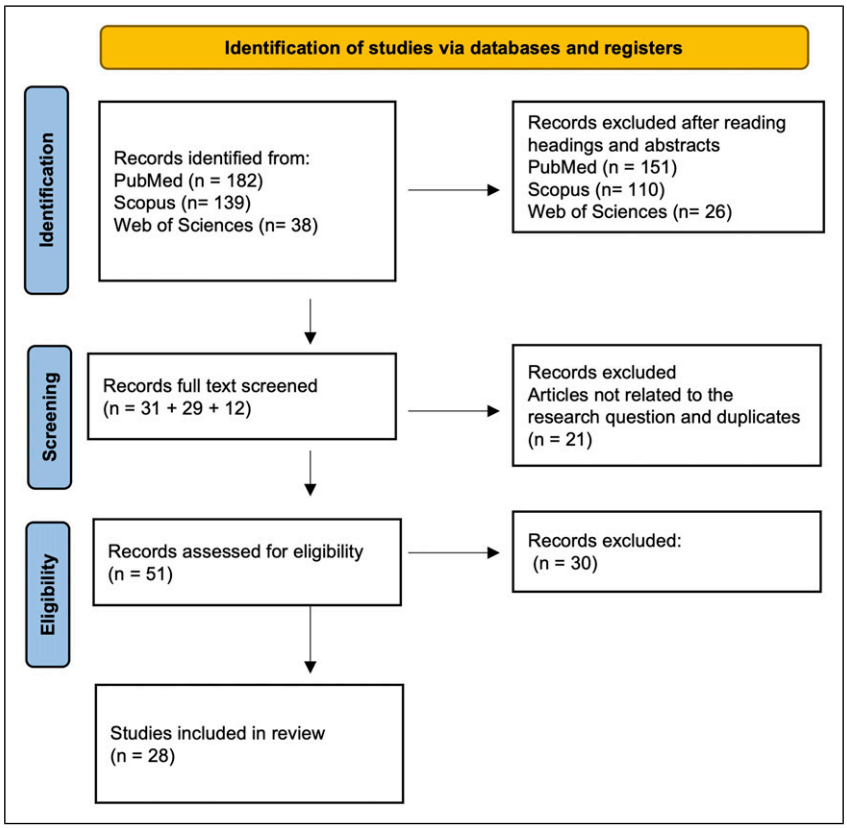

Figure 1. Flow chart of the data collection according to PRISMA.[20]

Table 2. Inclusion criteria.

Inclusion criteria			
PCC format	Participants	Concept	Context
Synonyms included	- Teachers - Students - Education planners - Study advisors - Executive teams - Different teams related to the teaching area	- Educational recommendations - Curricula - Degree programs in HI	- Educational environments in HI - University educational levels (undergraduate, graduates and postgraduates)
Timeline	2016 – 2020		
Document type	- Articles (qualitative and quantitative) - Chapters in book - Conference proceedings - Book series		
Language	English		

Three members of the scoping review team screened the headings and abstracts of 359 publications (Figure 1). 72 full-text publications met the criteria for the second screening, of which 21 publications were excluded after the inclusion and exclusion criteria or were duplicates. Keywords (Table 1) that could be found in both the headings and abstracts were used as main inclusion criteria to find relevant publications. Figure 1 shows the PRISMA flowchart with a step-by-step method for how the scoping review was done .[20] Twenty-eight publications (Appendix 1) were chosen for the in-depth analysis and each of them was reviewed by at least two reviewers independently. The content was analyzed with deductive content analysis using a structured matrix[21]: 'target audience', learning arrangement', and 'course content'. Further, these preformulated themes were categorized into more accurate main themes and sub-themes. The content of the selected publications was read thoroughly and only content relevant to the preformulated themes were analyzed, categorized, and added under suitable main categories and sub-categories. Each main category and sub-category are presented in the tables with presentation of the results. Microsoft excel was used as the data extraction tool.

Results

Out of the 28 publications included, five studies were conducted in the USA, eight in Germany, four in Austria, three each in Finland and the UK, two in Canada, and one in Australia, Norway, and the Netherlands. Eight studies were published in both the years 2019 and 2017, six publications in 2018, and five publications in 2016. Only one study was published in January 2020.

11 studies discussed adapting and validating competencies in informatics, different standardized framework (e.g. TIGER and IMIA), nursing informatics and education in HI. Seven publications focused on the educational curriculum in HI and two publications discussed recommendations in HI. Two highlighted courses in HI, two highlighted hands-on skills, and one of each was concerned with online education, continuous education, and Health Data Sciences (Table 3).

Who are the targets for HI education

Previous publications showed that healthcare professionals, including physicians[25,30,32,44] and nurses,[23,25,26,30,31,46,48] as well as managers[25,31,46,48] should have competence in HI. It is also suggested for healthcare organizations,[26,27] employers [24] and anyone working with HI[41] (Appendix 1, Table 4).

These competencies are also important for undergraduates,[33,34,36,42,43,46,48] graduates[23,27,28,34,35,39,40,42–46,49] PhD students and PhD candidates,[28,49] researchers[28] and teachers.[24,26,27] For those who want a certificate[36] or are interested in learning HI,[24,28,29] a continuing education program can be offered.

Course content

The studies (Appendix 1, Table 5) highlighted documentation and communication as one of the most important competencies in HI education. Documentation is the legal basis for electronic patient records and electronic medication and documentation systems[40] for transferring data between different systems in the care process.[24] To optimize the use of the healthcare systems, a standardized language is needed [24,28,29,31,33,37–40,43] to ensure the quality of documentation.[40] This also enables a better understanding of the care process[24] and patient-related work.[31] It is important to understand both clinical and non-clinical data[43] and how to store, collect and access them.[28] The

Table 3. Topics discussed in the publications.

Topics	Sub-category	References
Competency framework	Nursing informatics	22–24
	Technology informatics guiding educational reform (TIGER)	25–27
	American medical informatics association (AMIA)	28
	International medical informatics association (IMIA)	29
	Inter-professional eHealth competencies	30
	Health informatics competencies	31
	Medical informatics	32
Curriculum in HI	Nursing curricula	33
	Biomedical and health informatics	34
	Health informatics curricula	35–37
	Pharmacy informatics	38
	Public health informatics	39
Recommendation	Health IT-evaluation	40
	National health information work force	41
Online course	Joint program	42
	Cross-countries and inter-professional	43
Hands-on skills	Assess health informatics training	44
	Refresh [45]	
Online degree	Online master's program	46
Continuous education	Topics for continuous education in nursing informatics	40
Health data science	Health data system	47

Table 4. Target audience.

Main category	Sub-category	References
Graduates	Master's degree	23,27,28,34,35,39,42–46,49
Undergraduates	Second-year students	38
	Bachelor's degree	33,34,36,42,43,48
	Student trainees	28
PhD students	PhD in clinical transitional sciences	28
	Postgraduates	49
Teachers	Educators	22
	Teachers	24,26,27
Healthcare professionals	Employers	24
	Nurses	25,26,30,31,40,48
	Nurse managers	23,25,31,40,48
	Other staff members	29,37,40,41,44
	Physicians	25,30,32,44,47
	Specialists	29
Other	Learners with different backgrounds	24,28,29
	Certificates in informatics	36
	Frontline clinicians	44
	Healthcare organizations	25,26,42

ideal is that every nursing and IT curriculum would teach basic terminologies in HI, classification systems and generic healthcare terminologies, although in practice not every nursing and IT curricula has included them.[29,30,33] Competencies in documentation and communication have an impact on hands-on skills[31] in patient-related communication,[30,31,48] leadership-related communication,[26] and institutional-related communication.[28,30,33,42,44] These competencies can be achieved by completing a practical training in which one could learn communication and documentation with the terminology used in HI.[26] Data protection and security is an essential part of documentation[22,25,30,31,43,47] that needs to be taught. The same was true in the case of ethics in health IT.[24,25,30]

Another competency which was highlighted is different types of management. The differences between the information systems in hospitals can be significant, but in any case, it is important to have organizational structures for process management to monitor[25,41–43] and at the same time to

Table 5. Recommended course content.

Main category	Subcategory	References
Documentation and communication	Institutional-related information	28,30,33,42,44
	Leadership and communication	26
	Nursing-related documentation	22,25,27,31,40
	Standardized terminology	24,28,29,31,33,37–40,43
	Patient-related communication	30,31,48
	Health literacy	27
Data protection and security	Data privacy	43,49
	Patient privacy	22
Management	Change management	25,29
	Data management	27,28,32
	Leadership in direct patient care	24,30
	Knowledge management	22,33,34,44
	Process management	25,41–43
	Project management	22
	Quality management	26,30
Health information system	Architectures of health information systems	42
	Basics in information system	37,42
	Consumer-focused	32,47,48
	eHealth technology	40
	Electronic health record	28,38,42,43
	Information exchange	43
	Nursing information system	29
	Patient data	43
	System evaluation	39,42,43
Ethics in health	Confidentiality	24,26
	Direct patient care	30
Knowledge in computer science	Basic computer competencies	28,33,34,40,44
	Interoperability	43,48
Competency framework	CanMeds	32
	TIGER	22,27
	Guidelines	28,34,36,48
Research	Entrepreneurship	26
	Funding opportunity	48

have access to correct data.[27,28,32] Information and knowledge management in patient care is considered important,[22,33,34,44] even though it is not taught in all curricula.[33] Other competencies, such as project management,[22] change management,[25,29] and quality management[26,30] were also mentioned. Additionally, leadership in patient-related work[24,30] are ongoing current topics of interest.[42,43]

Apart from learning competencies in management, knowledge in using HIT was also highlighted as a competency healthcare professionals need to learn,[37] especially knowledge about how the systems and data are structured, functioned, and processed.[37,42] They also need to be able to evaluate the quality of the information system[39,42,43] and eHealth technologies or IT tools used in healthcare.[40]

Learning HIT requires basic knowledge of computer science to understand better the use of information systems within healthcare organizations.[37,42] Fundamental computer science competencies, such as data security and interoperability, are recognized as essential.[30] These competencies are considered qualifications that can be taught through standalone educational programs or as certificates integrated into continuing education offerings.[34] In some curricula, knowledge of computer science is included as a part of the education,[33,44] whereas in some curricula, competencies in computer science are seen as less critical.[40]

In a computerized environment in which technology changes rapidly and the use of technology is a part of daily routines, there is a need for hands-on training. Compulsory practical training[37,48] supports practical experiences[32,33,37] and is a possibility to learn the implementation of technical competencies.[33,39,43] A mentor or supervisor should show the competencies,[32,42] to set the learning objectives and evaluate the competencies.[49] However, all curricula do not include hands-on trainings.[33]

Internationally accepted frameworks such as the Technology Informatics Guiding Education Reform (TIGER),[22] The Canadian Medical Education Directives for Specialists (CanMEDs)[32] and other guidelines[28,34,36,48] contain different competency areas or domains. These competency areas can be used as guidelines for employers, learners, and teachers,[24] but not all are necessarily needed in every HI education program or related course.[44] For researchers, competencies in entrepreneurship should be an additional aim.[26]

Most common learning arrangements

Previous publications (Appendix 1, Table 6) have shown that integration and cooperation are relevant pedagogical methods and were used as examples when developing online learning courses.[46] A course in HI is not only a blend of practice and theory but also an integration and collaboration with other students[38,42,46] and teachers.[28,35,36,39,41–43,46] Another relevant pedagogical method used was creating learning activities suitable for the participants. Completing courses in HI could vary from face-to-face, online and hybrid teaching to blended learning activities.[46,49]

Since learning is an individual process, a variety of options for primary learning and teaching periods should be offered to the learners.[26] This process can be actively stimulated with the participants' general learning objectives and personal goals.[27,46] Each participant is given time to build their own learning outcomes based on the course content.[26,27,46] Setting personal goals in the learning process prepares students to think critically[28] and to develop their HI competencies.[33,40]

HI courses are divided into building blocks that can be realized as classroom lectures or interactive seminars.[36,42] Publications reported various HI course offerings on campus, online, or in a hybrid learning fashion. Each block has different assignments[42,44] with separate learning objectives,[49] instructions, and literature,[39] and the content may be independent publications and lectures

Table 6. Learning arrangements in the course.

Main category	Subcategory	References
Assessment	Evaluation	29,42
	Evaluation criteria	43
	Examination	32,43
	Feedback	42,44
Building blocks	Assignments	42,43
	Learning modules	27,32,36,39,44–46,49
	Learning objectives	49
	Learning techniques	39
	Seminars	36,42
	Validations and adaptions	23,28,44
	Workloads	35
Continuous education	Educators in HI	46
	Professional training	37,45,48
	Refresh knowledge	41
	Specialist in HI	49
Interaction and cooperation	Multi-professionally	23,28,33,35,48
	Cooperation internationally	42,48
	Discussion platforms	41,43
	With other students	38,42,46
	With students and educators	28,35,36,39,41–43,46
Learning activities	Deadlines	41
	Drop-in sessions	49
Pre-requisites	Sufficient background knowledge	33,35,40,49
Teaching and learning materials	Appropriate tools	28
	Decided before the course	42
	Easy to access	41,42
	Necessary materials presented	46
	Online materials	41
	Relevant regional and local materials	32
Hands-on skills	Evaluation of practical training	49
	Learning objectives	49
	Practical skills experience	28,30,32,36,38,39,42,43,45,48

to understand better the practical use and implementation of the information systems.[42] The publications reported that some of the building blocks were divided into learning modules,[27,32,36,39,44–46,49] some were integrated into another course,[44] and some were only 1 week long.[27] The building blocks are planned and created depending on the target audience's background and knowledge.[23,28,44]

Creating and structuring a course in HI can be achieved in different ways. One way is to provide teaching materials consisting of both online materials,[41] regional and local materials[32] and tools.[28] The teacher presents necessary materials and instructions[46] for each learning activity that was decided before the course.[42]

The assessment of the course is based on the evaluation[29,42] and evaluation criteria can be pre-defined for all assignments.[42,43] It is also important to present how the tasks are to be assessed,[29,32,42] for example examinations,[32,43] and the criteria should be presented during the first week.[43] Feedback should be given after an accomplished task.[42,44]

All healthcare professionals should acknowledge the benefits associated with digital health and data science.[47] HI should be taught to students and recommended as a component of continuous education, job training, internships, and academic training.[28,37,45,48] If the participant does not know about the topic, they are recommended to take courses to increase their competence.[41] They can take further education to become a specialist in HI or become educators.[46]

In a computerized environment in which technology changes rapidly and the use of technology is a part of daily routines, there is a need for hands-on training. Compulsory practical training[37,48] supports practical experiences[32,33,37] and is a possibility to learn the implementation of technical competencies.[33,39,43] A mentor or supervisor should show the competencies,[32,42] set the learning objectives and evaluate the competencies.[49] However, all curricula do not include hands-on.[33]

Discussion

Looking back at how healthcare systems have changed over the years and how the roles of HIT have changed, the need for effective use of IT in daily working lives,[42] as well as knowledge and competencies in informatics, are growing.[7] Healthcare services depend on the smoothly integrating of patient data into daily work routines.[1,2] The user's proficiency and experience in HI notably affect the extent to which digital services are utilized[3] leading to a growing demand for HI education.[10–12] The findings emphasize the importance of healthcare professionals having HI competencies.[24–26,30,31,40,48] These competencies are first and foremost crucial for healthcare professionals,[28,39,49] including healthcare managers[25,31,40,48] who are directly working with the systems.

Because the demand for HI competencies is high, universities have created and developed courses on different levels of education.[10–12] The IMIA recommendations suggest that HI education should be introduced in the curricula for undergraduates[15] and this study suggest that HI education should also focus on graduate students.[27,28,34,35,39,42–46,49]

As a result, educational recommendations such as IMIA[29] and competency frameworks such as TIGER[25] are helpful in terms of improving competencies in HI. These recommendations and competency frameworks can be included in every curriculum[33] to support future education.[26] The competencies and recommendations can be interpreted and ranked differently[25,27] according to the healthcare professions.[44]

As healthcare professionals may feel they are not confident or satisfied with their competencies and knowledge in HI,[2,3] the finding suggests offering more education in HI to all healthcare professionals especially for nurses,[25,26,30,31,40,48] physicians[25,30,32,44,47] and nurse managers.[23,25,31,40,48] Having positive experiences in using digital technology creates more awareness at every organizational level.[38] To achieve this goal, one university does not need to be responsible for the whole content but can be shared among several universities.[43]

With the growing importance of acquiring HI competencies,[10–12] specific competencies were considered more relevant than others. Key competencies such as documentation and communication,[22,25–28,30,31,33,37,38,40,42–44,48] different types of management[22,24–30,32–34,41–44] and learning about the HIS[28,29,32,37–40,42,43,47,48] are recommended for incorporation in both theoretical and hands-on competency sessions.[28,32,33,37–39,43,45,48]

In terms of teaching HI, the specific method was not explicitly applied. However, the structured teaching of HI competencies involved different building blocks and levels fostering active interaction between students and teachers.[32] The arrangement of the HI courses seems to be a mix of online sessions, discussion panels,[41,43] and regular feedback from the teacher.[42,44] The findings highlighted that the preferred method for organizing HI courses involved building blocks with

learning modules [27,32,36,39,44–46,49] and interactions between students and teachers.[28,35,36,39,41–43,46] Additionally hands-on skills experiences were highly valued.[28,30,32,36,38,42,43,45,48] Interestingly not much focus was put on the teaching and learning materials[28,41,46,49] nor the learning activities.[33,35,40,46] The focus is on individual and team-based learning, interactions between students, teachers, and evaluation of the learning activity of each participant is suggested.[35]

A variation in teaching and learning styles was observed among universities,[25] and between different countries.[22,24,48] Joint programs[34] with preference for a hybrid teaching methodology. However, online courses in HI face challenges such as student isolation, lack of applicable knowledge, and no hands-on learning for the participants. The dropout rate is potentially higher, and the teacher might not be able to have interactive discussions with online students.[40,49] Further, some students might also have less experience in using the learning platform or different levels of interest in learning online.[43]

In summary, this study proposes the inclusion of three fundamental HI competencies in HI educational programs. The first topic is documentation and nursing-related documentation[22,25,27,31,40] with a focus on standardized terminology[28,29,31,37–39,43] and institutional-related information[28,30,33,42,44] The second topic centers around management and process management.[25,41–43] The third focuses on learning HIS prioritizing electronic health records[28,38,42,43] and HIS from a consumer's perspective.[32,47,48]

This study suggests adopting a blended teaching method for education programs in HI. The technique highlights interaction and collaboration among teachers and students[28,35,36,39,41–43,46] and a multi-professional approach.[23,28,33,35,48] The course content is structured in building blocks with various modules[27,32,44–46,49] and includes a hands-on skills component.[28,30,32,36,38,39,42,43,45,48]

This educational approach is designed to benefit healthcare professionals, graduates, and undergraduates.

Limitations

Three well-known databases were used to find the selected publications, but there is always a possibility of missing essential publications. Data retrieval was limited to January 2016 to January 2020, and as this review has taken time to finalize, newer publications may have been missed. Additionally, the indexation of publications based on specific keywords in databases always affects the use of keywords in data retrieval and search results. All the publications were read and commented on independently, and the reviewers were not influenced by each other. The first author did the content analysis, summarizing and analyzing the content independently from co-reviewers.

Most of the publications in HI were performed in developed countries, and we found only one study from the continent of Africa. A similar study focusing on developing countries would provide an exciting and valuable comparison to this study.

Conclusion

This study highlights the importance of adapting changes in healthcare systems, enhancing competencies in HI, and fostering positive experiences with digital technology in the healthcare field. It suggests the need for practical training in HI including key competencies such as documentation, communication, and data security, both in theory and hands-on sessions. The study proposes a plan to achieve competency and emphasizes practical teaching approaches. It also addresses the challenges faced by online courses in HI. The study highlights the universal importance of HI competencies, particularly for healthcare professionals and students.

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Data availability statement

All data used in this study is available to public. This study does not contain any personal data, or any data connected to a particular individual and therefore no ethical approval is required.

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Appendix

Table A1

Table A1. List of selected publications 2016-2020.

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Ahonen et al. 2018.[33] Finland Title: Identifying biomedical and HI competencies in higher education	Population: Undergraduates Context: Undergraduate curriculum	Course content: IMIA recommendations Learning arrangements: Not specified. Who: Undergraduates	The nursing curriculum contains more competencies than any other healthcare curricula, but IT has the highest number of competencies. It is important to take the student's background into consideration
Ammenwerth et al. 2018.[46] Austria Title: Building a community of inquiry within an online-based health informatics program: Instructional design and lessons learned	Population: Graduates Context: Online-based program	Course content: health informatics Learning arrangements: Learning activities (deadlines, interactions, literatures) Who: Graduates	An environment of effective learning and inquiry can be built. A guideline on how to create online cooperative learning is included
Ammenwerth et al. 2017.[49] Austria Title: How to teach health IT evaluation: Recommendations for health IT evaluation courses	Population: Experts in health IT and/or IT-evaluation courses Context: Course in health technology and informatics	Course content: Learning outcomes and activities Learning arrangements: Online, practical parts, different learning arrangements Who: Employed professionals and graduates	A course in HIT with 15 mandatory topics and 15 optional topics is recommended. Practical training should also be included

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Ammenwerth et al. 2019.[40] Austria Title: Topics for continuous education in nursing informatics: Results of a Survey among 280 austrian nurses	Population: Healthcare professionals Context: Education	Course content: Information systems, common language, computer sciences Learning arrangements not specified Who: Employed professionals, graduates	Five topics in health informatics are considered important in continuous education: Project management, IT in nursing, eHealth, nursing terminologies, and computer science basics. Both nursing managers and nurses with IT responsibilities see continuing education as necessary. However, suitable continuous education is missing
Ammenwerth et al. 2017.[42] Germany Title: On teaching international courses in health information systems: Lessons learned during 16 years of frank – van swieten lectures on strategic information	Population: Students learning health information systems Context: Online joint program	Course content: Information systems, management, learning outcomes Learning arrangements: Module, learning material, learning activities, seminar Who: Undergraduates and graduates	Positive feedback on an international course and international exchange on HI systems
Bhyat et al. 2017.[32] Canada Title: Implementing informatics competencies in undergraduate medical education: A national-level "train the trainer" initiative	Population: Students Context: Webinar	Course content: Framework Learning arrangements: Learning activities, practical part, assessments Who: Employed professional, undergraduates	Two canadian faculties created an online collection of e-health educational resources with open access and two activities: Endorsement of eHealth and involvement in curriculum planning. Workshops and webinars were a great success and improved awareness of eHealth
Breil et al. 2018.[37] Germany Title: A comparative literature analysis of the HI curricula	Population: Students Context: health informatic curricula	Course content: Competencies in information systems Learning arrangements: Practical part, learning outcomes Who: Employed professionals	Key competencies in HI are identified. Students are recommended to learn skills, critical skills, and health information management

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Butler-Henderson et al. 2017.[41] Australia Title: The development of a national census of the health information workforce: Expert panel recommendations	Population: Experts Context: Recommendations	Course content: Management Learning arrangements: Online, learning activities, interactions, learning materials Who: Employed professionals	Highlighted themes for the national census of the health information workforce: Census delivery, global census and census advertisement, longitudinal study, and participants. Recommended types of data elements are development, ownership, standards, access, and governance
Egbert et al. 2018,[24] Germany Title: Competencies for nursing in a digital world. Methodology, results, and use of the DACH–recommendations for nursing informatics core competency areas in Austria, Germany, and Switzerland	Population: Experts (nursing and management) Context: Competencies in nursing education	Course content: Framework, management Learning arrangements: Not specified Who: Employed professionals, teachers	Learning across other countries in a combined course in nursing informatics; evidence-based nursing is supported
Egbert et al. 2017,[22] Germany Title: An iterative methodology for developing national recommendations for nursing informatics curricula	Population: Experts Context: Competencies in nursing informatics	Course content: Framework Learning arrangements: Not specified. Who: Teachers	Core competencies in HI are defined and tailored to each country's specific needs
Fossum et al. 2017.[43] Norway Title: Crossing borders: An online interdisciplinary course in HI for students from two countries	Population: Graduates Context: Online course	Course content: Common language, learning activities, information systems, learning outcomes, management, interoperability, practical work Learning arrangements: Interactions, assessment, learning activities Who: Undergraduates	Learning internationally is an advantage for students. Students can conduct discussions and create relationships between disciplines and international boundaries

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Haux et al. 2017.[34] Germany Title: Should degree programs in biomedical and HI be dedicated or integrated?	Population: dual master's degree students Context: Education	Course content: Computer science, extended studiesHI. Learning arrangements: Combined degree Who: Undergraduates and graduates	Students with a dual master's degree in biomedical and HI may not be seen as computer scientists
Hincapie A. et al. 2016.[38] United States Title: Incorporating health information technology and pharmacy informatics in a pharmacy professional Didactic curriculum - with a team-based learning approach	Population: second-year students Context: Online course	Course content: Management, information systems, interoperability Learning arrangements: Interactions, extended studies Who: Undergraduates	Students are positive towards the course and have met the learning outcomes of the course content. The appropriate time for teaching informatics should be considered
Hübner et al. 2019.[26] Germany Title: Towards the TIGER international Framework for recommendations of core competencies in HI 2.0: Extending the Scope and the roles	Population: Experts Context: Framework	Course content: Framework Learning arrangements: Not specified Who: Employed professionals	Core competencies in informatics are highly important for nurses. The framework can be used as a support when shaping education in HI to improve safety and quality in using health information systems
Hübner et al. 2017.[25] Germany Title: Towards an international framework for recommendations of core competencies in nursing & inter-professional informatics: The TIGER competency synthesis project	Population: Experts Context: Framework	Course content: Modules, management, framework Learning arrangements: Learning outcomes, interactions, learning activities Who: Teachers, employed professionals, others	Informatics core competencies are highlighted in all domains. Different countries have their own ways of learning

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Hübner et al. 2018.[27] Germany Title: Technology informatics guiding education reform – TIGER	Population: Experts Context: Education or recommendation	Course content: Framework, learning outcomes Learning arrangements: Not specified Who: Employed professionals, graduates, teachers	24 core competency areas are defined for five major nursing roles. Greater awareness of intrapreneurship and innovation are key factors to successful health information technology
Jidkov et al. 2019.[44] United Kingdom Title: HI competencies in postgraduate medical education and training in the UK: A mixed methods study	Population: Postgraduates Context: Practical training	Course content: Competency Learning arrangements: Modules, assessments Who: Postgraduates, trainees	Competencies in HI should be universal for clinicians and should be included in training curricula. The existing digital competencies are not designed for physicians, and not all competencies are relevant to all specialties
Kinnunen et al. 2018.[35]Finland Title: A Synthesis of Students' theses in the accredited HHSI Master's program	Population: Graduates Context: Thesis writing	Course content: Learning activities Learning arrangements: Seminars Who: Graduates	Students focus on different research areas, and qualitative methods are used. There is a need for encouraging and guiding teachers to use more quantitative methods
Kinnunen et al. 2019.[31] Finland Title: Factors related to HI competencies for nurses-results of a national electronic health record Survey	Population: Healthcare professionals Context: Competencies in nursing informatics	Course content: Information systems. Learning materials Learning arrangements. Not specified Who: Employed professionals (nursing, management)	One-third of respondents do not have sufficient training, and older nurses need complementary training and support in using electronic health records (EHR). Nurses with higher education are more informatics-competent and more experienced in using EHR.

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Mantas et al. 2017.[29] The Netherlands Title: IMIA educational recommendations and nursing informatics	Population: Students Context: Education	Course content: Framework, management Learning arrangements: Learning outcomes, assessments Who: Employed professionals, education workers on all levels	Information technology skills are a part of most nursing courses, but it is not clear whether all undergraduate nursing programs teach nursing informatics. However, there are courses in HI for postgraduates. Reconsidering educational recommendations for nurses and other professionals is recommended
Sapci et al. 2020.[45] United States Title: Teaching hands-on informatics Skills to Future health informaticians: A competency Framework proposal and analysis of healthcare informatics curricula	Population: Graduates Context: Practical training	Course content: Information systems, competencies in health informatics, learning activities, extended studies Learning arrangements: Modules Who: Graduates	Not many publications have been conducted on hands-on skills in health informatics. There is a gap between in-demand skills and existing competencies, and most of the practical skills are gained from work experience. Occupational-specific terms in HI would enable technological solutions to health problems, and a specific competency assessment framework would be needed
Scott et al. 2018.[47] United Kingdom Title: Learning health systems need to bridge the 'two cultures' of clinical informatics and data science	Population: Research Context: health data science	Course content: Management, information system Learning arrangements: Not specified Who: Not specified	The gap between conclusion policy makers and research funders needs to be acknowledged to recognize the social and economic benefits of eHealth

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Strudwick et al. 2019.[23] Canada Title: Adapting and validating informatics competencies for senior nurse leaders in the Canadian context: Results of a Delphi study	Population: Management (nurse) Context: Framework	Course content: Competency Learning arrangements: Not specified Who: Employed professionals, graduates	24 informatics competencies are identified by canadian nurse leaders. Competencies related to collaboration are rated as important and highly relevant. The results will be presented to nursing informatics organizations and the senior national nursing leaders for approval
Thye et al. 2018.[30] Germany Title: What are inter-professional eHealth competencies?	Population: Healthcare professionals, management, researchers, experts, education Context: Education in eHealth	Course content: Direct patient care, IT, management, common language, learning outcomes, information system, practical part Learning arrangements: Not specified Who: Employed professionals (nurses, doctors)	There were not many differences between the various professions, but professionals involved in direct patient care rated some competencies differently from executives. Organizations issuing educational recommendations are encouraged to clarify their competency areas (e.g., communication and leadership, and ethics in health IT)
Topaz et al. 2016.[48] Canada Title: Advancing nursing informatics in the next decade: Recommendations from an international survey	Population: Students Context: Nursing informatics curricula	Course content: Practical work, research, visibility, collaboration, and integration Learning arrangements: Learning activities, learning outcomes, interactions Who: Undergraduates	Nursing informatics includes five central areas of recommendation: Nursing informatics visibility, practice, research, collaboration and integration, and education and training
Valenta et al. 2016,[28] United States Title: Core informatics competencies for clinical and translational scientists: What do our customers and collaborators need to know?	Population: Others (trainees) Context: Framework	Course content: Information systems Learning arrangements: Learning activities, learning materials, interactions Who: Graduates, PhD candidates, researchers	A set of new competencies updated by the clinical research informatics workgroup of american medical informatics association (AMIA) is presented. In the future, the current model of competencies can be used as a model for editing competencies over time

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Table A1. (continued)

First author, year (reference), country. Title	Population Context	Course content Learning arrangements Who to teach	Results
Walpole et al. 2016.[36] United Kingdom Title: HI in UK medical education: An online survey of current practice	Population: Teachers from school and work life Context: Curriculum in HI.	Course content: Framework (national guidelines) Learning arrangements: Learning activities, lectures and seminars, modules, learning arrangements Who: Undergraduates	Three main findings: 1) little education in HI is included in the curricula, 2) the pedagogy, content, and timing of teaching HI vary between schools, 3) the course content is not always updated, and HI is seldom assessed
Wholey et al. 2018,[39] United States Title: Developing workforce capacity in public health informatics: Core competencies and curriculum design	Population: master's degree and certificate Context: Training curriculum	Course content: Practical part Learning arrangements: Learning activities, practical part Who: Graduates, certificate programs	Competencies in public HI are taken from information and organizational sciences and computer sciences. There is a need for core competencies in public health and in data sciences. The proposed educational program in public health can be used as a guideline