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Research Article

The Current State of Medical Informatics Curricula in Undergraduate Medical Education: A National Survey

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Abstract

Introduction: The Medical School Objectives Project (MSOP) focuses on the competencies integrated in medical school curricula. As student education in informatics was not deemed as intrinsic to achieving competency, the penetrance and format of integration have varied across medical institutions.

Purpose: The primary goal of this study was to describe the integration of medical informatics (MI) currently in curricula across medical schools within the United States.

Methods: This is an IRB-approved cross-sectional national survey conducted between January and April 2022. The survey focused on the presence of medical informatics in curricula across US-based allopathic and osteopathic medical schools.

Results: The response rate was 40% (77 out of 192) with up to 50% of respondents reporting formal integration in their UME curricula. The material was offered in elective format (67%), integrated into existing required courses (23%), and as stand-alone required courses (10%); however, only 20% reported seamless integration into the curriculum. In-person lectures (63%) and online modules (27%) were the main formats utilized with 61% initiating learner exposure in the preclinical years. The topics included clinical decision support (46%), reference searching (24%), EHR use (23%), and security and ethics in healthcare (19%). Up to 37% of the educators were informatics-credentialed faculty, 27% had supplementary training permitting informatics mentoring, and the rest were medical librarians.

Conclusion: Undergraduate medical education has no required medical informatics curriculum, resulting in varied exposure and training among medical schools. Students may benefit long-term from competencies set up by educational regulatory bodies.

Keywords: *Competency; Curriculum; Informatics; Medical Education; Students; Survey*

Background

Health informatics is the science of how to use information and knowledge to improve healthcare services. It applies principles of computer and information science to the advancement of life sciences research, health education, public health, and patient care [1]. In 1998,

the Association of American Medical Colleges (AAMC) initiated the Medical School Objectives Project (MSOP) to identify thirty program level learning objectives to be added to medical school curricula, one of which specified the ability to utilize databases to retrieve and manage biomedical information for clinical decision making [2]. However, student education and their knowledgebase in informatics, were not set as a requirement or components intrinsic to achieving competency. As such, penetrance, exposure, and format of integration, as well as faculty support with update regularity varied among medical institutions. In 2007, a survey of 70 medical schools in the United States and Canada was devised to assess the impact of the MSOP guidelines. This study suggested that a limited number of schools had set either medical informatics objectives or formally assessed competencies related to the domain [3].

The current generation of students is no stranger to computers or technology, and are well-equipped to evolve with technological advances. To be successful, students must be armed with the skills not only to access and interpret data efficiently, but also to apply that information to clinical practice [4]. In a survey done at Case Western Reserve University, first- and second-year medical students reported lack of proficiency and desired formal education applicable to their medical practice [5]. In a 2013 study focusing on understanding meaningful use, the internal medicine clerkship students reported lack of readiness to navigate EHR tasks to successfully implement the required actions [6]. Despite the limited literature, the need for structured medical student focused-informatics curricula is necessary so as to complement current health care practices which focus on enhancing patient outcomes. Whether related to EHR navigation and documentation, clinical decision making, or otherwise, the current needs of students may vary based on institution as well as legacy of the school curriculum. As the facets of medical informatics are many, identifying which components to include and train students on from a national basis standpoint becomes vital. This standardization becomes more critical when students transition institutions upon initiation of residency training. While the ACGME does have program requirements for fellowship-level training in clinical informatics, there is no unified documentation for competencies in medical informatics for general undergraduate medical education (UME) given by the AAMC.

On a graduate level of education, in the areas of fellowship training and master's level education, there are defined objectives and competencies to be attained. The American Health Informatics Management Association (AHIMA) defined five areas of health informatics that professional medical education should address: literacy and skills, basic computer literacy, electronic health records, privacy and confidentiality, information and data technical aspects and security and further defined core competencies at the master's degree level [7,8]. While some focused on developing comprehensive and current descriptions of what subspecialist clinical informatician practitioners need to know and do, AMIA attempted to define the domains and formalize the knowledgebase necessary for such providers [9,10]. This concept is critical as the HITECH Act of 2009 placed major emphasis on utilizing technology to improve patient care and decrease healthcare costs. Thus healthcare professionals are required to have basic knowledge and skills in health informatics and data analysis [11]. This act also allows grants to be awarded to develop academic curricula that integrate certified EHR technology into the clinical education of health professionals. One of the results of this has been the development of HealthIT.gov which houses ONC Health IT Curriculum Resources for Educators which can be utilized by all healthcare professions at no cost (https://www.healthit.gov/topic/health-it-resources/health-it-curriculum-resources-educators).

The set of instructional materials, available online to current healthcare workers at no cost. Although physicians and medical students do not require a masters-level understanding of medical informatics, these frameworks can be valuable for development and support of related curricula and educational frameworks.

Given the discordance of expectations set by educational bodies with variability in the perceived and actual importance of such skills, our study aimed to assess the current state of health informatics curricula in US medical schools, from a content, delivery modality, and practical application standpoint through the engagement of educators responsible for students' educational experience.

Methods

This study was an IRB-approved cross-sectional survey conducted across the US between January and April 2022. This national survey consisted of a total of 27 open- and close-ended questions focused on the presence of current medical informatics platforms, interest, integration, and perceived utility in current medical school training based off curricular concerns and suggestions from the MSOP developed in 1998 (See appendix attached).

The survey was devised by a focus group consisting of academic educators with either advanced graduate education in health informatics or clinical practice focused on medical education and health informatics, as well as medical students. The format was overseen and reviewed by an Associate Dean of Curriculum with advanced graduate training in medical education, to ensure alignment and appropriateness of design. The anonymous survey was disseminated electronically to all representatives (associate deans of medical education and/or curricula and those involved in curricular development including foundational and clinical courses) of 155 accredited allopathic medical schools and 37 colleges of osteopathic medicine via DR-ED@list.msu.edu listserv. Having received permission to share the survey from the registry within a prespecified time period within the study and prior utilization by involved faculty promoted its selection as the contact reference for the study. An initial email, with two monthly reminders, explained the study and permitted for informed consent with one response per institution requested. This study was funded by the Sheely Grant where $25 gift cards were delivered electronically to participants completing the study. Demographic features of the study population were assessed using descriptive statistics using JMP (version 11.0; SAS Institute, Cary, NC).

Results

The survey response rate was 40% (77 out of 192 of all US allopathic and osteopathic medical schools) completing the majority of the survey questions. Based on the applicability to their institutional informatics setup, 73% (56 out of 77) filled all components of the survey. Fifty seven percent of respondents were female with most being from the Midwest and the Mid-Atlantic regions (Table 1). Sixty percent of respondents were between 35 - 54 years old with most being in their position for less than 10 years.

	Count (N, %)
Total Respondents	77
Age	
18 - 24	1 (1)
25 - 34	5 (7)
35 - 44	24 (31)
45 - 54	23 (30)
55 - 64	18 (23)
65+	6 (8)
Gender	
Female	44 (57)
Male	32 (42)
Prefer not to say	1 (1)
Region in the US	
Mid-West (ND, SD, NE, KS, MN, IA, MO, WI, IL, MI, IN, OH, KY)	22 (29)
Mid Atlantic (NY, PA, WV, VA, NJ, MD, DE, DC)	19 (25)

Southeast (AR, LA, TN, MS, AL, GA, NC, SC, FL)	11 (14)
Southwest (UT, AZ, CO, NM, TX, OK)	9 (12)
Northwest (AK, WA, OR, ID, MT, WY)	7 (9)
West (CA, NV)	5 (6)
Northeast (ME, VT, NH, MA, RI, CT)	3 (4)
Islands (HI, PR, VI)	1 (1)
Respondent's Highest Current Position	
Faculty (Assistant, Associate, Professor)	33 (43)
Dean-Connected Position (Vice, Assistant, Associate)	19 (25)
Thread/Block Director	5 (6)
Clerkship Director	4 (5)
Dean/Director of Assessment	4 (5)
Medical Librarian	2 (2)
Accreditation Manager	2 (2)
Other	8 (12)
Time in Current Position	
< 5 years	38 (50)
5 - 10 years	28 (36)
> 10 years	11 (14)

Table 1: *Survey respondent demographics.*

Half of the respondents reported that medical informatics was integrated in their institution's medical school curriculum for the academic year 2021 - 2022, with 67% having formal, well-defined learning objectives (Table 2). Additionally, 30% had curricula that focused on interprofessional education platforms.

Question (n=Number of Respondents per Question)	Responses (%)*
Medical Informatics is Part of the Institution's Current Medical School Curriculum (n = 72)	
Yes	36 (50)
No	36 (50)
Format of Objective Setup in the UME Curriculum, if Present (n = 30)	
Formal objectives (well-defined)	20 (67)
Informal objectives (non-specific)	10 (33)
Medical Informatics is Taught in an Interprofessional Manner (n = 30)	
Yes	9 (30)
No	21 (70)
Personnel Teaching Informatics-Related Subjects in the UME Curriculum (n = 55)	
Informatics trained or credentialed department faculty	20 (36)
Medical Librarians	18 (33)
Current faculty with informal training in informatics	15 (27)

All of the above	2 (4)
Describe the Ideal Individual who Should Lead the Content of Informatics in the UME Curriculum (n = 63)*	
Physicians who are trained in informatics	41 (65)
Informatics trained personnel (non-physicians)	11 (17)
Medical Librarians	6 (10)
Institutional Informatics officer (CMIO, CIO)	5 (8)
Barriers Hindering having the Ideal Individual to Optimize the Informatics Component of the Curriculum (n = 63)*	
Perceived importance	31 (49)
Time	20 (32)
Financial Constraints	15 (24)
Recruitment difficulties	14 (22)
Other	13 (21)

Table 2: *Informatics integration and personnel involvement in UME curricula.*

**Multiple selections permissible (percentages displayed are based on n, the denominator denoted for each question).*

Informatics-related subjects were generally introduced to students in a longitudinal manner in 67% of institutions surveyed, with 77% of respondents reporting heavy emphasis in the preclinical years with frequent integration into existing required courses in 93% of cases (Table 3). Content delivery was reported to be highest through in-person lectures. Regarding preparing students to utilize electric health records in the transition to the clinical years, the process largely started gradually throughout the preclinical years (43%) with 10% offering "no clinical informatics training" in the use of EHRs. Those surveyed suggested that the group to lead such education would ideally be physicians professionally trained in informatics (75% of responses) (Table 4).

Question (n = Number of Respondents per Question)	Responses (%)*
Subjects Currently Taught in the Medical Informatics Curriculum at the Respondent's Institution (n = 30)*	
Literature searching	27 (90)
Electronic health records	26 (86)
Clinical decision making	24 (80)
Ethics and security	22 (73)
Computer assisted clinical diagnosis	14 (47)
Hospital information systems	14 (47)
Other	7 (23)
Subjects Considered Necessary to be Included In Informatics Curricula as Per Respondent (n = 61)*	
Electronic health records	57 (93)
Literature searching/information curation	54 (89)
Hospital information systems	51 (84)

Ethics and security	50 (82)
Computer assisted clinical diagnosis	46 (75)
Clinical decision making	43 (70)
Other	10 (16)
Barriers Preventing Implementation of Informatics-Focused Education in Medical Curricula? (n = 56)*	
Lack of educator interest/time	25 (45)
Inability to adjust the curriculum	19 (34)
Lack of perceived need by the medical school	17 (30)
Access to databases/resources	14 (25)
Other	12 (21)
Lack of student interest	9 (16)
> Time in curriculum	7 (13)
Modalities Where Students Commonly Utilize Informatics-Related Skills (n = 56)*	
Electronic health records	51 (91)
Research/literature searches	51 (91)
Telehealth	33 (59)
Patient education	33 (59)
Learning medical decision-making	24 (43)
Learning visit coding (reimbursement)	9 (16)
Other	4 (7)
Format of Education of Informatics-Related Subjects (n = 30)*	
Integrated into existing required courses	28 (93)
Elective course	10 (33)
Distinct required courses	4 (13)
Timing of Informatics-Related Education in Medical School Training (n = 63)*	
All throughout/longitudinal	20 (67)
Pre-clinical	16 (54)
Clinical	10 (33)
Method of Delivery of Informatics-Related Content (n = 30)	
In-person lectures	19 (63)
Institution-produced modules	6 (20)
Outside (purchased access) modules	2 (7)
Other	3 (10)

Table 3: *Educational integration and delivery of informatics in UME curricula.*

**Multiple selections permissible (percentages displayed are based on n, the denominator denoted for each question).*

Subject	Should Be Taught (n = 61, %)
Literature Searching	54 (89)
Electronic Health Records	57 (93)
Clinical Diagnosis and Decision Making	46 (75)
Hospital Information Systems	51 (84)
Ethics and Security	50 (82)

Table 4: *Viewpoints of curriculum content based on desirable offerings of health informatics.*

Discussion

The impetus for this study was the student solicitation for formal support in informatics as medical documentation has transitioned into digital platforms and virtual care has become a reality with projected longevity. Our study attempted to elucidate current initiatives identified through a survey format and which suggested that half of the respondents from various institutions had already integrated informatics in their medical curriculum; moreover, significant variability in methodology was noted as there is a lack of standardized required competencies. As half of the respondents reported lack of focus on informatics in their institutions' respective curricula, the survey demonstrates the considerable variation in emphasis, perceived importance, and need for medical informatics training among medical schools within the Unites States, irrespective of whether allopathic or osteopathic. Additionally, if institutions currently integrate informatics into their curricula, they don't have a shared formalized set of learning objectives, no standardized content and context, or present level of development if such material. This may be due to the marked variation in training and limited availability of faculty members who could appropriately develop and deliver the material.

In 2005, the Board of the American Medical Informatics Association (AMIA) developed Goals as part of the AMIA Strategic Plan. Goal III specifically aimed to strengthen the competencies of those who practice biomedical and health informatics in the United States. The most salient of these is the use of Electronic Health Records on which increased emphasis was placed by the HITECH act of 2009. Since this time, EHRs have become an invaluable tool in patient care. However, platforms differ by hospital system, and this poses an additional challenge to some institutions who are faced with educating the next generations of practitioners. The supplemental clinical decision-making tools in these complicated systems may increase the burden of knowledge on the student. Conversely, providing these support systems could stifle student curiosity and exploration of the "why" of algorithms provided. A 2020 systematic review found that there were few high-quality initiatives focused on training both undergraduate and graduate learners in the use of EHRs both for individual patient care as well as population health. Most interventions were targeted to clinical students, and those that were implemented in the preclinical years focused exclusively on the patient encounter and not adjunctive decision-making tools [12].

Despite the emphasis on the importance of integration of informatics into undergraduate medical education by regulatory bodies including the ACGME and AAMC, there is limited uptake and lack of structured or standardized implementation by the institutions. In the 1998 Medical School Objectives Project (MSOP), the AAMC identified "the ability to retrieve (from electronic databases and other resources), manage, and utilize biomedical information for solving problems and making decisions that are relevant to the care of individuals and populations" as a primary objective for students to demonstrate before the time of graduation [13]. Despite twenty years passing since the MSOP was first devised, the implementation and integration of these core objectives remains slow and the widespread being modest.

Our study suggests limited focus and faculty available to address the informatics curricular needs across the institutions. Most institutions utilize individuals who have at least some additional training in medical informatics (whether formal or informal) and respondents

of the survey report that these individuals are relatively capable in their roles. However, when asked who the ideal person would be to deliver such content, most respondents stated that a physician with informatics training would be the best suited person. This opinion may well be shared by students, as they likely see the physician as someone that they can relate to by demonstrating how they integrate medical informatics into their own clinical practice. It must be considered that these clinicians may be volunteers who are sacrificing clinical time and financial compensation to participate in teaching. Additionally, their familiarity with all facets of the curriculum may be limited, and thus impact the ability to effectively integrate their specific content to optimize what may already be in place [14].

Strengths of this study include the methodology for the survey setup, inclusion of both allopathic and osteopathic medical schools, and being the largest US-focused national assessment on record of informatics in medical curricula to date. However, a significant limitation of the online survey is the 40% response rate, suggesting a moderate nonresponse bias and limiting the accuracy in representing the population in question. With various databases available for connecting representatives across the institutions, the mailing list selected for this study may not be adequately inclusive of all who participate in curriculum development across the country impacting the generalizability of the findings. This impacts the generalizability of the study findings especially that the survey was only submitted to one faculty register (one listserv was utilized). Use of alternative registers or sources may permit for improving the response rates in future studies. Lastly, the opinions of survey respondents are being used as surrogate markers of the status of the education being delivered at their respective institutions but may not accurately reflect the quality of such content. Furthermore, impacting generalizability of the findings is the non-unified response rate among respondents when analyzing by question. Only 29% of those surveyed completed all questions whereas 40% completed more than 75% of the survey. Accordingly, the findings may be patterns that require further investigation, but in a more robust study format that may help with development of related competencies.

In January of 2017, the AAMC Journal of Academic Medicine aimed to develop a curricular framework for Health Systems Science-related curricula and identified three types of domains: core, cross-cutting, and linking. Clinical informatics was identified as a core domain and this framework may be used as a model to integrate these topics throughout medical students' education to future physicians to enter an increasingly complex healthcare system [15]. The Medical Informatics Advisory Panel as part of the MSOP also released implementation strategies which recommends an "ideal state" in which medical informatics related concepts are taught 1) throughout all four years, 2) embedded in all courses and 3) taught by all faculty. In terms of instructional issues, the committee recommended self-paced formats implemented in the clinical years. Opting for developing curricular modules applicable nationally through a central organization may ease institutional financial strains, overcome the lack of credentialed faculty dedicated to development of the material and who continuously update the modules, as well as ensure alignment and integration with preset curricula.

Developing competencies requires consensus and identified benefit from the format and approaches used. Our study identified a significant variability in what is perceived as topics and formats useable for supporting students. For example, more stressed the need to educate on use of EHR but less focused on investing in clinical diagnosis and decision making. This may be due to the current application programming interfaces many EHRs implement from a clinical decision support standpoint. Although the nomenclature may sound similar, these concepts are distinct. Additionally, developing material to support the educator becomes another necessity to permit for success of the optimization effort in the suggested 'ideal state'. Future studies will be needed to establish a cohesive and standardized framework that is easily administered across various institutions and seamlessly integrated into an already packed curriculum.

Conclusion

In conclusion, medical school curricula across the US do not integrate medical informatics in a uniform and cohesive manner to optimize student preparedness. Developing educational opportunities structured aligning with set competencies may help address the current and upcoming needs within undergraduate medical education and the ever-evolving nature of healthcare.

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Competing Interests

None of the authors have no potential conflict of interest to declare.

Contributorship Statement

DZ: Study design, survey setup, manuscript edits, manuscript revision, manuscript finalization.

LL: Study design, survey setup, manuscript draft.

CB: Literature search, study design, survey setup.

CV: Study design, manuscript edits.

AT: Study design, survey setup, manuscript edits.

Data Availability Statement

The data is available on request.

Appendix

Demographic questions

Q1. What is your age?

☐ 18-24

☐ 25-34

☐ 35-44

☐ 45-54

☐ 55-64

☐ 65+

Q. With which gender do you most identify?

☐ Female

☐ Male

☐ Transgender Female

☐ Transgender Male

☐ Gender nonbinary or nonconforming

☐ Other

☐ Prefer not to say

Q. In what region is your medical school located?

☐ Northwest (AK, WA, OR, ID, MT, WY)

☐ West (CA, NV)

☐ Southwest (UT, AZ, CO, NM, TX, OK)

☐ Mid-West (ND, SD, NE, KS, MN, IA, MO, WI, IL, MI, IN, OH, KY)

☐ Mid Atlantic (NY, PA, WV, VA, NJ, MD, DE, DC)

☐ Northeast (ME, VT, NH, MA, RI, CT)

☐ Southeast (AR, LA, TN, MS, AL, GA, NC, SC, FL)

☐ Islands (HI, PR, VI)

Q. What is your current title? (please type)

Q. For how long have you held this position?

☐ < 5 yrs

☐ 5-10 yrs

☐ > 10yrs

Primary survey Qs

Q. Is medical informatics a part of your current institutional medical school curriculum (for Academic Year 2021-2022)?

☐ Yes

☐ No

Q. If yes, do you have a stated institutional program or learning objectives for your UME curriculum?

☐ Formal objectives (well-defined)

☐ Informal objectives (non-specific)

☐ None

Q. Is medical informatics or a related topic taught in an interprofessional manner?

☐ Yes

☐ No

Q. Who teaches the informatics related subjects?

☐ Informatics trained or credentialed department faculty (ex. master's in health informatics, bioinformatics, clinical informatics...)

☐ Existing faculty who have had additional informal training in informatics

☐ Medical Librarians

☐ Other (please specify)

Q. Overall, how prepared are current faculty in teaching this information?

☐ Very unprepared

☐ Somewhat unprepared

☐ Neither unprepared or prepared

☐ Somewhat prepared

☐ Very prepared

Q. Ideally, who do you believe should be the individual who leads the development and implementation of informatics content in your UME curricula?

☐ Informatics trained personnel (non-physicians)

☐ Physicians who are trained informatics

☐ Institutional informatics officer (CMIO, CIO)

☐ Medical Librarians

Q. If not the same, what prevents your current system from utilizing the 'ideal' person for such a task? (select all that apply)

☐ Financial constraints

☐ Recruitment difficulties

☐ Perceived importance

☐ Time

☐ Other (please specify)

Q. What subjects are currently taught in your institution's medical informatics curriculum? (select all that apply)

☐ Literature searching

☐ Electronic health records

☐ Computer assisted clinical diagnosis

☐ Hospital information systems

☐ Ethics and security

☐ Clinical decision making

☐ Other (please specify)

Q. What subjects do you believe should be included in informatics curricula? (select all that apply)

☐ Literature searching/information curation

☐ Electronic health records

☐ Computer assisted clinical diagnosis

☐ Hospital information systems

☐ Ethics and security

☐ Clinical decision making

☐ Other (please specify)

Q. How are these subjects taught? (select all that apply)

☐ Integrated into existing required courses

☐ Distinct required courses

☐ Elective Course

Q. Are these subjects taught in pre-clinical, clinical, or all years? (select all that apply)

☐ Pre-clinical

☐ Clinical

☐ All throughout / longitudinal

Q. Are there specific years when these are focused/more common?

☐ Preclinical Phase

☐ Clinical Phase

☐ Advanced Clinical Experience Phase

Q. What is the method of delivery of such content?

☐ Institution produced modules

☐ Outside (purchased access) modules

☐ In person lectures

☐ Other (please specify)

Q. To what extent is computer-based learning/informatics seamlessly integrated into curriculum delivery?

☐ Not at all integrated

☐ Somewhat integrated

☐ Very much integrated

☐ Unsure

Q. In what ways do students commonly utilize informatics-related skills? (select all that apply)

☐ Electronic health records

☐ Research/Literature searches

☐ Telehealth

☐ Patient education

☐ Learning visit coding (reimbursement/diagnosis)

☐ Learning medical decision-making complexity

☐ Other (please specify)

Q. How are medical students prepared to engage with electronic health records and applications when switching from preclinical to clinical settings?

☐ Modules offered immediately upon switching to the clinical setting (no preparation through the preclinical years)

☐ Preparation through one focused session or module just before switching to the clinical setting (presented during the pre-clinical years)

☐ Gradual preparation throughout the pre-clinical years

☐ No clinical informatics training

Q. Is there any person or group that has an overall responsibility for introducing electronic health records in undergraduate medical education? (select all that apply)

☐ Assigned faculty

☐ Group of faculty

☐ Hospital administrator

☐ EHR superuser

☐ Introduced through educational modules only (no assigned faculty)

☐ No specific assignment

Q. To what extent are students educated on quality improvement measures currently in use in the healthcare setting?

☐ Not at all

☐ Somewhat

☐ Extensively

Q. To what extent are medical students informed of the integration of informatics in current healthcare settings?

☐ Not at all informed

☐ Somewhat informed

☐ Extremely informed

☐ Unsure

Q. Have students reported concerns regarding their preparedness for managing EHR and other health informatics related topics by the time they graduate?

☐ Yes

☐ No

Q. What barriers prevent implementation of education in medical informatics or evidence-based medicine in medical curricula? (select all that apply)

☐ Lack of student interest

☐ Lack of perceived need by the medical school

☐ Access to databases/resources

☐ Lack of educator interest/time

☐ Inability to adjust the curriculum

☐ Other (please specify)

Q. What features of a medical informatics curriculum do you feel are lacking at your institution? (Please type).

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