Viewpoint Paper ■

Integration of Telemedicine in Graduate Medical Informatics Education

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Abstract An essential part of health informatics is telemedicine, the use of advanced telecommunications technologies to bridge distance and support health care delivery and education. This report discusses the integration of telemedicine into a medical informatics curriculum and, specifically, a framework for a telemedicine course. Within this framework, the objectives and exit competencies are presented and course sections are described: definitions, introduction to technical aspects of telemedicine, evolution of telemedicine and its impact on health care delivery, success and failure factors, and legal and ethical issues. The emphasis is on literature review tools, practical exposure to products and applications, and problem-based learning. Given the rapid advances in the telecommunication field, keeping the course material up to date becomes a challenge for the instructor who at the same time aims to equip students with the knowledge and tools they will need in their future role as decision makers to detect a need for, design, implement, maintain, or evaluate a telemedicine application.

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Telemedicine refers to a wide range of technologies and applications and can be defined as the use of medical information "exchanged from one site to another via electronic communications for the health and education of the patient or health care provider and the purpose of improving patient care."[1] The growth of technological innovations such as high-capacity digital networks, powerful computer hardware and software, high-resolution digital image compression, and the Internet has had a great impact on the process of health care delivery. A survey by the US Healthcare Information Management Systems Society (HIMSS) found that 34% of the responding health care executives reported that their organizations currently use telemedicine, 10% plan to use telemedicine within the next year, and 28% are investigating its use in the future.[2]

The use of telecommunications technology in health care is no longer considered an innovation. Telemedicine applications have become part of the routine care for several urban and rural areas across the country. There have been many initiatives to train professionals in the management and use of telemedicine systems. The Telemedicine Center at East Carolina University,[3] for example, provides intensive training sessions presented as "tracks" (administrative, technical, and clinical), with each track consisting of one hour "Modules." Each of these tracks has the corresponding target audience (administrators, technicians, clinical staff). The UC Davis Telehealth Program,[4] funded by the California Endowment and the California Telehealth & Telemedicine Center, aims to provide telemedicine training to practitioners and administrators throughout California. The Telemedicine Research and Training Center of the Texas Tech University Health Sciences Center[5] is committed to providing training to health care professionals in telemedicine and its uses. Similarly, the Center for Telehealth and Distance Education at the University of Texas Medical Branch (UTMB)[6] aims, in addition to providing medical care to remote populations, to assist other institutions in developing and implementing telemedicine and distance education programs.

All these initiatives intend to provide intensive workshops or two- or three-day courses and familiarize practitioners and technical staff with the use of innovative systems in health care. Because telemedicine has become an essential part of the field of health management and informatics, it also needs to be integrated into a graduate informatics curriculum. This requires a somewhat different educational approach because the aim is not to familiarize practitioners with a specific tool (as was the case in the initiatives described earlier), but rather to introduce the concept of telemedicine and its applications to a group of students who will become expert consumers and possibly developers of such systems. In their future positions as system designers and chief information or executive officers, they will have to understand the notion of utilizing telemedicine to support

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care delivery and education and be in a position to evaluate its effectiveness, detect a possible need for such application in a specific setting, and determine the design principles that would make it successful.

In the following section, the introduction and integration of telemedicine into a medical informatics curriculum are discussed, and a framework for the design of a course is presented. The purpose of this report is not to present a unique course; there have been several graduate introductory courses in telemedicine: among others, the course "Introduction to Telemedicine Technologies" offered by the Department of Computer Science and the School of Human Medicine at the University of Wyoming, "Telemedicine and e-Health Systems" by the Department of information Systems and Computing at the Brunel University in the United Kingdom, "Introduction to Teleradiology & Multimedia Technology" at the Department of Biomedical Engineering at the University of Southern California, and "Introduction to Teleheath" offered by the School of Health Information Science at the University of Texas Health Science Center. The aim of this report is to discuss concepts and topics that would be essential for a telemedicine course designed specifically for integration in a medical informatics curriculum and to present one approach that addresses these specific educational needs.

Objectives and Exit Competencies

A telemedicine course should be designed to develop intelligent consumers, managers, and researchers of telemedicine technology through guided exploration into the components of telemedicine systems. The course should be designed to introduce many of the challenges facing designers and managers of telemedicine systems and delivery networks. Specifically, the course should address the following:

- Overview of the field of telemedicine and its specialty fields
- The role of telemedicine in practical applications of information systems in health care
- Fundamental concepts of telemedicine systems in the health care setting
- Current trends in health care and telecommunication technology that affect the design and evolution of telehealth applications

Upon successful completion of this course, students will be able to:

- Determine the need for a telemedicine application and design its implementation
- Understand the role of telecommunications in care process reengineering
- Understand the data and information security needs of health care processes
- Implement an evaluation framework for telemedicine applications

Course Framework

The proposed course should include the following sections:

Definitions/Glossary

Telemedicine is defined as the use of information technology and telecommunications to bridge geographical distances and improve health care delivery and education. Because of the continuous advancements of telecommunications, application areas of telemedicine are evolving, and new terms arise. Students should be introduced to formal definitions of *telemedicine*, *telecare*, *telehealth*, and *e-health*.

The general use of the term *telemedicine* by medical doctors and administrators often does not cover the wide variety of significantly different technologic methods, devices, and procedures necessary for correctly performing specific tasks of telemedicine applications. Frequently, one term is used to describe different tasks (for example, in some studies the term *teleconsultation* is used to describe an interaction between a health care provider and a clinical expert at a remote site utilizing videoconferencing technology, but there are cases in mental health settings in which this term is used to describe the interaction between patient and provider). It is important for students to be equipped with a definitions list that can function as a "dictionary." The proposed list should include the items of the Telehealth and Telemedicine Manifesto proposed by Pinciroli[7] and should be expanded to incorporate specific terms that are currently widely used and refer to telemedicine in a specific clinical area (e.g., teleradiology, teleoncology, telehomecare) as well as the mode of care delivery (e.g., virtual visit, remote monitoring, teleconsultation). In addition, students should be introduced to the wealth of resources related to telemedicine such as the major journals of the field, the sites of national and international associations, and online databases.

Technical Background

Informatics students are traditionally being introduced to theory and design of networks, data transfer, and communication within other undergraduate or graduate courses related to computer science. However, a brief review of telecommunications technologies and protocols that are being utilized for telemedicine applications is a necessary component of a telemedicine course. This section is not designed to provide expertise in the technical aspects of telemedicine but rather to familiarize students with the terminology and different types of technology and networks, their features, limitations, and cost. Students' awareness of technology limitations (e.g., in image quality or data transfer speed) and cost ranges facilitates the understanding of telemedicine evaluation studies. This task becomes a challenge for the instructor who needs to ensure that the material is complete and up to date given the constant developments in telecommunications.

Evolution of the Field

Although interest in telemedicine seems to have increased in the last few years due to recent advances of telecommunication technology, the concept is not new. Even in 1924, as

radio had just started reaching residential settings, the magazine *Radio News* had a cover showing a "radio doctor" linked to a patient not only by sound but also by live image.[8] One of the first references to telemedicine that appeared in medical literature was an article published in 1950 that described the transmission of radiologic images by telephone between West Chester and Philadelphia, Pennsylvania, a distance of 24 miles.[9] Further landmarks in the evolution of the field include the closed-circuit television system at the Nebraska Psychiatric Institute[10], the STARPAHC Project (Space Technology Applied to Rural Papago Advanced Health Care),[11] and the Alaska ATS-6 Satellite Project.[12] An introduction to the history and evolution of telemedicine will help students understand the diffusion and development of this innovation as well as the permanent need to bridge time and geographical gaps in health care delivery. Emphasis should be placed on the introduction and discussion of the Telecommunications Act of 1996, which has had a great impact on the number and nature of telemedicine initiatives.

Telemedicine's Impact on Health Care Delivery

Cost of Care

The cost of telemedicine should be analyzed in relation to how it improves the health of a population by preventing or treating a disease through access to information and communication. One of the learning objectives of this section should be to make clear that the measurement of potential cost savings associated with a telemedicine application depends on the interest group (e.g., patient, health maintenance organization, provider, society). It is a general assumption, for example, that telemedicine decreases the opportunity costs for patients in seeking care (by reducing, for instance, travel expenses to visit a specialist). However, cost savings that might be accomplished by unit price decreases may be offset by an increase in volume. That is, increasing access to health services could lead to increased demand.

For the context of the proposed course, emphasis should be given on the societal perspective, which is most relevant for public policy decisions and encompasses the total costs of resources used to provide a service through telemedicine compared with alternative means.[13] Thus, use of examples could clarify the learning objective further. For example, a scenario can be studied in which an analysis is based on a private insurer's perspective that incorporates costs only for health care benefits or services covered by the insurance plan. Such an analysis would exclude uncovered medical expenses (e.g., transportation) borne by the insured. Students could discuss alternative perceptions or ways of measuring cost savings for this example.

In relation to the issue of cost, several studies should be studied by the students and discussed within groups (e.g., studies that have found teleradiology to cost less than alternative delivery systems,[14–16] detection of potential cost savings from teledermatology,[17] a cost analysis of a teleoncology practice[18]).

Quality of Care

Bashshur et al.[19] suggest that the quality of care provided by telemedicine can be evaluated either on a biomedical/bioengineering basis (clinical performance, clinical efficacy, effectiveness, safety) or a health services basis (appropriateness of the treatment chosen, policy adapted to improve health status). Fineberg et al.[20] distinguished several process and outcomes dimensions that might appropriately be assessed when evaluating the quality of care and should be discussed within the context of the proposed course. These dimensions include the technical capacity that addresses the safety and reliability of the technology used, diagnostic accuracy and impact, and patient outcomes.

A discussion of telemedicine's impact on quality of care can be enhanced with the review of published studies that have examined several aspects of this concept. O'Sullivan et al.,[21] for example, compared digital image quality (used in a teleradiology application) with the quality of original radiographic films used to detect urinary calculi and came to the conclusion that a highly affordable teleradiology system is effective and accurate compared with plain films. Other studies have investigated the diagnostic accuracy of advanced video-capturing systems.[22–24]

Access to Care

Access to health services reflects the "fit" between health care resources (including hospitals, clinics, doctor's offices) and the health care needs of the people they serve.[19] Students should discuss the three primary types of barriers to access[25] in relation to telemedicine: structural, financial, and personal/cultural barriers, and the ways telemedicine can eliminate those and possibly introduce new ones because of the technology use.

Success and Failure Factors

Many explanations have been offered for the limited adoption of telemedicine in the 1970s and 1980s in which the majority of projects were unable to achieve a market niche. The most often listed reasons include limitations of and unfamiliarity with the technology at the time,[26] the absence of long-term institutional funding commitments,[19] and poor planning and design, which affected the stability of the systems.[26] The number of telemedicine applications started to expand rapidly in the 1990s. Students should study literature that shows the success or failure of telemedicine interventions and identify common patterns that could be listed as success predictors or lessons learned from past applications. This is significant because they, in their future professional positions, will be in charge of converting data from past practice and experience into knowledge to support future decisions.

Legal and Ethical Issues

Although telemedicine applications have been growing and expanding, the legal and regulatory environment has not progressed as rapidly. A series of legal and ethical issues that are associated with the utilization of telemedicine

should be introduced to students in a way that stimulates them to think of and analyze matters, some of which still remain to be addressed. These issues should include licensure, accreditation, privacy of medical data, malpractice liability, and reimbursement.

Interstate telemedicine raises licensure questions, such as whether physicians can be practicing (tele)medicine in a remote state in which they do not have a practicing license. In addition, questions regarding the need for separate standards and regulation for "virtual" practices and the responsibility of the "host" site to continuously monitor "remote" physicians' competence to the same extent it does with its own medical staff members, can be discussed. Students will be familiar with the issues of privacy and confidentiality of medical data from other informatics courses. It should be emphasized that telemedicine applications often require that electronic medical records are shared across state lines (and this could become an issue when confidentiality and privacy laws have been enacted on a state basis without consistency across state lines), physical examinations are being broadcasted within the videoconferencing network, and interactions are being taped and integrated into the medical record.

Some argue that although the legal system aims to ensure that health care agencies and systems supervise and monitor their own staff members providing services, it does not account for the case in which a network of independent physicians and remote experts participate in "telemedicine" activities.

Telemedicine services are in some states, for the most part, not reimbursed by Medicare, Medicaid, and private/third-party payers (except for the cases of federal grant funding for research). The type and amount of evidence showing telemedicine's impact required to enforce reimbursement for telemedicine activities can be discussed.

Tools

Throughout the course the following tools should be used.

Literature Review

One approach to organizing the articles reviewed within the course is to use the Matrix Method and Matrix Indexing System for conducting and organizing literature reviews.[27] This method provides a plan for organizing references and reprints and managing this information on an ongoing basis, enabling an efficient and thorough search of the literature using electronic databases and an organized review of published studies.

The specific format proposed for the literature review in this context includes columns such as the year the studies were published, instruments used to collect data, subject selection criteria and sample size, clinical area the study focused on, results as presented by the author(s), technology used, reference to reliability, and validity of the instruments used. Reviewing the matrix, one can study it "horizontally" (examine one study at a time) or "vertically" (scan each column to have an overview of the technology trends over time, changes in the methods, or results). This structure supports the detection of clinical areas that have been unexplored and research questions that have remained unanswered. This is of importance for a field that is relatively new and rapidly growing.

Unlike other medical literature and because of the innovative nature of the field, telemedicine literature is lacking a great number of clinical trials, data collection instruments that have been tested for reliability and validity, and, in some cases, sound statistical methods. It is therefore of importance to encourage students to be critical of the generalizability of methods and results and incorporate their remarks into the matrix.

This literature matrix should be an ongoing project maintained and updated by and accessible to all students.

Practical Exposure

Site visits to clinical settings where telemedicine is being practiced can be of benefit to students who will be exposed to a practical implementation of the concepts they have been introduced to throughout the course. During these visits students will have the opportunity to assess health care providers' perceptions of and attitudes toward telemedicine applications and discuss their impact on daily care delivery. In addition, several vendors can be invited to present their products for different application areas.

Problem-based Learning Tools

Problem-based learning (PBL) is "an educational method characterized by the use of patient problems as a context for students to learn problem-solving skills and acquire knowledge."[28] PBL can be applied to the area of telemedicine, which is an interdisciplinary field that requires reasoning and problem-solving skills. Several PBL cases can be developed based on literature review, synthesis of controlled evidence, the definition of learning objectives, and questions. These cases, based on previous research and evaluation studies as well as anecdotal reports, can provide the teaching framework for comprehensive scenarios of future health care technologies, issues of concern, and ethical or financial issues associated with the use of telemedicine technology.

Conclusion

Telemedicine is no longer considered an innovation but rather a mode of care delivery that has the potential to support access to high-quality medical care for isolated and/or underserved populations. It can enable consumers to play an active role in their disease management and could decrease the cost of care. Health informatics students need to acquire knowledge and skills required to implement and

evaluate action plans for telemedicine research and development. The proposed framework can constitute the outline of a graduate telemedicine course for informatics students that will provide them with an overview of the field and prepare them for their future role as decision makers and transformational leaders.

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