Review

Solving the disjuncture between research and practice: Telehealth trends in the 21st century

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Abstract

Despite the great promise that telehealth holds for improving cost, quality and access, there is currently a disjunction between what we know about telehealth and system growth and performance. To better understand the relationship between these two facets of telehealth development, this paper examines trends in telehealth, both as an intellectual endeavor and as a practical means of providing health services. Although there are promising avenues for government intervention in the way of coordination, funding, and regulatory practice, lack of knowledge regarding what works and what does not work has served as a major impediment to further progress in this area. In the absence of solid empirical evidence, key decision makers entertain doubts about telehealth's effectiveness, which, in turn, limits public leadership, private investment, and the long-term integration of telehealth into the health and technological mainstream. Solving the disjuncture between research and practice will require additional clinical trials and evaluation studies that examine the efficacy of various technologies, both relative to each other and to conventional in person medical encounters. At the same time, it will require more even distribution of research across applications, service locations, regions, and nations. But the generation of additional high-quality empirical data on process, benefits, costs, and effects is only the beginning. That data must in turn be used to effectuate change. This will require researchers to take a more proactive stance in promoting use of their findings, both instrumentally, to adjust, modify or improve particular programs or policies, and conceptually, to influence how key stakeholders think about telehealth more generally.
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Contents

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Since the early-1990s, there has been a tremendous growth in the application of information technology to health care. This is reflected in the rise of telehealth, which involves the use of telecommunications and computer technology in the delivery of health services to enable provider–patient and provider–provider consultation across geographic boundaries. Telehealth encompasses several different forms of information transmission (voice, sound, video, still picture, and text), communication technologies (standard telephone lines, coaxial cable, satellite, microwave, digital wireless, Integrate Service Delivery Networks (ISDN), and Internet), and user interfaces (desktop computers, laptop computers, personal digital assistants, fax machines, telephones, mobile phones, videophones, and various stand alone systems and peripherals). These technologies allow for a range of activities, including store-and-forward applications, which involve the asynchronous transmission of medical information, patient/provider communications and other data; live audiographic encounters, which combine sound with still pictures, and perhaps the most interesting possibility in the telehealth field, live two-way interactive video consultations. There are also several potential uses as reflected in prevailing terminology, with the term "telemedicine" often reserved for clinical, patient care applications, and the term "telehealth" used more broadly to describe both clinical and non-clinical applications in the way of education, administration, and research.

Perhaps greatest enthusiasm for telehealth lies with its potential to provide high-quality care to remote patients living in medically underserved communities [1]. Because doctors and advanced technologies tend to be concentrated in certain regions and countries, rural residents and those living in inner city areas and developing nations typically go without sufficient levels of service. In the U.S., this is reflected in the maldistribution of physicians across hospital referral regions where in 1999 the generalist workforce varied nearly three-fold, ranging from 39 to 113 per 100,000 between the highest and lowest regions in the country. Such variation is even more pronounced among medical specialists, which varied by nearly six times and ranged from 12 to 69 per 100,000 [2]. It is widely believed that telehealth may be an efficient way of bridging this gap in "care capacity," thereby improving access to high-quality health care both within and across nations.

It is also expected to reduce costs while improving quality. This is reflected in Hillestad et al. [3], which estimates that extensive adoption of interoperable electronic medical records (EMRs) in the U.S. could produce annual efficiency and safety savings of US$ 81 billion; perhaps double when accounting for improved prevention and management of chronic disease. Potential efficiency benefits include increased productivity and reductions in administrative costs, unnecessary lab tests and other utilization. Potential health benefits include eliminating 2.2 million adverse drug events at a cost of US$ 4.5 billion annually, in addition to gaining 13,000 and 138,000 life years, respectively, due to increased screening for cervical and colorectal cancer for savings totally up to US$ 2.0 billion per year for these two conditions alone [3].

Despite the great promise that telehealth holds for improving cost, quality and access, there is currently a disjunction between what we know about telehealth vis-à-vis its benefits and costs, and system growth and performance. To better understand the relationship between these two facets of health information technology development, this paper examines whether knowledge about telehealth matches its promise as a practical means for expanding access to high-quality health care services. It begins by reviewing progress in telehealth as an intellectual enterprise. Next, it gauges the extent of telehealth use by reviewing recent trends in activity in the U.S. and other countries. This is followed by a discussion of barriers to further acceptance and diffusion and the role that government leadership and existing levels of research activity play in perpetuating those barriers. It concludes by highlighting the need to develop a more productive partnership between research and practice.

1. Telehealth as an intellectual endeavor

There has been considerable growth in intellectual activity related to telehealth. This is reflected in the steady increase in both electronic and print resources, the staying power of various telemedicine societies and Websites, and the growing number of well-attended conferences [4]. It is also reflected in the maturation of the professional literature. Between 1964 and 2003, 5911 telehealth articles could be identified in the MEDLINE database, which indexes more than

4300 biomedical- and health-related journals. Growth in telehealth publications has followed an S-shaped distribution. It increased rapidly from but a handful of publications prior to 1990 to nearly 100 in 1994 and 800 in 1998 before leveling off and declining slightly after 2000. The most often cited applications include teleradiology (12%), telepathology (5.3%), teledermatology (1.5%), and telepsychiatry (1.4%). Although 42 countries are represented, most articles derive from the U.S. (49.8%), U.K. (11.4%), and other industrialized nations (35.8%), with more articles per capita being written by authors in Norway, Finland, and Australia than any other countries [5]. In general, publication output in telehealth is greater in more developed countries with higher gross national products and more advanced technological development.

Not only does research activity vary across nations, as the above findings indicate, but it varies within nations as well. This is reflected in a recent study which used MEDLINE to identify 118 telemedicine articles written by Spanish authors. Results reveal that the number of publications increased steadily from 1 in 1988, the year of the first published paper, to 21 in 2002. However, only a handful of authors exhibited an active research agenda in this area as most (79%) contributed to but one publication. Furthermore, nearly half of the articles identified (47%) derived from three institutions; nearly a third (29%) from one community, Madrid. Thus, although research activity has grown, like the literature more generally, it has been uneven, as reflected in both the geographic and institutional distribution of publications noted [6].

By 2004, 1321 articles had been published in the two leading peer-reviewed journals—*Journal of Telemedicine and Telecare* and *Telemedicine and E-Health*. Like the broader literature, the majority of articles derive from the U.S. (24.2%) and U.K. (21.0%), in addition to significant contributions from Australia (11.5%) and Canada (7.6%). Whereas telaradiology is the most often cited application (14%), the rise of the Internet in health care is reflected in the relatively high percentage of articles classified under that term (10%). Only 4.7% of publications could be classified as clinical trials, however; 5.5% as evaluation studies [7]. Most published articles are case reports, research syntheses, and small-scale qualitative investigations. Thus, while the literature supports the feasibility of telemedicine for specific clinical applications [8], there is a paucity of

high-quality research evidence documenting its impact on various outcomes, including cost, quality, and access [9–12].

This lac of definitive evidence regarding tehealth's effectiveness is widely recognized. Consequently, several evaluation frameworks have been proposed over the last 10 years [12–17]. These typically suggest rigorous comparisons of costs and benefits, or costs and effects, including telehealth's impact on quality and access. A variety of research methods have been proposed. These range from randomized experiments to quasi-experimental designs, secondary data analyses, and in-depth qualitative investigations. Especially salient is the distinction between formative and summative evaluations. Whereas formative evaluations are assessments of how well a program is being implemented, or how closely program implementation fits with the intentions of program designers, summative evaluations assess whether a program has achieved its desired objectives. Good evaluation designs will both differentiate impact and process objectives, as well as match data collection and analysis to these different needs.

2. Telehealth as a practical enterprise

Despite a dearth in clinical trials and evaluation studies, telehealth as an intellectual enterprise has nonetheless grown. Growth has also taken place in the use of telehealth as a practical means for delivering health services. This is reflected in a recent survey of U.S. telehealth activity published by the Telemedicine Research Center (TRC) [18]. According to the survey, more than 85,000 non-radiology patient–provider teleconsultations took place in 2003 in 88 responding telehealth networks involving more than 2000 health care facilities located in 39 states and the District of Columbia. Including 57 non-responding but active networks, there were a total of 145 telehealth programs in 45 states and the District that year, up from just 10 programs 10 years earlier. Fifty-four non-U.S. programs operating in 6823 sites in 20 countries also responded to the TRC survey, with half of these deriving from the U.K. (9 networks), Canada (10), and Australia (8). That English is the predominant language used in two thirds of the non-U.S. telehealth networks surveyed implies that people living in non-English speaking nations may

have less access to the opportunities that telehealth provides [18].

The average number of non-radiology teleconsultations per U.S. network increased nearly three times since 2000, from 682 to 1806. Furthermore, the average network size nearly doubled from 16 to 27 sites. No networks were identified in five states—Alabama, New Hampshire, Mississippi, Ohio, and Delaware. By contrast, most activity among surveyed networks took place in 28 programs located in Texas (32,663 consultations), Tennessee (17,969), Oregon (7709) California (6329), Arizona (4298), Kansas (2200), and Maine (1886), which together accounted for more than 85% of all non-radiology consults. Telemedicine activity also tends to concentrate in certain specialties—mental health (43 networks), cardiology (33), pediatrics (33), dermatology (31), neurology (27), orthopedics (25), radiology (25), and home health (22) [18]. Thus, despite significant growth in activity, there continues to be uneven access to different telemedicine services around the country.

Major clinical applications reported by U.S. networks include ongoing patient management (58%) and diagnostic exam interpretation (49%). Other frequent activities include patient case review (30%), specialist referrals (26%), and patient/family visits, medical/surgical follow-up, and specialist clinics (24% each). Networks were also used for several non-clinical activities, which can make it easier to rationalize the investment in bandwidth and equipment necessary for clinical uses. At 81%, the most common was education, including continuing medical and nursing education, ground rounds, and patient education. Also common were administrative applications (72%), such as patient scheduling, tracking, and billing. Less common were research-related activities (42%). Like in the U.S., the most common clinical applications reported by non-U.S. networks included diagnostic exam interpretation and patient management. There was also a similar distribution of clinical specialties. Unlike U.S. programs, however, non-U.S. networks tend to engage in a more even distribution of non-clinical activities, including education (59%), research (52%), and administration (50%) [18].

Although interactive video was the most common delivery mode reported by U.S. networks, use of audiographic and store and forward applications have grown over time, with the former now surpassing the latter for the first time, due, in part, to advances in software development, convenience and reductions in cost. These are in contrast to telemetry—the measurement of physiological parameters at distance, which is used by only a handful of programs. Whereas 32% of surveyed networks rely on one delivery mode (usually interactive video), 35% rely on two and 33% three or four. Use of interactive video, store-and-forward and audiographic modes of delivery were fairly evenly distributed among non-U.S. networks [18].

Room-based videoconferencing is the most common system utilized by U.S. programs (64% of networks). However, desk-top computer systems (56%) and rollabout units (41%) are becoming increasingly common, perhaps reflecting the growing convenience and speed and processing of personal computers. Laptop computers (27%) and videophones (21%) are also being used more often. At 68.5% and 51.8%, respectively, desktop computer, and room-based video conferencing are the most common equipment systems reported by non-U.S. networks. Laptop computers (38.9%) and rollabout units (25.9%) are also fairly common [18]. Greater use of these latter two technologies reveal a growing preference for mobility, which should become even more evident with increasing adoption of wireless devices and related applications in health care [19]. Beyond wireless are the frontiers of telemedince, which includes remote surgery [20] in addition to advances in nanotechnology (molecular level products and devices), artificial intelligence ("Knowbots" that automate repetitive human tasks), ubiquitous computing (unobtrusive and unnoticeable application of computing capabilities), and grid computing (systems that harness computing power from multiple resources) [21].

Some U.S. networks report using the World Wide Web to manage medical records (22%), to undertake patient education (36%), or to provide teleconsultation (34%) [18]. The most common Web-based applications included store and forwarding of medical information (15.3%) and the development and maintenance of Web pages to provide services (21.3%). By contrast, email to transmit text (12.7%) and text/images (14.0%), interactive video (13.3%), and audiographic applications (9.3%) were used less frequently [18]. Indeed, the Internet revolution in health care is occurring more slowly than might have been anticipated. For example, only 13% of 1200 solo/small physician group prac-

tices surveyed by Miller et al. [22] had adopted EMRs. While approximately one-third used email to communicate with colleagues, close to one-quarter used email to communicate with patients, with about half of those communications pertaining to patient symptoms/treatment. Consumers have also been somewhat reluctant to embrace the use of the World Wide Web in health care. Although 40% of adult Internet users search for health information and advice online, only 6% indicate that they have used email to contact a physician or other health care professional, and less than 5% claim to have used the Internet to purchase medical prescriptions [23].

3. Impediments to further acceptance and diffusion

Although financial concerns associated with a lack of reimbursement, long-term funding, telecommunication charges, and other costs are important barriers to long-term sustainability, organizational impediments to telehealth have increased in saliency in recent years [18]. Perhaps the greatest organizational obstacle to long-term integration has been the piecemeal development of the telecommunications infrastructure in health care which promotes the adoption of health information technologies that cannot "speak" to one another [24]. Craft (p. 385) [25] defines interoperability as "the ability of a system or product to work with other systems or products without special effort on the part of the customer." Existing telehealth networks tend to rely on custom built systems made for specific users operating in specific settings. This leads to networks that lack open connectivity with other systems because they do not share the same hardware or software, resulting in higher than necessary infrastructure costs while limiting telehealth's relevance to mainstream health care [25]. In achieving interoperability centralized administration appears to be critical. At 17%, for example, adoption of EMR systems by primary care physicians in the U.S. have lagged far behind adoption in countries, such as the U.K. (58%) and Sweden (90%) [26]. This in part reflects difficulty in adopting uniform standards and technologies in nations with decentralized health care systems compared to those with more centralized models of financing and organization [27]. Indeed, recognizing the importance of coordination, the U.S. gov-

ernment recently established a National Coordinator for Health Information Technology as part of a concerted national effort to promote adoption of a uniform EMR, instituted with funds awarded to both technology standards setting entities as well as to states and Regional Health Information Organizations (RHIOs). Without further government leadership, however, and adoption of an expanded agenda beyond EMRs to other technologies and functions, telehealth networks will continue to operate in isolation of one another, thereby limiting their ability to improve efficiency and enhance access.

Another significant obstacle to further diffusion is cost and reimbursement. Although some progress has been made, there continues to be a lack of reimbursement for health care services delivered electronically. In the U.S., this is reflected in modest growth in telemedicine spending by Medicare—the federal health insurance program for the elderly and disabled. In addition to providing reimbursement for teleradiology, telepathology, and a few selected other services (e.g., cardiac monitoring, diabetic retinopathy screening), Medicare now provides reimbursement for video-based services in non-metropolitan areas, though at less than US$ 1 million annually, this remains fairly minimal. There are also federal projects demonstrating reimbursement for store-and-forward applications, but in being restricted to Alaska and Hawaii, this too has been fairly limited [28]. Lack of payment for email consultations is a further impediment. While this may be less of an issue for providers who are paid a fixed prepaid amount per patient no matter how many services are rendered, email-specific reimbursement (see [29,30], for example) may be an especially promising strategy for stimulating initial investment in telehealth on the part of providers paid on a fee-for-service basis.

Beyond reimbursement for services rendered providers often wonder whether the costs of adoption exceed the benefits, at least financially. Although telehealth requires significant investment—US$ 44,000 per physician in initial start-up costs and US$ 8500 per year in ongoing maintenance for EMR systems alone, [31] 89% of financial gains accrue to other stakeholders, payers being foremost among them [29]. There are also non-financial costs that limit provider enthusiasm, including time, staff, and other resources devoted to learning new systems and to staying up-to-date with ongoing changes in hardware and software,

in addition to possible workload increases if new technologies compliment rather than substitute for in office visits. Integrating telehealth into providers' daily routines is viewed as a particular challenge [32]. Unless government provides additional assistance in the way of start-up grants, reimbursement, and continuing support, it may be difficult for many providers to sustain telehealth efforts over the long run.

In addition to organization and financing, there are several socio-legal barriers to widespread acceptance. One of the more frequently highlighted is changes in the way telehealth effects relationships among key stakeholders, including patients, providers and the organizations with which they interact [33,34]. Many of these changes relate to the technical and interpersonal aspects of the technology employed. Whereas the technical aspects are concerned with the communication technologies used and the clinical processes enabled by those technologies, the interpersonal aspects are concerned with relationships among system personnel, providers and patients, and the way in which those relationships are organized [34]. Since these changes can have both positive and negative ramifications for patient–provider relations [15,34], it is critical that government further identification of how different technological configurations affect medical encounter behavior so as to promote use of those practices which have the most favorable impact on patient and provider satisfaction, understanding, adherence to treatment, and outcomes.

Other socio-legal barriers include concerns about confidentially, professional portability, and malpractice. Consumers often highlight privacy and security, which typically pertain to third party access to electronic health information [35], but may extend beyond informational privacy to include psychological, social, and physical privacy as well [36]. Indeed, social and physical privacy are particular concerns with telemedicine where control over transmitted information is uncertain and participation by individuals other than the patient and immediate providers common. To a large extent, professional portability, or the "ease with which health-care professionals can move in person or virtually across barriers, and among and between jurisdictions [37]," is driven by state licensure requirements, which vary from to state-to-state and often require health care providers to be licensed in the states within which they practice. This limits

the extent to which providers based in some states may use telehealth technology to diagnosis and treat patients in other states. There are also several malpractice issues that remain to be resolved; for example, whether current legal criteria apply to consultations taking place via two-way interactive video, email, or other electronic medium, and what new expectations, practice standards, and potential liabilities may arise with the use of this new technology [38,39]. Although the federal government addressed privacy issues, in part, with Title II of the Health Insurance Portability Act (HIPA) of 1996, which established privacy rights and controls through standards governing the confidentiality, availability, and integrity of patient information, it has yet to address professional portability and malpractice. Promotion of interstate licensure agreements and malpractice standards consistent with the local standards of originating sites may be good places to start.

Barriers to adoption may be especially difficult to overcome in regions and nations that lack the infrastructure and resources necessary to sustain telehealth use and development [17]. Not only are there well-documented gaps in health care cross-nationally but there are well-documented gaps within the U.S. between whites and minorities, seniors and young people, and urban versus rural dwellers [40]. There are also disparities in access to advanced telecommunications technology, which is one reason why most telehealth networks have been adopted in nations such as the U.S. and U.K. while relatively few have been adopted in the developing world [18]. Maldistribution of telecommunications resources is also why telemedicine has made fewer in roads in poorer U.S. regions while traditionally underserved groups are less likely to use the Internet, visit various websites, or have broadband capabilities [18,41,42]. Clearly, the promise of telehealth for improving access to health information and services will be limited unless leading adopters, such as the U.S., join in distributing telecommunications resources more widely, not only within their own nations but around the world.

Complimenting the absence of government leadership is a prevailing lack of knowledge regarding what works and what does not work in telehealth. To a large extent the dearth of high-quality empirical research (clinical trials and evaluation studies) reflects the relatively slow adoption of telehealth technology, which

although experiencing growth, is still used at comparatively low levels by a relatively small minority of health care providers. It also reflects the nature of telehealth itself, which, because it encompasses several different technologies and applications, makes it difficult to generalize from any one particular study to the field in general [12,13]. Regardless of why there is a lack of definitive evidence, telehealth cannot reach its full potential without a strong, empirically, and scientifically sound foundation. Lack of data on benefits and costs contributes to the adoption of inefficient systems that fail to maximize patient care and clinical outcomes. Lack of data on what factors influence successful adoption and implementation of sustainable systems contributes to underused/short-lived networks that fail to garner sufficient stakeholder support [43,44]. In the absence of solid empirical evidence, key decision makers will continue to entertain doubts about telehealth's effectiveness, which, in turn, limits public leadership, private investment, and the long-term integration of telehealth into the health and technological mainstream.

4. Conclusion

Without government leadership, further diffusion of telehealth will be difficult to achieve. This leadership should involve expansion of standard setting activities to a broader array of technologies and functions, in addition to increased investment in telehealth and its various applications through start-up-grants, continuing support, and reimbursement for services rendered. It should also involve the identification and promotion of best practices, and adoption of cross-jurisdictional regulatory frameworks, including interstate licensure agreements and more consistent application of malpractice standards. At the same time, there must be additional clinical trials and evaluation studies that examine the efficacy of various technologies, both relative to each other and to conventional in person medical encounters. This should include more even distribution of research across applications, service locations, regions, and nations. An excellent example is Wallace et al. [45], which reports the results of a clinical trial comparing "virtual" and standard outpatient appointments using multiple specialties, settings, and outcomes.

Though additional research is important, it should be recognized that the generation of high-quality empirical data on process, benefits, costs, and effects is only the beginning. That data must in turn be used to effectuate change, which, as the program evaluation literature has shown us, is by no means a guarantee [46,47]. This is one reason why Ho and Sharman [48] stress that researchers not only collaborate with policymakers, health administrators, and health professionals in sharing knowledge, best practices, and innovations, but that individuals with special expertise in this area take advantage of their unique experience and serve as early adopters, coaches, advisers, and enablers. Indeed, it behooves scholars to recognize that the results of their labors can be used both instrumentally, to adjust, modify or improve particular programs or policies, and conceptually, to influence how key stakeholders think about telehealth more generally. Shadish et al. [49] identify several activities that may be used to promote instrumental use. These include "identifying users early in the evaluation; having frequent contact with users, especially during question formation; studying things that users can control; providing interim results; translating findings into actions; and disseminating results through informal meetings, oral briefings, media presentations, and final reports with brief and non-technical executive summaries" (p. 55). These same activities may also further conceptual use when users cannot act immediately on the findings reported. Conceptual use may also be facilitated if researchers assume the role of entrepreneurs distributing results widely across a network of similarly concerned scholars, policymakers, and other interested actors [49]. Instead of taking use for granted researchers need to plan ahead and assume a more proactive approach to promoting it. This should result in fewer barriers to adoption and more widespread diffusion of effective telehealth programs around the world.

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