Medical education for rural areas: Opportunities and challenges for information and communications technologies

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Resources in medical education are not evenly distributed and access to education can be more problematic in rural areas. Similar to telemedicine's positive influence on health care access, advances in information and communications technologies (ICTs) increase opportunities for medical education. This paper provides a descriptive overview of the use of ICTs in medical education and suggests a conceptual model for reviewing ICT use in medical education, describes specific ICTs and educational interventions, and discusses opportunities and challenges of ICT use, especially in rural areas. The literature review included technology and medical education, 1996-2005. Using an educational model as a framework, the uses of ICTs in medical education are, very generally, to link learners, instructors, and organizations, to provide learning materials, to enhance collaboration for learners at all levels and for institutions. While ICTs are being used and offer further potential for medical education enhancement, challenges exist, especially for rural areas. These are technological (e.g., overcoming barriers like cost, maintenance, access to telecommunications infrastructure), educational (using ICTs to best meet learners' educational priorities, integrating ICTs into educational programs) and social (sensitivity to remote needs, resources, cultures). Finally, there is need for more rigorous research to more clearly identify advantages and disadvantages of specific uses of ICTs in medical education.

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Resources in health care are not evenly distributed and access to high quality medical care can be more problematic in rural areas. The same is true for medical education, and learners at all levels of the curriculum—medical students, residents, and physicians—in rural locations often experience decreased access to education. Factors interfere with access to both formal programs, such as distance from a clinical teaching centre, and informal learning; e.g., limited availability of current medical information.[1,2] In fact, working in isolated environments where access to peers, education and information is limited, is one of the highest risk factors for physicians' loss of medical competence.[3]

Similar to telemedicine's influence on health care access, advances in information and communications technologies (ICTs) have increased opportunities for medical education. [4][5][6][7]
This paper provides a descriptive overview of the use of ICTs in medical education from an educational perspective. Its purposes are to:

1. Suggest a conceptual model as a framework for reviewing ICT use in medical education.
2. Describe the use of specific technologies and integrated technology systems in medical education.
3. Consider opportunities and challenges the technology offers for medical education, especially in rural areas.

:: Materials and Methods

The literature review was conducted using PubMed-Medline, PubMed-Central and ERIC databases, 1996-2005, for research studies and pertinent theoretical publications including journals and texts. Key search words included general terms such as: "telehealth," "telecommunication," "distance learning," "distance education," and specific terms such as: "videoconference," "audioconference," "computer-aided instruction," "Web-based learning," "handheld technology," "learning repositories; levels of medical education: undergraduate," "graduate," "post-graduate," "continuing;" and "rural health," and "international approaches." Theoretical approaches were included to place the review within an educational and social context, and selected studies to demonstrate use of ICTs within diverse elements of medical education.

A conceptual model for reviewing ICT use in medical education

Guidance for the appropriate use of ICTs for distance and distributed learning comes from research and theory in general education. As in traditional face to face education, a number of learning theories (e.g., behavioral, cognitive, social) provide information about educational strategies and effective education takes place within an educational system. This system is composed, very simply, of the following interactive components:

1. learner/s
2. educational materials and information resources
3. instructor/s
4. connections among the above and is influenced by the:
5. educational environment, and
6. social environment (In medical education, this specifically includes the healthcare environment.)

These components and environments are presented schematically in Figure - 1, suggesting a conceptual, yet practical model for considering the roles which ICTs play a role in medical education. In traditional education, learners, learning materials (both specific course materials and general information resources) and instructors are temporally and physically connected. In distributed learning, ICTs connect learners, instructors and materials. When using ICTs for education, the temptation is often to focus more on the technology and less on the learners and instructors, often to the detriment of the educational quality. And, education does not take place in a vacuum and environments moderate learning and educational outcomes. These include the educational environment, influenced by factors such as available support systems and learners' prior experiences, and social and health care environments; e.g., local support and access to relevant health care resources. Each component deserves attention.

Using this model, individual ICTs and functions each serves in distributed learning will be briefly discussed, followed by a more detailed description of the uses of specific ICT within medial education.

ICTs in medical education, similar to the ones used in telemedicine and general education, range from simple to complex and fall into four general groupings:

1. The telephone is the earliest, simplest and sometimes the most overlooked technology.
2. Video-conferencing incorporates computer technology to provide interactive, "real-time" transmission of audio and video, and transmission of files, graphics, etc.
3. Computer technology and software enable computer-aided instruction and with the Internet, support Web-based learning, computer conferencing, and access and transmission of large databases, files and images.
4. Handheld technologies can be used alone or linked to the Internet to provide "just in time" information.

The conceptual model in Figure - 1 depicts the general functions which these ICTs serve in medical education. They connect learners, instructors and educational materials in different ways:

1. Connecting learners and instructors in "real-time" or synchronously: Simple ICTs, like the telephone and audio-conferencing, and more advanced ones like video-conferencing connect learners and instructor for "live" educational sessions. Internet "chat" or conferencing programs also provide synchronous communication.
2. Connecting learners and instructor "asynchronously:" This refers to interpersonal interaction occurring over time, not at the same time, enabled through the Internet via email, list serve and numerous conferencing programs.
3. Connecting learners, instructors to learning resources (specific course materials): Before ICTs and even today, correspondence courses provided paper course materials to learners by mail. With computers and the Internet, these are now available electronically; e.g,
To summarize, computer-mediated multimedia instruction and the Internet can effectively link learners to learning materials and designing medical education curricula. Online evidence-based databases show promise in answering clinical questions. Increasing use of electronic resources via the Internet, US physicians reported decreased use of journals and local CME programs. In Canada, this use increased from 63% in 1999 to 88% in 2003. Access to the Internet by North American physicians is increasing in the US from 10% of physicians surveyed in 1997 to 78% in 2001, and current medical information is serious for learners at all levels and especially for practitioners.

In addition to facilitating formal learning, the Internet provides access to medical information, journals, libraries and databases for all levels of education. It effectively provides traditional programs for physicians and other health professionals at distributed sites and supports their interaction.[22][23][24][25][26][27] Videoconferencing connects sites for grand rounds and other sessions traditionally hosted by a medical centre, and allows peripheral sites to present clinical material during these rounds. [28][29][30][31][32] Electronic diagnostic images (e.g. computerized tomography, angiograms) and video-clips or live videoconferencing of the patient can also be transmitted, adding value to the programs.[22][32] Other CME initiatives using videoconferencing include journal clubs and small-group learning.[33][34][35][36][37][38][39]

In undergraduate and residency education, videoconferencing use is increasing and includes students and residents in rural and distributed sites, including family medicine and cardiology residents. More recently, videoconferencing is being used in combination with other ICTs to develop distributed campuses for faculties of medicine. (see section 5 below). Videoconferencing also facilitates skills instruction and assessment at a distance. Examples include teaching surgical procedures through off-site observation, teaching hand assessment techniques for physical therapists, improving pediatric resuscitation skills through observation and participation, assessing neonatal resuscitation skills and assessing surgeons’ informed decision-making skills using a video conferenced standardized patient. [40][41][42][43][44][45]

3. Computer-assisted instruction and Web-based learning

Computer-assisted instruction (CAI) refers to using computer technology to enhance instructional design and provide instruction, while Web-based learning incorporates these features with the connectivity of the Internet.[46] CD-ROMs are an example of an accessible yet sophisticated multimedia computer-aided instructional medium. They can be an effective learning tool for knowledge and skills and are easily and cheaply distributed. The relative accessibility and affordability of digital camera and video technology enable the creation of sophisticated materials; e.g. multi-media texts. [50][51][52] CD-ROMs link the learner and learning resources.

Multi-media CAI combined with the Internet for formal courses connects learners to sophisticated learning resources. Examples include an undergraduate program teaching examination of the eye and ear using computer-assisted interactive learning and virtual reality.[53] Other multi-media programs include assessment of the learner; e.g., the “interactive patient” program evaluates performance in history taking, physical examination, diagnosis and treatment.[54] In radiology, a sophisticated Internet-based program assesses knowledge and skill matched to the learner’s level.[55] In pathology, a web-based tutorial hosted on a US web site improved grading of images by 643 practicing pathologists from across the United States (72%) and outside the US (28%), emphasizing the broad population the Web serves. [56]

Web-based programs enable interpersonal interaction and collaborative learning among learners or teachers, either synchronously or asynchronously, especially important for rural and isolated medical and health professionals. An example is an interactive electronic notice board developed as a forum for discussion of clinical problems for medical students in rural settings and their clinical preceptors.[57] Other multi-media programs on the Internet link learners, resources and instructors for formal instruction. One such CME program included a didactic multi-media component, interactive cases with feedback and enabling tools and resources, supplemented with Web-conferencing.[58] WebCT is an educational course management software supporting both synchronous and asynchronous communication, used for undergraduate, post-graduate and continuing education.[59] Evaluation of formal CME programs using this courseware showed that physicians valued access to relevant programs and interactions with instructors and learners, but interpersonal interaction required appropriate facilitation.[60][61] Another intervention for Web-based learning is a journal club, including links to pertinent articles and a discussion board for interaction.[62]

In addition to facilitating formal learning, the Internet provides access to medical information, journals, libraries and databases for all levels of medical education and lifelong learning. These resources are traditionally easily accessed by learners at modern medical schools, but are often less accessible to learners and practitioners outside these facilities. Access to the Internet by North American physicians is increasing in the US from 10% of physicians surveyed in 1997 to 78% in 2001, and in Canada from 63% in 1999 to 88% in 2003. Most use it as a source of information for clinical practice and particular patient problems. In the US, about 90% responders used email and about 65% used the Internet to search the medical literature. With increasing use of electronic resources via the Internet, US physicians reported decreased use of journals and local CME programs. Online evidence-based databases show promise in answering clinical questions. Students graduating from US medical schools in 2001 reported feeling comfortable in conducting sophisticated searches of medical information databases. These findings have implication for designing medical education curricula.

To summarize, computer-mediated multimedia instruction and the Internet can effectively link learners to learning materials and...
Opportunities and challenges related to the effective use of ICTs, especially in rural areas

To return to the educational model, [Figure - 1], ICTs and integrated systems using them connect learners, instructors and experts, formal learning materials and information resources in various ways, with the potential to realize a more equitable distribution of high quality medical education. While benefiting all learners and teachers, the opportunities are greatest for rural areas with limited access to the resources of academic medical centres. Summarized briefly, opportunities are in three general categories: interpersonal connection, connections with resources, and collaborative systems for international partnerships:

1. Interpersonal connections: Through ICTs, individual learners can interact with and learn from fellow students, colleagues, experts and instructors, previously inaccessible.

2. Connections with resources: As well as increasing access to formal course materials, ICTs also provide novel and important learning experiences; e.g., virtual patients and environments provide risk-free settings for practicing skills ranging from history-taking to complex surgical procedures. New cellular phone technology can provide access to these resources anywhere, anytime, emphasizing that one of the most significant contributions of ICTs is the potential for universal access to timely and accurate clinical information.

3. Collaborative systems for international partnerships: In addition to benefitting individual learners and institutions, international collaborations using learning repositories and Internet communications, are working to improve medical education globally through shared resources and expertise.

While these benefits may now be realities for some learners, practitioners and medical schools, they are not universal and rural areas in particular may have more difficulty realizing them. Benefits result from a sophisticated combination of technology, applied educational theory, and environmental factors, held together by a high degree of organization.[11] Challenges identified in studies cited above and by reviews of medical education interventions using ICTs,[83],[84] arise in three main categories: 1) technology, 2) educational environment and 3) health care and social environments. [Figure - 1]
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special use of ICTs in medical education, to determine the specific conditions under which they are effective, and to understand the use of telecommunications infrastructure), educational (using ICTs to best meet learners' educational priorities) and social (sensitivity to remote challenges do exist, especially for rural areas. These includes technological (e.g., overcoming barriers like cost, maintenance, access to access to medical education, to improve the quality of education and to facilitate collaboration amongst individual learners and institutions; Synergy between the goals of the education program and those of the local health care community facilitates learning. On a practical level, this also means having the appropriate health care resources at remote sites so that learners can put into practice the skills and knowledge newly acquired via ICT-enabled education, usually from urban sites with greater resources.\[95],[97],[98] More broadly, educational programs offered by ICTs have the capacity to cross demographic, social, economic and national boundaries. Hence, they need to be culturally sensitive, relevant to local health care priorities and supportive of local resources. Medical education has the potential to "bridge the digital divide", to enhance health care of underserved populations and education of remote physicians and other healthcare providers.\[97],[98]

On a related note, many rural areas suffer from a shortage of physicians. While recent studies have identified many factors influencing physician recruitment and retention, several medical schools have designed specific rural undergraduate programs which appear to be positively influencing recruitment and retention.\[99],[100],[101],[102],[103],[104],[105],[106],[107] One small CME study found limited evidence that providing distance education positively influenced recruitment and retention and further research is needed.\[108]

:: Summary

This paper proposed a conceptual model as a framework for reviewing ICT uses in medical education (i.e., linking learners with instructors, specific course materials and/or information resources). Using the model, it described specific technologies and their uses as educational tools, and identified opportunities and challenges presented by ICT use in medical education. While there is a great opportunity to improve access to medical education, to improve the quality of education and to facilitate collaboration amongst individual learners and institutions; challenges do exist, especially for rural areas. These includes technological (e.g., overcoming barriers like cost, maintenance, access to telecommunications infrastructure), educational (using ICTs to best meet learners' educational priorities) and social (sensitivity to remote needs, resources, cultures). Finally, there is a need for more rigorous research to more clearly identify advantages and disadvantages of specific use of ICTs in medical education, to determine the specific conditions under which they are effective, and to understand the use of complex educational systems using multiple ICTs.\[109]

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