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Education and Training

Health Informatics Training at the University of Missouri

Abstract: Health informatics training has a long tradition at the University of Missouri. The current program prepares future researchers for the rapidly changing field of health informatics. This paper describes the training program, the fellowships, the interdisciplinary strengths of the program, and representative projects. Research opportunities range from information analyses of basic medical sciences through development of clinical information systems to the evaluation of information systems. The informatics training program at the University of Missouri promotes evidence-based medical informatics and has a strong emphasis on the organizational aspects of successful information system implementation.

Keywords: Medical Informatics Training.

Introduction

The University of Missouri (MU) offers a flexible program to train postdoctoral and predoctoral candidates for an academic career in medical/health informatics. The program and curriculum prepare fellows to develop, use and evaluate applications of innovative information methods and computers in the health care environment. The program emphasizes the synthesis, retrieval, organization, and effective management and communication of information and knowledge. More information is available at our web site, http://www.hsc.missouri.edu/mig/.

Dr. Donald A. B. Lindberg directed the first training program (1975-1985), which trained 60 predoctoral and postdoctoral fellows. In 1984, Dr. Lindberg left MU to direct the National Library of Medicine and Joyce A. Mitchell, Ph.D., became the director of the Information Science Group, which merged with the Biostatistics Group and was renamed the Medical Informatics Group. The training program was redesigned in 1990 and continues to flourish. Dr. Mitchell assumed the new role of Associate Dean of Integrated Technology Services (ITS) for the Health Sciences Center (HSC) in 1994. The resultant group has responsibility for technology services, research and strategic direction for the School of Medicine, Hospitals and Clinics, and the practice networks.

The Missouri Program

MU's program is unique because of our cross-disciplinary approach, collaborative research opportunities, and integration with the hospital and clinics operations group. Program faculty and fellows actively collaborate with many of MU's colleges, departments and programs, including the Department of Computer Engineering and Computer Science (College of Engineering), the School of Medicine, the Sinclair School of Nursing, the School of Library and Informational Sciences, the Instructional Technology department in the College of Education, and the College of Veterinary Medicine.

In conjunction with a funded Integrated Advanced Information Management System (IAIMS) project, the Missouri Telemedicine Network project, and a National Information Infrastructure project, ITS has focused its research efforts on three areas: (1) electronic health care records, (2) information systems for managing health, and (3) telemedicine/telehealth informatics and distance technologies (Table 1). All three research foci are part of institutional initiatives and provide fertile areas for research and development projects for health informatics trainees.

We have ten fellows, currently six postdoctoral and four predoctoral fellows. Fellows usually stay for two or three years. Fellows who are M.D.'s, D.O.'s or D.V.M.'s may participate in clinical activities to a limited extent but are not assigned general clinical responsibilities.

Three Foci of Research

1. Electronic health care records
2. Information Systems for Managing Health
3. Telemedicine/Teleinformatics

Five Areas of Competencies

1. User Skills or Operational Proficiency
2. Research Methods
3. Computer Science
4. Information Science
5. Health Care and Health Care Systems

Table 1. Foci of Research and Areas of Competencies in the Health Informatics Program

Both predoctoral and postdoctoral trainees need to demonstrate satisfactory completion of the core courses and informatics competencies described below and to complete research projects and other courses as outlined by their advisory committee and the informatics core faculty. Moreover, all fellows are involved in interdisciplinary research projects involving a health topic but using system development and analysis tools with experts in other schools and colleges. Fellows must develop some technical skills (Table 2).

The informatics curriculum is based on five pillars of content, competencies and skills which give trainees the breadth and knowledge to understand informatics: (1) user skills or operational proficiency, (2) research methods, (3) computer science, (4) information science and (5) health care and health information systems. Each of these is described below.

1. User Skills or Operational Proficiency

Trainees must have basic information literacy, defined as demonstrable proficiency in word processing, spreadsheets, literature searching, electronic reprint creating and searching, electronic communications, graphic and slide presentations, and internet use. Trainees develop information literacy on their own, typically by self-study and by taking short courses.

2. Research Methods

Trainees develop a basic proficiency in the design of experiments, data acquisition and quality control, information processing, analysis of data, sampling issues, evaluation, writing skills, verbal reporting, and research project management. Trainees also learn analytical skills from their mentors or from consulting with statisticians from the Biostatistics Unit. Ethics are also emphasized in our program. Trainees have several seminars discussing the responsible conduct of research. Their participation with on-going projects brings them face-to-face with realistic issues in confidentiality, privacy, security, authorization, authentication, and ownership.

3. Computer Science

Fellows master the skills and concepts in three areas of computer science: (1) database management systems, (2) decision sciences, and (3) computer programming by a combination of formal course work and working on projects.

4. Information Science

Many projects use controlled vocabulary, thesaurus and coding systems for bibliographic cataloging, information and data representation, information and data entry, and information and data retrieval to link diverse information systems across the enterprise. Trainees become involved in how MeSH, SNOMED and ICD9 are used, particularly in enterprise-wide electronic health care record systems and in designing information systems for managing care, as well as realizing the significance of the Unified Medical Language System (UMLS).

5. Health-Care and Health Information Systems

Trainees become involved with the organization of the health care system, and how technology is used in the three areas of emphasis. Trainees usually are well versed in at least one content area of health or biomedicine but take courses if needed.

Expectations of Health Informatics Trainees

- Fellows are expected to be active in specific research areas exploring critical issues which are vital to health care and to spend at least 20 hours per week in informatics research activities above and beyond graduate courses. Fellows taking no formal courses are expected to spend their entire time in project research.
- Each trainee joins one of the core faculty as a research preceptor.
- All candidates are formally evaluated each quarter by faculty.
- Trainees attend a weekly research symposium. They present one or two research topics a year to get opinions and critiques about their work and to learn of ongoing research. These seminars teach trainees writing and oral reporting skills in defending their own position and in analyzing others' projects. This symposium series also includes guest speakers presenting research

topics, statistical methods, and ethical issues.
- Trainees also participate in one or more three parallel working groups supervised by the core faculty on the three focus areas: the electronic health care record, information systems for managing health, and telemedicine/teleinformatics and distance technologies.
- All successful candidates, including any non-degree candidates, regularly complete and publish research projects on a topic in health informatics under the supervision of a senior faculty researcher. All candidates are expected to publish at least one research paper per year in peer-reviewed, Medline-indexed journals or conference proceedings.

Representative Research Projects in the Three Focus Areas

Interdisciplinary research projects in *electronic health care records* include analysis of clinical narratives, integration of different information systems, designing an image database, building enterprise vocabulary servers based on Unified Medical Language System thesauri, and establishing standards in data elements, security, access, and authentication.

One research project in electronic health care records originated when a patient care planning committee realized that much of the content of the health care record was transcribed clinical narratives. Their recommendation to put these clinical narratives on line resulted in the System for Text Archive and Retrieval (STAR) project [1,2]. Some of the goals for the STAR project include the ability to (1) edit clinical narratives on line, (2) electronically sign and authenticate clinical documents on line, (3) retrieve patient reports based on structured data and also on information contained, (4) integrate with other systems, and (5) provide security and a scalable architecture that could support up to 2000 users.

The system architecture includes a single interface to the text archive for the feeder systems, building the intelligence on the system on the server side rather than the client side, and including a multi-tiered server design to integrate the relational database and document archive with the web server. The WWW-based system supports access to a clinical document repository. The multi-tiered server design permits the maintenance of a user's state, and also provides essential security through an intermediate interface for authentication.

Projects in information systems for *managing health care* include using clinical trial studies to evaluate the effectiveness of various interventions and implementation of HEDIS and other clinical outcome indicators. With the emergence of managed care, health care quality improvement, and efforts to control costs, the management of health care processes attracts increased attention. Health care is an information intensive business and information itself is increasingly recognized as an intervention to manage patient care. To provide good quality care for more people, physicians and other health care professionals have to look at the chain of activities in which they participate from a more group oriented perspective. Medical Informatics at the University of Missouri responded to this need by making the management of patient care one of its priority research areas.

Information is important not only as a source of knowledge, but increasingly is viewed as a clinical intervention. Therefore, the value of information can be measured in randomized controlled clinical trials. In the priority area of managing patient care, recent projects include (a) systematic reviews and meta-analyses to specify the effect of interventions aiming to improve quality and control costs [3,4]; (b) development of an expert system to facilitate the implementation of clinical practice guidelines [5]; and (c) information system adjustments to support the analysis of clinical outcomes [6]. In the Medical Informatics Fellowship Program, the projects focus on critical areas of applying and testing computerized and conventional clinical infor-

Table 2. Technical Skills Targeted by the Health Informatics Program

Artificial Intelligence	Multimedia	Cognitive Science
Fuzzy Logic	Image Analysis	Dynamic Programming
Neural Networks	Computer Vision	Fractal Geometry
Expert Systems	Natural Language Processing	Mathematical Morphology
Semantic Networks	Wide Area Networks	Image Algebra
Linguistics	Epidemiology and Statistics	Algorithm Development
Object Oriented Systems	Database Management Systems	Meta-Analysis
Information Retrieval		Distributed Computing

mation services. The Columbia Registry of Information and Process Management trials was established to assist health care executives by offering evidence on organizational interventions attempting to change the practice and outcome of patient care. More than 1,400 randomized controlled clinical trials are on file, an unparalleled source of high-quality evidence.

One team consisting of physicians, physical therapists, a nurse, programmers, artists, and education experts devised a decision support system called PEP for older adults with osteoarthritis [7,8]. The system recommends exercises based on their perceived limitations, and offers information about osteoarthritis and medications. The system has been validated with three nationally-known physical therapists, and a reliability study has been completed. Further research on effectiveness is in progress.

Projects in *telemedicine/teleinformatics* and distance technologies include establishing standards for web-based instruction, promoting alliances with other institutions for joint development and distribution of curricular programs, and designing and evaluating the application of telemedicine techniques to health care. In a recent systematic review, electronic communication with patients was evaluated based on randomized controlled clinical studies [9]. This study concluded that in many clinical areas there is ample evidence that electronic communication can lead to improved outcomes (e.g., diabetes care, asthma management, follow-up after emergency room visits).

Representative Program Examples

Example 1: Postdoctoral Training

Susan Jones, a fictitious post-doctoral student, is an M.D. with residency training in pediatrics who decides to train for a research career in health informatics. She plans to pursue a Master's degree in Computer Engineering and Computer Science, emphasizing electronic health care records. After Dr. Jones talks with faculty members about their current research, Dr. Klimczak becomes her major advisor, with Dr. Selva serving as liaison to pediatrics clinics and records. Dr. Jones and Dr. Klimczak determine the appropriate courses to ensure competent training for a health informatics career. Dr. Jones' graduate committee approves her proposed course work.

Dr. Jones takes six hours of computer science prerequisites before taking the training program core courses. Dr. Klimczak meets with her regularly to ensure regular progress in her training and her research projects. Drs. Patrick and Reid meet with her quarterly to discuss her test grades, papers and research accomplishments. Dr. Jones attends the weekly research symposium and each year presents one or two papers on her own research. She also attends the weekly electronic health care records symposium directed by Dr. Klimczak. She submits research papers to the spring and fall American Medical Informatics Association (AMIA) meetings and each year submits a manuscript for publication. Her graduate committee approves her thesis topic— using client/server methods to incorporate pediatrics evaluation into the STAR project. Upon successful completion of her coursework and thesis, she receives an M.S. degree in Computer Engineering and Computer Science.

Example 2: Predoctoral Training

David Smith is a fictitious predoctoral student in the School of Library and Information Sciences. He has an undergraduate major in mathematics and several years' experience as a paraprofessional in an academic health sciences library. After he is accepted into the School of Library and Informational Sciences, he is selected as a trainee. His program includes nine hours in health sciences librarianship and nine hours in information science. It will also include a 3-credit internship in the Library Systems Office. In addition, he will take the other core courses in informatics, plus computer programming prerequisites. For one of his projects, he works with Drs. Sievert and Reid on a problem involving management of digital image collections and their effective use for education and patient care.

During his two years of training, Mr. Smith participates in the weekly research symposium and the symposium on information systems for managing care. He presents papers on his research, conducts a poster session at the Annual Conference of the Medical Library Association (MLA), and enters the student paper competition for the fall AMIA meetings. After completing his coursework and thesis, he receives his Master's degree in library and information science. He plans to apply for a National Library of Medicine internship and to pursue an advanced degree in information and computer science.

Conclusions

Although there are numerous ongoing Integrated Technology Services research projects, priorities for health informatics research are focused on three specific areas: (1) the development of an electronic health care record, (2) information systems for managing health care, and (3) telemedicine/teleinformatics and distance technologies. These priorities have been developed by an institutional effort in strategic planning for an Integrated Advanced Information Management System (IAIMS). Since health care is an information intensive

service, informatics research is needed for health care quality improvement and cost control. These three priority areas are being investigated with the tools and techniques of informatics including the decision sciences, information sciences, and computer sciences.

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References

1. Klimczak JC, Witten II, DM, Ruiz M, Mitchell JA, Brilhart JG, Frankenberger ML. Providing location-independent access to patient clinical narratives using web browsers and a tiered server approach. In: Cimino JJ, ed. J Am Med Inform Assoc 1996(S);623-7.
2. Klimczak JC, Bopp K, Mitchell JA, Frankenberger ML, et al. Reengineering medical records with a text archive and retrieval system. In: Proceedings. 1996 Annual HIMSS Conference: Overland Park, KS: Atwood, 1996;3:64-76.
3. Balas EA, Austin SM, Mitchell JA, Ewigman BG, Brown GD, Perkoff GT. The effect of physician profiling on utilization of clinical procedures: A multi-level meta-analysis of randomized clinical trials. J Gen Intern Med 1996;11:584-90.
4. Balas EA, Austin SM, Mitchell JA, Ewigman BG, Bopp KD, Brown GD. The clinical value of computerized information services: A review of 98 randomized clinical trials. Arch Fam Med 1996;5:271-8.
5. Balas EA, Li ZR, Spencer DC, Jaffrey F, Brent E, Mitchell JA. An expert system for performance based direct delivery of published clinical evidence. J Am Med Inform Assoc 1996;3:56-65.
6. Harr SD, Balas EA, Mitchell JA. Developing quality indicators as educational tools to measure the implementation of clinical practice guidelines. Am J Med Quality 1996;11:179-85.
7. Reid JC, Minor MA, Mitchell JA, Patrick TB, Griffin JZ, Cutts JC III, Morrow M, Thompson N. OA-Rehab: Designing a personalized exercise program for people with osteoarthritis. In: Ozbolt J, ed. *Transforming Information, Changing Health Care. Proceedings of the 18th Symposium on Computer Applications in Medical Care.* Philadelphia: Hanley & Belfus Inc, 1994:987.
8. Patrick TB, Cutts JH III, Griffin JZ, Reid JC, Minor MA, Mitchell JA. PEP: An information and decision support system for osteoarthritis patients. In: Gardner RM, ed. Towards Cost-Effective Clinical Computing. Proceedings of the 19th Symposium on Computer Applications in Medical Care. Philadelphia: Hanley & Belfus Inc, 1995:984-5.
9. Balas EA, Jaffrey F, Kuperman GJ, Austin Boren S, Brown GD, Pinciroli F, Mitchell J. Electronic communication with patients: Evaluation of distance medicine technologies. JAMA (in press).

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