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Chapter 7

The Diffusion of Telemedicine

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INTRODUCTION

THIS CHAPTER DESCRIBES general trends in the growth and diffusion of telemedicine worldwide. It begins with a description of the diffusion in the United States, and is followed by examples from a range of other countries. A theoretical model is then presented that contains factors that affect the adoption of new technologies, particularly in a free market economy and with a high degree of professional autonomy. Attention is then focused on the analysis of important factors slowing the spread of telemedicine on several different levels.

Analyzing the diffusion of telemedicine and telehealth is complicated by virtue of the complexity and inclusiveness of the field. Although telemedicine or telehealth refers to the delivery of medical or health services at a distance, there is no single and uniform telemedicine or telehealth service as such. As well, there is no specific, fixed, or uniform technology that enables telemedicine or telehealth. Instead, telemedicine and telehealth encompass a full range of diagnostic, clinical, and educational services and activities aimed at the promotion of health, the prevention of disease, and the treatment of illness. The technology of telemedicine also is variable; design configuration, transmission, and equipment are all developing quickly, with much of it becoming obsolete almost as quickly. Hence, it is neither possible nor perhaps appropriate to postulate a target or desirable rate for the diffusion of telemedicine as a whole, in isolation from a host health care system, the specific applications of telemedicine, or the alternative means of providing the same services.

In addition to its inherent complexity, the major difficulty in assessing global diffusion of this field derives, in large part, from the fact that health care systems, health care technologies, and the availability of health care vary enormously between nations and even among developed industrialized nations.[1,2] As expected, many developing nations are economically disadvantaged to such an extent that even basic public health systems are either lacking entirely or overwhelmed by the aggregate burden of poverty, unemployment, limited education, the double weight of infectious and chronic diseases, and disabilities. Hence, a discussion of the areas in which the majority of the world's population lives may involve a very different set of considerations and hierarchies of need than those of its counterpart.

A further complication—but one that can also be an enriching factor—is that telemedicine, by definition, can cross national boundaries and indeed circle the globe. Hence, the patient and the referring health professional

can be in one health system and economic environment, and the expert in another. This can bring new expertise to areas in need of it. But it also has the risk of destabilizing or bringing new priorities to local settings.[3,4] It may be difficult to determine when such external influences are beneficial or when they are inappropriate because of opportunity cost, inequity, or distortion that can only be determined by applying local values.[5] Thus, global diffusion is a significant issue in its own right.

Most discussions of diffusion of technology assume an economic base that would permit the purchase, maintenance, and operation of the requisite infrastructure and the ability of patients or payers to purchase the services it might provide. Because of the complexity and differences of economies and health care systems from one nation to another, the economic issues underlying the differential diffusion of telemedicine on a global basis (intranationally or internationally) will not be discussed here. They represent a separable set of issues that is best handled independently.

GROWTH AND DIFFUSION OF TELEMEDICINE

Telemedicine had its beginnings in the United States in the 1960s[6] as a means of providing specialty consultation using closed circuit interactive television. The idea of telemedicine, however, was decades ahead of the limited quality, availability, and affordability of the technologies then available. Consequently, the development of this modality for providing health services continued to be slow and sporadic. By the early 1990s, dramatic improvements in information and communications technology heralded the dawn of a new era for telemedicine.

It is 10 years since the resurgence of interest in telemedicine. The technology has undergone considerable development: the cost of equipment and communications has declined substantially; a wide range of applications has been deployed; telemedicine has been used in a variety of unique and extreme environment[7,8]; the quality of the published literature on telemedicine has improved; administrators have more realistic ideas about how to plan and use the technology, tempered by years of uphill struggle; and slow progress has been made in the areas of coverage and payment. Yet, apart from the notable exception of teleradiology, the overall diffusion of telemedicine is below the expectations of its proponents.

Data from the Association of Telemedicine Service Providers (ATSP) Annual Survey of Telemedicine reveal a positive trend of growth in the number of programs and providers (Table 1). However, the aggregate statistics mask the uneven distribution of growth. In 1998, fully 30% of nonradiology activity occurred in a handful of state prisons; 20% of all encounters involved mental health services.[9] In the 132 programs in the 1999 sample, only 15 reported more than 1000 teleconsultations a year, suggesting uneven regional distribution

Table 1. Growth in North American Telehealth Activity

	1994[a]	*1995*[b]	*1996*[c]	*1997*[d]	*1998*[e]	*1999*[f]
Number of programs identified	24	49		132	157	179
Number of teleconsultations	2,110	6,138	21,732	41,740	52,223	74,828[g]
Avg. teleconsults/responding program	88	125	253	316	428	608
Total number of facilities reported				747	1,345	1,521
Avg. number of facilities per program				8.3	10.3	11.1

[a]Allen and Allen, 1995.[10]
[b]Allen and Scarbrough, 1996.[11]
[c]Grigsby, 1997.[9]
[d]Grigsby and Brown, 1998.[43]
[e]Grigsby and Brown, 1999.[44]
[f]Excludes teleradiology activity.
[g]Projected growth, based on first quarter report of 18,706.

of services. Distribution by clinical specialty also showed a handful of high-volume specialties (mental health, orthopedics, neurology, dermatology, and cardiology). The number of physicians who reported participating in telemedicine in 1999 was less than 4,000, and the annual average number of teleconsultations per site for 1998 was less than 40.

TELEMEDICINE DIFFUSION IN OTHER COUNTRIES AND SETTINGS

Presented here are illustrative examples of the adoption of telemedicine in countries outside North America. These examples are not fully inclusive, nor do they present a complete picture of telemedicine diffusion in the respective countries. They do demonstrate, however, the variations in scale and nature of telemedicine diffusion across the international scene, largely as a result of differences in influences, driving forces, and opportunities.

Malaysia

As Malaysia seeks to develop its economic position and improve the quality of life of its citizens, the government of Malaysia has seen the potential of telecommunication services to modernize a range of infrastructure and public services. Because a healthy economy requires a healthy population, a key part of this national strategy for development is the transition from "industrial age medicine to information age medicine."

This strategy has a wide range of ambitious but carefully interlinked components in a cohesive strategy, the "Telemedicine Blueprint," harnessing an information superhighway to make health care resources more accessible to the population. This is coupled with a change to a culture of wellness. Telecommunication-based health records and the application of appropriate telemedicine services will be enabled by an integrated framework that supports the technology, operating standards, staff development skills, and legal framework, with key components being electronically held, such as "Lifetime Health Records" and personal "Lifetime Health Plans."[12,13]

The role envisaged for telemedicine includes personal self-help with health problems and choices for a health-promoting lifestyle through availability of sound information and virtual health services. Telemedicine is also expected to redress imbalances in the distribution of physical health services.

South Africa

The newly democratized South Africa realized that it had immense challenges in modernizing its services in rural areas, not the least of which was to increase the number of doctors and nurses in these underserved regions. Telemedicine has been seen as a way of spreading health care skills equitably and efficiently. In many countries any move toward a distributed virtual health system requires major organizational and behavioral change. Given the paucity of traditional health services in large parts of rural South Africa, there was a blank canvas on which to produce a totally new picture. Significant investment is needed, but there are no existing health resources in many areas to modify, with all their traditional inertias and change management issues.

Consequently, a strategic framework has been published, and a development strategy is being applied. Funding has been specifically considered as part of the guidelines for development.[14] This example shows how telemedicine can be used as a backbone for a health system in the 21st century. It also shows how the investment cost of the technical infrastructure will be offset by more cost-effective use of the scare and expensive health resources. This is, of course, significantly different from telemedicine diffusion in a long-established health sector.

Australia

As a large country with a widely dispersed population and developed economy, Australia might be considered a classic location for telemedicine applications. It has a long history of remote health care, including the Radio Doctor and the Flying Doctor services, which exemplified how telecommunications can become part of normal health care delivery. Modern

telemedicine is widespread in Australia, with individual applications being developed according to local need and appropriateness. This is facilitated by the recent development of specialist professional expertise and specialist university departments that facilitate research and teaching in telemedicine. In this context, the Commonwealth government has seen the importance of an overall framework and standards and has invested in rigorous collation of evidence and knowledge.[15,16]

Special populations

Telemedicine services have particular attractions for dealing with special populations that are not easily reached. These include penitentiary programs,[17] scattered rural populations,[18,19] and passengers and crew of ocean-going vessels[20,21] and airplanes in long distance travel.[20] We have yet to determine the cost effectiveness of telemedicine in all these situations, as compared with traditional face-to-face consultation. But, it is not as expensive or cumbersome as the alternatives (escorting prisoners, extensive escorted ambulance or air journeys, air-sea rescue services, or emergency landings).

Military telemedicine

Military telemedicine presents a special situation. The military has an essential need for acute secondary and tertiary health care that is normally divorced from local health services, and it has access to expensive, advanced telecommunications. Among the active users of military telemedicine are the United States and British armed forces.[22,23] In terms of general implementation, military telemedicine differs significantly from its civilian counterpart. It normally has high political support, a clear line of command, including direction to follow agreed procedures and technologies, and considerable technological investment resources. In addition to being an important arena of telemedicine diffusion in its own right, military telemedicine serves as an important generic telemedicine learning environment.

Integrated specialist services

Telemedicine can be a powerful vehicle for creating integrated virtual services for special patient populations that depend on specialist clinical expertise, which is necessarily concentrated in tertiary care centers of large catchment areas. For example, in Trentino, Italy, a pilot project has been initiated to provide an integrated service for patients of the regional oncology service. Telemedicine and secure Internet-based integrated records have been used to integrate primary care and local hospitals with the tertiary specialist service.[24] After tertiary care assessment and determination of therapeutic plans, patients can avoid long journeys for regular treatments by receiving their regular treatments at their local hospital. Real-time telemedicine links, coupled with access to a shared virtual record that includes treatment plans and parameters, mean that the local clinician has readily available support from the specialists. This reduces the need for ill patients to travel to receive straightforward individual procedures within a prescribed treatment plan; makes optimal use of clinical skill-mix; and still ensures a seamless standard of safety and surveillance by creating a virtual therapeutic environment.

Preventive telehealth

Telehealth can be applied successfully in preventive health settings, as was demonstrated by the Volta River onchocerciasis prevention project.[25] In this international program, environmental monitoring identifies increases in environmental causal risk factors (e.g., variations in stream flow and water level), and triggers targeted preventive measures (e.g., pesticide application) to avoid epidemics of this vector-borne disease. The expensive administration of pesticides and use of other scarce resources is targeted to the times and locations of need, where they can be most effective, and this targeted use also minimizes adverse health effects.

A THEORY OF DIFFUSION OF INNOVATION

With notable exceptions, the process of adopting innovative technology is seldom rapid or linear. Many technical, economic, social, political, and psychological factors affect

the rate and pattern of diffusion. Those relevant to the diffusion of telemedicine will be discussed here under four headings: economic, societal, institutional, and individual.

The extent to which a new technology is adopted by its intended users varies as a function of the nature of the technology, the nature of the users, and the setting for which its use is contemplated. Various factors that have a general effect on diffusion have been studied for nearly a hundred years,[26,27] but the increasing pace of technological innovation of all types, especially since the 1970s, has led to considerable interest in a comprehensive model of the process. Rogers[28,29] had already developed such a model. Its relevance to telemedicine is discussed here.

For Rogers,[30] diffusion is "the process by which an **innovation** is **communicated** through certain channels over time among the members of a **social system**" [the basic elements highlighted for emphasis]. A thorough discussion of this model is well beyond the scope of this report; instead, attention is drawn to the components most relevant to the spread of telemedicine technology.

Rogers suggested that innovations do not necessarily benefit all adopters. For example, whereas increased access to care may be a socially desirable benefit of telemedicine, payers may view it as a potential threat in terms of increasing their expenditures. A tertiary care center may derive substantial benefits from a heavy investment in information technology that can be used for various purposes (administration, education, and clinical services), but the same investment for a rural critical access hospital may represent a large expenditure with little gain.

At the provider level, a consulting specialist may stand to expand his or her practice and increase revenues by offering remote consultation. For a busy primary care physician, however, there may be no compelling reason to refer patients for teleconsultation. The financial gain from such a referral is likely to occur only if the physician participates in the consult—and the benefits from participating exceed the cost. In short, different parties in telemedicine are likely to have very different incentives to use, or not use, the technology. Even if there may be obvious advantages for a given provider or organization (e.g., retention of patients in a rural hospital), those advantages "are not always clear-cut."[30]

A list of the factors affecting the diffusion of new technologies is presented in Table 2. These factors relate to the four different aspects of the diffusion process and may be manifested at the level of the health care system, the organization, the technology, the institution, or the individual provider. The left-hand column of the table contains a list of factors that influence the adoption of innovative technologies (taken from the work of Scott[31] and Rogers,[30] while the right-hand column lists the significance of these factors for the diffusion of telemedicine.

The health care context: international variety

Global and national diffusion of telemedicine will be faster and easier where there is a strategic environment that supports it. Of course, health care environments vary globally by type (structured and regulated, or free market); form (centralized or decentralized); financing (public, private, or a combination); and other ways as well. In addition, there are also significant variations in terms of the economic and developmental status of any particular country, including the telecommunications infrastructure, as discussed earlier.

In all these contexts, early identification of the potential beneficial use of telemedicine, together with a framework in which it can be applied, enhances the diffusion of telemedicine in appropriate ways. At the same time, drawbacks and potential problems must be anticipated and, as far as possible, controlled. And, the costs must be estimated so cost-benefit ratios can be analyzed.

The integration of telemedicine systems into the local health sector can facilitate its effective diffusion and use. A number of examples from around the globe are cited here.

Small islands. Providing health care to small islands can be challenging. Trauma services or specialist diagnosis of referred symptoms can require sea or air evacuations. These are expensive, often cause delay, and are often inconvenient to the patient and the family. Not surprisingly, in a number of locations, telemedicine is being used to link the island to the

Table 2. Influences on the Diffusion of Telemedicine in Industrialized Nations

Factor	*Relevance to telemedicine*
Authoritarian decision-making	Adoption fastest when the decision to adopt is made by an individual with authority to enforce the decision
Improvement in efficiency	Little increase in efficiency for many applications—especially using video-conferencing—because of inconvenience
Cost of the technology	Relative cost to institution varies by site; absolute costs declines but is excessive for small/rural facilities
Organizational/social structure	Diffusion facilitated by hierarchical, authoritarian systems, and hampered by loosely organized systems
Return on investment	Revenue is minimal, but this varies by application, size of facility, and geographic location
Risk or uncertainty	Payment for services is questionable, as is the issue of whether providers will use the service
Communication channels	Information dissemination most effective if done by peers with similar interests and concerns
Consistency with social norms	Greater likelihood of adoption when an innovation is close to the professional/organizational mainstream
Effect on quality of services	Quality probably comparable to in-person care; possible improvement associated with increased access
Role of opinion leaders	Mainstream, charismatic individuals are likely to influence their peers to adopt new technology
Complexity of skills required	Reasonable learning curve, but requires acquisition of new habits associated with providing care
Social approval	Moderately high appeal to general public and news media, but many providers remain skeptical
Compatibility with status quo	Significant systemic changes may be required in the way care is provided
Capable of pilot test	Depending on technology and application, there may be sufficient opportunity for pilot testing
Organizational change required	Some degree of change may be required, but not necessarily disruptive to ordinary processes of care
Significance of research data	Important for early adopters, but less important than interpersonal channels involving professional peers

From Scott 1990,[31] and Rogers, 1995.[30]

mainland to provide both initial triage and advice on trauma management and secondary care diagnosis for less common illnesses. Examples include linking Easter Island with mainland Chile, Gozo with Malta, and Guadaloupe with Bordeaux (the islands of the French Caribbean being classified as a department of mainland France). In each of these settings, the driving force has been the ethic of equity within one health care system, with telemedicine the appropriate technology to reduce the time and financial barriers of distance.

Isolated populations. A similar driving force for telemedicine diffusion occurs with remote and isolated populations within individual health provider catchment areas, an application pioneered in a number of locations including Newfoundland.[19] In other settings, telemedicine now reduces the number of long and uncomfortable ambulance or private journeys in settings as far apart as the Grampian region of Scotland, southwest Ireland, and outback Australia. In Norway, telemedicine is part of the national strategic approach to tertiary referral, with a specialist support resource in Tromsø.

Locally integrated services. The Andalusia region of Spain invested in modernization of information and communications environments in health care as well as in direct service delivery. The region has a history of innovative partnering with the information technology sector. It has recently integrated emergency, outpatient, and primary care clinical communication systems. This effort is being led by a private sector company contracted to provide the emergency ambulance service. An investment in mobile telemedicine ensued, and the region became an active innovator in a European Union Research and Development proj-

ect.[20] The 24-hour, managed telemedicine communication system has had a capacity added for wider emergency, outpatient, and primary care telemedicine communication.[32]

Integration into a national clinical hierarchy. The Kingdom of Saudi Arabia developed a hierarchical system for targeted distribution of clinical skills. It is important to develop sound and appropriate clinical skills at the local level and to ensure that they have backup in the event of more difficult cases. At the same time, tertiary skills that may not be available at the national level need access to global knowledge. The country has, therefore, developed a tiered telemedicine structure. This is focused on the King Faisal Specialist Hospital, which provides a referral service within the country, and a nodal point for selective consultations for advanced cases with selected partners in the United States.

GENERIC HEALTH SYSTEM ISSUES

In health systems with less governmental involvement, the financial framework plays a significant role in the diffusion process, whereas the role of government may be directed toward quality, client safety, and confidentiality. Consideration of the diffusion of telemedicine should, therefore, be specific to the contextual setting. It must be based on the following clearly articulated set of criteria:

- Demonstrable need
- Explicit statement of anticipated benefits
- Detailed methodology for implementation
- Sound methodology for evaluation
- Service delivery policy and protocols.

VARIABLES AT DIFFERENT LEVELS OF ANALYSIS AFFECTING TELEMEDICINE DIFFUSION

The variables that influence the rate of telemedicine diffusion are manifested at different levels of the health care system. These variables may include aspects of the technology itself, the reaction of different individuals (providers, clients, and others) to the technology; the integration of the technology into other technologies and into organizational processes; the effects of the technology on other components of an organization; and institutional, regulatory, or social policies, among others. The effects of some of these may be felt across providers, provider groups, institutions, and networks because they are associated with policies and regulations at the national, regional, or provincial or state level.

Nonetheless, all variables influencing diffusion can be classified into four categories: economic, societal, organizational, and individual.

Economic variables: information technology and productivity

Economic productivity is the amount of output per unit of input. It is most commonly defined in terms of the cost of labor (labor productivity), or of all input variables (total factor productivity). When we examine the effects of information technology on economic productivity, we find that not all service industries have benefited from the introduction of information technology in the same way or to the same extent. One sector of the economy in which information technology has apparently yielded significant gains is manufacturing. In this sector, computerization and industrial robots have permitted increased production and lower labor costs. Likewise, the economy, finance, insurance, and real estate portions of the service sector have also benefited from information technology. Many derivative investment instruments owe their existence to the development of computing power and the ability to relay large amounts of information around the world in real time. These industries, however, can experience negative effects on productivity as a consequence of any number of unanticipated changes or hidden costs. It has been estimated, for example, that in some organizations the obvious and hidden costs of supporting a client-server computer network may range from $5,000 to as high as $20,000 per personal computer (PC) per year.[33,34]

While many manufacturing processes can be automated, it is not yet possible to automate the work done by physicians, nurses, and the other highly educated and well-paid individu-

als who make up the health care labor force. Health care is labor-intensive. Moreover, health care management does not have the same degree of control over its labor, as does management in other industries. Physicians have a certain degree of independence, and they tend to dominate management. Even when lower physician charges have been negotiated, the negotiations have not been easy.

In health care, there is little solid evidence that information technology had a significant effect on productivity from 1973 and through the 1990s. However, this finding may not stand scrutiny. The lack of evidence may be due, at least in part, to the difficulty of measuring productivity in health care[35–38] On the other hand, Roach[37] suggested that the time input variable in productivity may be underestimated because during the past decade or so people in the United States have worked an increasing number of hours (estimated at 25% more). This increase in hours may be the result of blurring the lines between home and office work as a result of heavy use of information technology.

In short, the introduction of telemedicine into health care systems may have been done in ways that counter improvements in productivity. In some cases, providers must spend more time to accomplish the same amount of work, as, for example, has been the case with the introduction of many electronic medical record systems. There may well be a trade-off between the quality of the patient experience, and the use of clinical time (a familiar conundrum in a new guise). For instance, in a Swedish pilot telemedicine environment, there was strong support for telemedicine as it led to quicker referral, fewer and shorter patient journeys, and greater participation in case discussion and treatment setting by the referring clinician. However, it required more clinician time (and discipline when keeping appointments) since clinicians were involved simultaneously at each end of the link.[39]

When a technology is not at least as convenient as the process it is intended to replace, productivity suffers. The failure of a technology to improve economic productivity may be felt both at the institution's bottom line and by providers who find themselves putting in more work for the same outcome. If there are other gains, as indicated above, they need to be explicitly identified as the corporate gain, justified against the identified resource loss.

The societal level: health care systems and government policy

In the United States, it is customary to attribute what appears to be the slow diffusion of telemedicine to such societal barriers as lack of a widely accepted coverage and payment policy, restrictive interstate licensure issues, inadequate human factors design, lack of uniform engineering standards, and concerns over confidentiality, security, and liability.[40–47] These commonly cited barriers operate primarily at a broader level than individual institutions or providers, and hence they affect most providers in similar ways.

Coverage, licensure, and related issues have been dealt with at length elsewhere.[40–42,47] They are not trivial matters, but they will not be examined here.

The institutional level: health care organizations

Bashshur[40] addressed the diffusion of telemedicine, noting "when technological innovations are not accepted or implemented properly, generally the failure may be traced to a poor fit between the nature of the innovation and the vested interests, resources, and expectations of its major gatekeepers." He listed 16 variables identified by Scott[31] as intrainstitutional factors influencing the process of adoption of new technologies. These included: initial or continuing cost of the innovation; returns on investment; improved efficiency; effect on quality of services; risk or uncertainty; testability in a pilot project; social approval and recognition; consistency with existing procedures and values; extent to which other changes in the organization are required; ability to implement a part of the program on a trial basis; potential for modification if necessary; ease of explaining changes; extent to which new and complex skills are required to use the technology; clarity of results; social desirability; and origin of the innovation (inside or outside the organization). Previously, Kaluzny and Veney[49] investigated the relative

importance of these variables and found the following three as the most significant: anticipated payoff, rate of recovery of investment, and social approval.

It is important to note that the adoption of telemedicine at the institutional level is influenced by the structure of authority behind it, and the degree to which management is able to mandate the use of the technology. This would explain the relatively higher activity levels of adoption in prison programs, the Veterans Administration, and Department of Defense,[9] all of which have a significant degree of institutional control over both physicians and patients.

One fruitful way to consider the effects of institutional structure on the diffusion of telemedicine is through the perspective of the neo-institutional school of thinking in sociology. According to this theoretical paradigm, an institution can be thought of as "an organized, established, procedure,"[50] essentially, a set of habits at the level of a group of people. Often, institutions are resistant to change.[51] Health care professionals and organizations are significantly institutionalized as a consequence of tradition, organizational complexity, and the existence of structured processes, some of which are incremental developments over time, and others of which are carefully designed controls to ensure quality and safety. The adoption of telemedicine necessitates significant changes to this status quo. Consequently, institutions resist such change.

Three types of influence on organizational behavior, relevant to a change such as adoption of telemedicine, have been hypothesized.[52] These reflect the rules and norms that characterize the organizational fields (in this case, health care), rather than reflect responses to market conditions. They are:

1. Coercive isomorphism entails external pressure, which could be exerted on organizations (e.g., federal regulations regarding reimbursement, by grant funding agency guidelines dictating specifics of how telemedicine networks should be constructed and operated), or by cultural expectations within society. Cultural expectations might include pressure from consumer groups to make telemedicine services more broadly available, from physician groups, or from common assumptions about technology innovation as a technical or supply problem. Coercive isomorphism increases in importance with the degree of dependence of the organization on the entities exerting external pressure.
2. Mimetic isomorphism is a process of mimicry in which one organization, especially in an uncertain institutional environment (e.g., in telemedicine, where cost effectiveness is often unknown or ambiguous), may model another. The degree of competitiveness within the health sector may lead organizations to invest in telemedicine and telehealth networks not because of perceived clinical need or comparative market advantage, but because their competitors have telemedicine programs. Mimetic isomorphism may be one explanation for the preponderance of "hub-and-spoke" telehealth network models.
3. Normative isomorphism is a process derived from professionalization. An example of this is the creation or changing of physician attitudes about technology through medical school curricula or through activities or materials generated by professional society subsections (the active telehealth subsection of the American Psychiatric Association is a prime example; whether it is in any way responsible for the high levels of mental health activity within telemedicine is an empirical question). This is more likely to have an effect within organizational fields where the professional class has a relatively high degree of potential influence, as is the case with telemedicine.

Neo-institutional theory yields two important insights. First, organizations and institutions can exhibit habitual behaviors just as individuals can. These behaviors can, under the proper circumstances, become quite resistant to change (i.e., they become institutionalized). Second, the organizational outcome of interest (here, telemedicine networks) is often not the product of rational, market-driven forces. The

extent to which networks are born out of coercion or institutional copying (i.e., rather than being internally driven by clinical and organizational need) may affect their prospects for long-term sustainability.

The individual level

At the level of the individual provider, early adopters of a new technology are more likely to be influenced by the scientific literature than are those who are slower to embrace innovation. The latter group is more likely to be influenced by the experience of peers. The technology itself (complex equipment with a steep learning curve or equipment that either decreases or fails to enhance efficiency) may be less likely to be adopted because it is relatively inconvenient and time consuming.

Many other variables are intrinsic to individual providers or small provider groups. These represent significant impediments to more rapid diffusion of telemedicine, and their influence is felt at the individual level. These variables may be thought of as psychological in nature.

For example, much of economic theory is predicated on the assumption that humans make rational choices about the things that are important to them. While this assumption may facilitate economic theory building, it runs counter to prevailing thinking in both cognitive psychology and cognitive neuroscience (for a readable review of cognitive psychology.[53] People do not necessarily make rational decisions. In fact, as a rule they tend not to do so. Instead, human reasoning relies on rapid pattern recognition (whether the patterns are truly there or not, as in racial stereotyping), and on a number of shortcuts in thinking that psychologists refer to as heuristics. For example, McNeil et al.[54] demonstrated "framing errors" among a sample of American physicians; that is, the physicians responded differently depending on how a question was framed. They were told either that a certain procedure was associated with a 7% mortality rate over five years, or that there was a 93% survival rate over 5 years. When the statistics were presented in terms of a survival rate, physicians said they would be significantly more likely to recommend the procedure to their patients than when the outcomes were presented in terms of mortality, despite the fact that these rates mean exactly the same thing. This is only one of a number of such heuristics.[55]

Cognitive neuroscientists have likewise shown that people tend not to make deliberate, conscious decisions about their behavior. Instead, they tend predominantly to act on the basis of habit—behaviors performed automatically and nonconsciously, learned through the procedural learning system (which is specialized for skills, processes, and habits) as opposed to the declarative learning system, which is specialized for the retention of information and facts.[56] This is advantageous in that habits are frequently efficient, require little thought, and in an emergency could be much more adaptive than having to deliberate over a course of action.[57,58] This efficiency comes at a cost, however, in that novelty may not be well received, in large part because a new way of thinking about or doing things requires deliberate conscious effort until it eventually becomes habitual. In other words, it may be inconvenient.

There are several difficulties associated with these findings. First, people tend not to do things because it is rational to do so; instead, they tend to do them because they are habitual. Second, habits, once established, may persist over a lifetime unless the habit is disrupted by some external force, or one makes a deliberate, conscious, effortful attempt to disrupt the behavior in question. Third, the memory system specialized for learning habits and skills is relatively independent of the system specialized for acquiring knowledge (information). This means that giving providers information will not necessarily change their behavior—something providers see repeated again and again among patients with diseases that are associated with lifestyle.

If we apply these findings to telemedicine, we can formulate the hypothesis that, absent a strong motivating influence or disruptive external force, providers are unlikely to be persuaded to use telemedicine technology on the basis of information (e.g., research findings) alone. Their ordinary habitual mode of practice is generally efficient, they are usually busy, and

to do things significantly differently may well require too great an investment of time and energy, not to mention some opportunity cost. This may be the case even when one is able to argue with them that their choice is not entirely rational. In fact, they are likely to have an immediate and plausible (even if not quite accurate) explanation for their habitual (albeit irrational) behavior.[59]

In short, providers' habits represent a strong inertial force which must be considered if we are to alter behavior and promote the adoption of new technologies. This is especially true when there is no compelling, intrinsic motivation to do so; when the new technology involves inconvenience or a steep learning curve; and when they are already satisfied with the status quo.

Diffusion of MRI: a comparison with telemedicine

The case of nuclear magnetic resonance imaging (MRI) represents an important contrast to telemedicine. MRI is now commonplace in North America. Most urban hospitals in the United States have at least one magnet, and many are purchasing a second or third, often of greater field strength. MRI is widely used, and the number of scanners operating in both Canada and the United States has increased markedly in recent years. Yet in the mid-1980s, there were significant questions about the rate of diffusion of MRI. A study of the diffusion of MRI was published in 1986, about the time the Health Care Financing Administration (now Center for Medicare & Medicaid Services) and many private insurers had decided to cover most clinical uses of the machines.[60] Data were collected, however, prior to the availability of coverage. According to the authors,

> HCFA did not allow reimbursement for Medicare patients. With a few exceptions, Blue Cross/Blue Shield plans refused to pay for MR scans. Many private insurers were just receiving their first claims for MR scans and were still establishing a policy. The grounds for refusal were universally that MR scanning was still an experimental procedure of unproven diagnostic value and was not yet a part of accepted medical practice (p. 47).

This may sound eerily familiar to anyone involved with telemedicine in the United States. Hillman et al.[60] further reported,

> At the time of our interviews, there was (and there continues to be) considerable uncertainty about the ultimate clinical value of MR and about which technological embodiment of basic MR principles will ultimately prove most successful. Not surprisingly, these uncertainties figured prominently in decisions about acquiring MR. Few respondents believed that MR's current capabilities were in themselves sufficient to justify the high costs of the new technology. Uncertainty about the ultimate clinical utility of MR was compounded by uncertainty about the future reimbursement regime: Would important third-party payors recognize sufficient value in MR to reimburse its use? (p. vi)

By 1995–1996, there were approximately 16 magnets per million people in the United States, second only to Japan (at 18.8 scanners per million), and well ahead of Germany, which ranked third at 5.7 per million. In Canada the corresponding figure was 1.3 per million.[1]

There is obviously considerable variation in the organization, quality, and availability of health care in different nations. Yet, even within countries, changes in a single variable may produce significant effects throughout the health care system. For example, Baker[61] reported that the increase in the market share of health maintenance organizations (HMOs) in the United States in the decade between 1983 and 1993 was associated with slower diffusion of MRI into hospitals. HMOs were also associated with lower availability and use of MRI in the mid- and later 1990s.[61]

As was true with MRI, the United States government has on the one hand invested heavily in the development and deployment of telemedicine technology, and on the other it has attempted to control health care costs by

placing significant constraints on coverage and payment.

The situation for MRI in the early 1980s was similar in certain fundamental respects to the current situation for telemedicine. One important difference, however, is that MRI became established as an important clinical tool relatively quickly and for a large range of potential diagnostic uses. Moreover, for many purposes it yielded images that were clearly superior to those of computed tomography or standard radiography. With telemedicine, it is more difficult to make an equally compelling case for its clinical utility. Nevertheless, it may be the case that telemedicine is passing through an unavoidable phase in its evolution and diffusion. It is still primarily the innovators and early adopters[30] who now use the technology and encourage its use.

THE MEASURED PACE OF TELEMEDICINE DIFFUSION: SLOW OR TO BE EXPECTED?

The slow pace of telemedicine diffusion is a problem for those who have invested their time, money, and energy in developing programs and applications, and who struggle to promote this modality of care. Yet, from a more reflective perspective, perhaps this slow pace of development is to be expected. A brief review of some of the factors influencing its diffusion suggests numerous reasons why it may be unrealistic (and indeed inappropriate) to expect faster growth.

A number of the variables influence the rate of diffusion of telemedicine in North America, especially in the United States, and these are likely to be relevant on a wider basis. These include economic, social, organizational, and psychological issues. Economically, for example, it is unclear whether telemedicine and related technologies have had (or could have) a clear and beneficial effect on economic productivity, and hence on organizational profitability. Theoretical models of the diffusion of innovative technology generally help to illuminate the problems faced by those who attempt to promote telemedicine. A focus on the issues (such as uncertainty on the part of providers about the technology and its effect on quality of care, fears of rapid obsolescence, inefficiency, inadequate return on investment) may clarify the directions that need to be taken by organizations that offer telemedicine services. Moreover, it is instructive to note that in the mid-1980s, there was considerable uncertainty about the future of MRI, a technology that seems—at least until it is superseded by a more advanced technology—to be firmly established.

Habit and normal human cognitive functioning are major influences on the behavior of individual providers. People tend—as individuals, and in organizations—to behave in ways that are relatively automatic and nonconscious. These habits make much of our activity more efficient, although they may interfere with an individual's ability to react flexibly to novel situations. Habits, especially those that allow efficient patterns of practice, take some time to establish and may take even longer time (and considerable conscious effort) to alter. In the absence of some strong intrinsic motivation or coercive external forces, the inertia of habit is likely to interfere with change.

Therefore, in current health care behavioral and financial contexts, there may be little stimulus to expand telemedicine use rapidly, and indeed powerful inhibiting factors can be identified. This may be highly appropriate; as with any new technology in health, too rapid an uptake may create risks ranging from lack of development of appropriate clinical skills and of control and quality assurance systems to rapid technical obsolescence. The development of experience, education, and health sector policies and infrastructures appropriate for telemedicine delivery, matched by evaluation and organizational learning, should ensure safe and steady development and expansion, rather than a premature deployment.

The role of government

The role of the government in influencing the pace of telemedicine diffusion varies considerably, at least in relation to type of health care system. In the United States, the government has an interest in ensuring access to quality health care at a reasonable cost, but it also is

interested in controlling costs, and controlling the spread of technologies that might increase costs. In essence, the United States government encourages health care organizations to invest in technologies for which it is, at the same time, unwilling to pay.

The problem is compounded by the fact that to influence the development and future direction of a technology, governments must establish policy early. Unfortunately, this is typically at a time when the clinical and economic outcomes of the diffusion of the technology cannot be predicted because too little is known about the technology, its cost, and its utility.

The situation in the United States is not dissimilar from the situation in the United Kingdom, where telemedicine is advocated as a means of avoiding greater capital expenditure, without guidance or consideration of the deeper issues, both of which are needed in the context of a public health service. In contrast, Finland has approved a virtual hospital, but the hospital has been required to conform exactly to the licensing and regulating procedures for any other, physical hospital. The United States and United Kingdom's approaches also contrast with the integrated approaches adopted in Malaysia and South Africa (described elsewhere in this report).

Toward a telemedicine enablement policy

Separate from, but a key basis for, a telemedicine enablement policy is establishing an appropriate health information infrastructure. There have already been calls for this kind of vehicle in the United States—not a public sector-dominated system or database, but a set of agreed standards, policies, and, when necessary, essential technologies to ensure effective and safe communication of data and other electronic health information.[62–64] Although individual point-to-point telemedicine systems, or hub-and-spoke systems within an individual state, can occur under present circumstances, a federal information infrastructure would facilitate safe and effective telemedicine diffusion. A strategic investment policy in both public and private sectors is necessary for the effective diffusion of telemedicine. In 1997, the United States General Accounting Office (GAO) called for a federal telemedicine strategy to enable effective investment in telemedicine[65]; this was an encouraging step.

Research priorities

The only way to ensure the development of an effective body of knowledge on the impact of telemedicine, to demonstrate its benefits, to ensure that there are no adverse effects that cannot be managed, and to ensure that risks can be adequately controlled and managed, is the development of an objective evaluation program. This has already been argued for in the context of the harnessing of modern information technologies in health. In 1998 the President's Information Technology Advisory Committee argued, "if, as a Nation, we are to fully capture the promise of the new technologies we develop, it is important to include within that program a research agenda to address the social and economic implications of information technologies adoption and diffusion."[66] This is especially appropriate for telemedicine.

Any development, particularly novel technology-based services, must ensure quality and reliability and control known risks. This is particularly pertinent given the current focus on avoidable adverse incidents in current health care systems.[67] A European-led study has shown that there are issues in ensuring reliability and safety in telemedicine, particularly when it crosses international boundaries.[68] Governments must develop appropriate quality control requirements for telemedicine services within their own national boundaries. They must also come together to support international principles, standards, and agreements to ensure the safe mutual trust and dependence on telemedicine services that are intended to make the most efficient use of international expertise but for that may put citizens and local health care professionals at risk from incompetent or even malicious activity.[68]

The role of government is neither to manage telemedicine nor to instigate complex bureaucratic approval or control mechanisms. However, one of the strongest potential barriers to the appropriate diffusion of telemedicine is the concern of individuals and organizations that

neither quality nor adverse outcomes are adequately monitored.

Therefore, the development of an appropriate, impartial evaluation mechanism and knowledge base and agreement on regulatory standards and frameworks seems essential. While excessive governmental control in any setting is liable to stifle telemedicine diffusion, so too is government inaction or abnegation of responsibilities likely to have a similar effect by failing to provide the climate in which telemedicine can grow and develop safely and with mutual trust. An evidence-based support to appropriate mechanisms, and a similarly evidence-based set of quality requirements, are essential enablers of the diffusion process.

Conventional wisdom points to financial, technical, and institutional barriers as reasons for telemedicine's slow and uneven growth. While these may represent important problems, some of them are beyond the ability of single institutions or networks to address. Telemedicine networks may comprise multiple organizations, may rely on physicians only loosely affiliated with the facilities, and in general may represent complex combinations of individuals and organizations. In some cases, networks may be nothing more than congeries of organizations, in some cases including potential competitors, brought together to take advantage of federal funding opportunities. There is a fair amount of "social engineering" required to ensure that incentive structures reflect the needs and constraints of various participants. Solving technical and financial problems is no guarantee of participant satisfaction, efficacy, or high utilization.

Theoretical models of the diffusion of innovative technology help to illuminate the problems faced by those who attempt to promote telemedicine. In fact, a brief review of these issues suggests that we should not be surprised at the current pace of telemedicine adoption. A focus on these issues (e.g., uncertainty on the part of providers about the technology and its effect on quality of care, fears of rapid obsolescence, inefficiency, minimal return on investment) may clarify the directions that need to be taken by organizations that offer telemedicine services.

Finally, we should not ignore the influence of habit and normal cognitive functioning on the behavior of individual providers. In the absence of some strong intrinsic motivation or coercive external forces, the inertia of habit is likely to interfere with change.

RECOMMENDATIONS

- National governments should develop a comprehensive policy framework to enable the safe and effective practice of telemedicine, to include technical and practice standards, and quality assurance best practice. Scientific research must be required in all funded projects.
- A database of telemedicine evidence must be established that extends beyond a mere listing and description of current applications, so as to include evaluative material. This would be compiled in a structured way so as to indicate type of health system and economic context. Above all, it would have a classification of the strength of the evidence, derived from the principles of evidence-based medicine.
- It is important for the World Health Organization (WHO) to identify the focal point of expertise in telemedicine within its organizational structure in order to serve as an international resources for all countries seeking help in designing and developing their telemedicine systems. The WHO can compile and regularly update a comprehensive bibliography and knowledge base of descriptive and evaluative literature, to be available to those wishing to consider potential telemedicine applications. This would be compiled in a structured way so as to indicate type of health system and economic context.
- It is also recommended that the WHO initiate, in conjunction with other relevant organizations such as the International Telecommunication Union and the World Trade Organization, an international scientific forum and resultant international conventions on principles, standards, and underlying reciprocal legal ratification thereof, to ensure safety and public protection in health care delivery by telemedicine across international boundaries.

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