Suggesting a Diffusion Model of Telemedicine  
- Focus on Hong Kong’s Case -

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Abstract
Telemedicine, enabled by state-of-art information technology, is rapidly gaining awareness in many countries. Despite the advanced telecommunication infrastructure, the introduction of telemedicine in Hong Kong has been slow. Hong Kong’s monopolistic health care system provides an answer for the protracted development of telemedicine in the region. This study attempts to reach a theoretical understanding of the structure of Hong Kong’s health care system. For this, we characterize the current health care industry in Hong Kong, identify the primary stakeholders of the health care system, and analyze the relationship among the stakeholders. Based on this understanding of the health care structure, we propose a causal model that describes the development path of telemedicine in Hong Kong. In addition, a current development effort for telemedicine in Hong Kong is introduced based on the case study of two telemedicine applications.

1. Introduction
In order to utilize medical resources effectively, the health care industry has been experimenting with various types of remote health care systems, collectively called telemedicine. Telemedicine can be defined as a remote work arrangement for the investigation, monitoring and management of patients as well as the education of patients and medical staff using information technologies. Health care organizations (i.e., hospitals, clinics and ERs), patients, physicians, and communications links constitute major components of telemedicine [1]. Communication links enable inter-organizational communication and cooperation as well as the integration of intra-organizational systems such as hospital information systems, radiology information systems, and picture archiving and communications systems (PACS) [16,20].

Telemedicine is seen as a potential solution in improving the efficacy of public services in a community with a limited number of medical experts and other related resources. Small and large scale telemedicine projects are underway in Europe, the U.S., and other areas. As Bashshur (1975) pointed out, the geographic separation of entities, the use of technologies, the establishment of staffing arrangements that can effectively perform all the necessary functions of telemedicine systems, and the development of appropriate organizational structures are some of important issues that need to be addressed for the success of telemedicine. Telemedicine naturally requires an interdisciplinary approach that comprises engineering, medical, communication, organizational and social factors.

Nevertheless, the academic work that can supplement the planning and implementation of telemedicine is severely limited. The lack of a systematic approach in the implementation of telemedicine can potentially turn the system into a complete failure. Because the success of a system depends, to the great extent, on non-technical issues as well as on those posed by technology [13].

This paper focuses on the current development of telemedicine at public hospitals in Hong Kong. Hong Kong boasts about an advanced infrastructure in information technology, especially in telecommunication. Nevertheless, the enthusiasm for telemedicine has not been as significant in Hong Kong as other industrialized countries (i.e., the U.S. and Europe) where large scale projects are already underway [12,39]. The slow response
The facilitation of information access.

Telemedicine ranging from simple teleconsulting to medical services can be provided as a form of teleservice. Medical service seeks to help those whose “benefit is constituent on medical treatment or health care provision [19].” A variety of medical services can be provided as a form of telemedicine ranging from simple teleconsulting to telesurgery by robotics. Many applications of telemedicine (i.e., teleradiology) require both services, whereas certain types of telemedicine (i.e., teleconferencing among physicians) involve only the teleservice.

Telemedicine could be understood from the complexity of used technology. For instance, Zieler (1995) identified four levels of telemedicine implementation. The transfer of textual information (i.e., medical records, patients’ demographic information, e-mail) is classified as the first level. The second level involves the transmission of static multimedia information such as X-rays and other images. The use of dynamic information such as interactive videos belongs to the next level of telemedicine. The last category requires technologies still at the experimental level. Virtual operations where “remote palpation and surgery guided by a specialist in a remote location and performed with the help of robotics [39]” are an example.

2.1. Motivating Factors

Access: Accessibility to health care can be understood from three different perspectives: removal of temporal and spatial constraints in health care access, increased effectiveness in utilizing medical resources, and the facilitation of information access. Temporal and spatial access to health care: Telemedicine’s greatest potential is to provide medical care beyond certain spatial and temporal limitations [1,19,31]. A spatial barrier can be the distance separating patients from health care delivery systems [36]. A temporal barrier represents the time delays in providing health care service to patients. The delay between the decision to seek health care and admission to a health care facility, and the delay between arrival at the facility and the initiation of care are instances of temporal barriers.

Improved effectiveness in access for medical resources: Telemedicine will promote more effective use of medical resources through the bypass of spatial and temporal constraints. It will facilitate the rapid redistribution and re-allocation of necessary resources as well as reduce the need for health care-related travel. For instance, it was reported that the more patients contact doctors through telemedicine, the less likely they are to run to the hospital [8].

Information access: Physicians and paramedics in rural areas experience a lack of support in gaining access to updated medical information and knowledge. Due to such isolation, health care personnel tend to avoid working in the remote areas. Consequently, rural patients can suffer from the resulting low-quality medical services. Effective use of telemedicine systems can enable physicians to be informed about and updated on recent medical advances and can provide remote education and training opportunities. In fact, information access has been the dominant use of telemedicine among medical professionals.

Cost: Telemedicine as a potential cost saver at the individual, organization, industry and community (or government) levels has been frequently discussed [18,22,39]. Use of in-home medication and monitoring services [1,8], the elimination of the need for on-call expertise and for maintaining expensive facilities [1,39], the use of video-conferencing instead of remote consultation contracts [3] are some of the ways that can significantly reduce health care costs at different levels. Limited empirical tests support the argument that telemedicine could become a significant cost saver [6,17]. To this end, the development of a methodology to determine accurate cost is critically required for the effective diffusion of telemedicine. In reality, however, few studies have been made on the issue. The lack of study on the cost justification and evaluation becomes one of the main reasons that insurance companies are reluctant to support the diffusion of telemedicine in the U.S. [18,28].

Quality: Three important quality dimensions of medical care are identified: access quality, treatment quality, and information (or data) quality. Parsons (1994) has suggested that the general requirement of quality improvement in medical service is through a good access to preliminary diagnosis, to physicians, and to medical
records. The quality of telemedicine systems can be measured tangibly from the quality of treatment [24]. The quality of a diagnosis and the treatment outcome of patients are the primary factors of treatment quality [20]. One of the ways that telemedicine improves the quality of treatment is through the videotaping of consultations, which enables repeated review of the consultation process by patients and their families [39]. The improvement of treatment quality for rural patients enabled by improved access to expertise and updated information through telemedicine is also expected. The enhancement of the treatment quality parameters can be measured by comparative analysis of empirical data between telemedicine treatment and non-telemedicine treatment. The quality of medical records, data on patients, and medical resources are also important quality factors of health care systems. So far, few empirical studies have been made regarding the impact of telemedicine on each of the quality dimensions of medical service. Morin’s study (1995) that compared the diagnostic report based on transmitted digitized radiographs with the one based on the original radiograph is one of the few studies.

Productivity: Increase of productivity resulting from physician expansion was suggested by Willemain (1975). The term physician expansion means the increase in the number of patients and the size of the geographical area that can be served by each physician enabled by telemedicine. The number of patients equals the “visit capacity.” It represents the maximum flow of patients through remote stations supervised by a physician and patients seen in person by the physician. Telemedicine can achieve the physician expansion by a factor of two or more [36]. Although four major motivational factors are identified, it is almost certain that they are highly correlated with each other. For instance, increased productivity of physicians results in increased access to the health service.

2.2. Barriers against Telemedicine

Barriers against telemedicine are also discussed in the literature. Cost-justification, infrastructure planning and development, telecommunications regulations, reimbursement, license, liability for medical malpractice, and confidentiality should be addressed for the massive diffusion of telemedicine [24,25,33]. The cultural barriers against telemedicine, such as tradition, perception and acceptance, and the lack of knowledge and of training among the people are discussed [13,24,29,31,38]. Technological issues such as compatibility, international linkage with different languages, standardization of systems and documents, and user-friendliness are suggested by Au et al. (1996) and Elton (1975). Collmann (1995) mentioned the legal issues of privacy, the access right to information, and the responsibility for ensuring accuracy of a patient’s records. Each of the barriers has a different characteristics. Some barriers (i.e., infrastructure, regulations) are more tangible and therefore relatively easy to change, whereas others (i.e., organizational attitude, cultural factors) are difficult to change. Some barriers (i.e., technology, education) can be dealt with at organization level, whereas others (i.e., reimbursement policy, licensing, liability) require community-wide efforts. Important barriers are classified under the categories of finance, technology, organization, and culture and legality as shown in Table 1.

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<thead>
<tr>
<th>General Category</th>
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<td>Finance</td>
<td>- Capital investment</td>
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<td>- Reimbursement policy</td>
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<td>- Telecommunication cost</td>
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<td>Technology</td>
<td>- Infrastructure</td>
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<td>- Organizational support</td>
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<td>Culture</td>
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Table 1. Major Barriers in Developing Telemedicine Systems

3. Telemedicine in Hong Kong

Hong Kong, as the third largest financial center and eighth largest trading center in the world, boasts that it has an advanced infrastructure in information technology, especially in telecommunication. The advancement in IT coupled with the current social situation that requires an advanced form of health care system naturally renders a great potential of telemedicine in the region. For instance, telemedicine in Hong Kong could significantly increase the access and quality of health care, compensate for the lack of medical resources, and address the backwardness of computerization at health care organizations [1, 34]. Despite its great potential, the attention and research effort on telemedicine in Hong Kong’s health care industry are not as active as other developed countries. For instance, there are more than 50 telemedicine projects underway in the U.S. and telemedicine is being
3.1. Organizational Characteristics

Hong Kong’s health care system has two distinct characteristics: government control in providing universal care to all the residents and the monopolistic nature of health care system. First, government has a virtual control over health care. In Hong Kong, people are provided medical care services that are virtually free or have nominal fees. The universal care system was introduced in 1950s with an economic motivation to increase economic productivity and to minimize economic loss due to sickness and illness [37]. The provision of medical care independent of one’s working ability and income level has been beneficial to the working population and the burgeoning economy [37].

This universal care system, right now, is provided through a quasi-governmental agency, the Hospital Authority (HA) [14]. It supervises 39 public hospitals and 48 specialist outpatient centers [35]. The HA was established in 1990 following the recommendation of the Scott Report (’85) to integrate both government and subsidized hospitals, to strengthen the internal organization of hospitals, and to improve the cost control including the fee charge structure [37]. It maintains a near-monopoly over Hong Kong’s hospital resources. For instance, public hospitals under the HA operate more than 80 percent of available beds in Hong Kong. Also, 90 percent of secondary and tertiary care services are provided through the public hospitals [1]. However, this government control over major health services appears to result in inefficiencies among the public hospitals. It appears, for example, that more focus of the hospital operation is placed on pleasing hospital management rather than patients [14].

The second feature of Hong Kong’s health care system is its monopolistic nature. First, all the public sector hospital services that have much more significant role than those of private sector are under the control of the HA. Such a monopolistic nature of medical practice seems prevalent in the private health care sector, too. There is no price regulation in the private sector and the private medical fees that reflect market value are among the highest in the world [14, 35]. Also, doctors in private practice engage in overt price discrimination, charging high-income patients much more than low-income patients. The existence of such price discrimination indicates that there is a monopolistic market structure in the private sector [14].

However, Hong Kong’s health care system is slowly changing into a more competitive form of health care. The demand for insurance coverage is increasing and, accordingly, the health insurance market is growing fast. Increasing supply of medical personnel in the private sector is putting pressure on the medical charges. With the construction of new hospitals under the HA, the private sector is losing patients to the public sector. There is a growing cost burden of the government in providing the universal care with nominal fees. While many people enjoy a high degree of health care, such universal coverage by government has resulted in the greater increase of health care expenses than the inflation rate. In response to this change, public hospitals are under pressure to improve efficiency and effectiveness of their processes [35]. Nonetheless, the public hospitals in Hong Kong are still plagued by the low efficiency and effectiveness [14, 35] due partially to their monopolistic status. The lack of competition in the health care industry requires a different approach in theoretical understanding of the organizational environment from those of other countries (i.e., the U.S.) where health care is a highly competitive business, and survival and making profits are the most important objectives.

3.2. Stakeholder Analysis

The study of resource flow among the stakeholders of an organization provides the information on the degree of competition it is facing and on its environmental situations [9]. Hospital strategies, actions, and successes are to a great extent the consequences of a negotiation process with stakeholders [5]. Generally speaking, stakeholders are “individuals, groups, or organizations that have a stake in what an organization does” [5]. Blair (1988) categorized stakeholders as internal, external, and interface types. Staff employees and clinical managers are typical examples of internal stakeholders. Government (HA), insurance companies, and other health care organizations are external stakeholders in Hong Kong. Medical personnel such as physicians and nurses are classified as the interface type stakeholders [4]. The resources in the health care environment flow in the form of information, cash, or any type of influences. We have identified hospitals in the public sector, the HA, people, the private health care sector, and medical staff as the primary stakeholders of the health care in Hong Kong. Although insurance companies are important stakeholders in the U.S. and other markets, they are not counted here because of the monopolistic nature and government-control of health care in Hong Kong.
Ehreth (1993) suggested that organizational dependence for stakeholders is dependent on the importance of the resources stakeholders provide for the maintenance of the organization. The critical resource provider naturally carries a higher influence on the health care organization. In Hong Kong, the monopolistic power of the HA on public hospitals indicates its high stake in the health care organizations.

On the contrary, with the domination of public hospitals in the health care system, certain feedback and competition from ordinary users, private sectors and insurance companies would not exert a significant influence on the hospitals compared to that from the HA.

This overall power structure shows a great difference from that of the U.S. where, because of the intense competition, hospitals are forced to balance responses to the consumers, insurance companies, government, medical staff and other hospitals. The description of the power structure between public hospitals and their major stakeholders in Hong Kong is illustrated in Figure 1. The solid lines represent the direction of resource flows and the dotted lines indicate the degree of criteria compliance by resource recipients. The darker the line, the stronger the influence and response between the entities.

![Figure 1. The Power Structure of Major Stakeholders in Hong Kong.](image)

In general, the more an organization depends on its stakeholders for resources, the higher effectiveness it achieves [19]. When an organization can exist independently (without resources from stakeholders), inertia begins to crop up and to suppress the force of adaptive change. The emphasis of organizational change and change management [15,32], and of massive re-engineering and restructuring [15] at U.S. hospitals result from the struggle to remain competitive by responding more effectively to important stakeholders.

For the public hospitals in Hong Kong, the HA is only one major stakeholder that can significantly influence their organizational processes. Therefore, the lack of market pressure to increase the organizational effectiveness among the public hospitals is prevalent. With this reason, the authoritative force from HA should be an effective agent for innovations to promote the organizational effectiveness and for avoiding inertia in the public hospitals. The adoption of telemedicine could be understood from this perspective.

The current development of telemedicine in Hong Kong is based on the top-down approach. Unlike other areas, especially the U.S., where telemedicine efforts are initiated both from government and hospital levels, Hong Kong’s efforts to adopt telemedicine are almost exclusively led by the initiative from the HA, a government agency. In the U.S., large scale telemedicine projects are usually supported by government grants and hospitals are actively searching for ways of implementing telemedicine to increase their market competition [9,11]. This two way interaction (top-down and bottom-up) provides an effective momentum for the development of telemedicine. In Hong Kong, the bottom-up initiative is virtually non-existent because of the monopolistic situation of public hospitals in the health care sector.

With the unilateral initiative from the HA, more complete understanding on organizational issues may be lacking in implementing a telemedicine systems in Hong Kong’s public hospitals. Because of this, an initial resistance to the innovation could be expected. Furthermore, a potential compatibility problem resulting
from the lack of validity with current process, culture, structure and management style [1] may cause the delay or failure of diffusion of the innovation. At this point, the dissemination of telemedicine in Hong Kong would need strong intra-organizational efforts (i.e., training, education) and the HA should be actively involved in the process.

3.3. Suggestion of an Adoption Model

Because of the uniqueness of its health care system, we suggest that telemedicine development in Hong Kong follow the proposed causal model depicted in Figure 2. Although market pressure is included, we indicate its minimal effect using a dotted line in the model.

Adoption of an innovation and the extent of diffusion of that innovation are dependent on the characteristics of the innovation perceived by the adopting organization [23]. For telemedicine, the primary driving force of its adoption is the benefits it provides rather than the development of technology itself. In Hong Kong, the need for telemedicine is recognized by the geographical condition of a chain of many islands, the high cost of living, insufficient medical resources in the public sector, the lack of medical specialists in certain areas, and the need for the improvement of accident- and emergency-related services [1].

![Figure 2. A Causal Model for Telemedicine in Hong Kong.](image)

Compatibility significantly influences the adoption of an innovation in organizations [23,26]. Compatibility is defined as the “degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the potential adopter” [27]. It is a positive indicator for innovation adoption. The compatibility factors are again classified into organizational and technical validities [30]. The compatibility with existing systems in terms of the organizational network, hardware devices, software applications, and data structure provides the technical validity [1]. The compatibility with current organizational values systems and organizational characteristics (i.e., procedures, cultures, structure, management style) provides the organizational validity. Because the system scope of telemedicine easily crosses an organizational boundary, the compatibility issue should be extended into that between or among the organizations.

The major barriers (Table 1) identified for implementing telemedicine fit into the frame of organizational and technical validity in that, unless they are reduced or removed, effective adoption of telemedicine will not be feasible. Some of the barriers such as capital investment, telecommunication cost, organizational training and support are the measures of intra-organizational validity. Reimbursement, user acceptance, licensing, regulations and legal issues are related to the inter-organizational validity. Technological infrastructure fits to the technical validity. Implemented telemedicine systems would be different in terms of benefits and user satisfaction. Also, telemedicine is expected to cause organizational changes in the structure, activities, and communication patterns. For example, the importance of process re-engineering for telemedicine to improve service quality and to reduce cost and process redundancy is noted [20]. Increased benefits and satisfaction from users (patients and medical staff) as well as appropriate organizational changes
would contribute for the increased diffusion of the telemedicine within and among the organizations.

4. Case Study of Telemedicine Applications

Hong Kong’s major push toward telemedicine began with the HA information technology/information systems (IT/IS) strategy instigated in 1992. The HA introduced a three-stage plan for telemedicine that will last until the year 2000 [34]. Stage I of the HA IT/IS Strategy (1992-1994) focused on providing hospitals with databases and establishing a network within and among the public hospitals. The patient database maintains longitudinal and inter-disciplinary information on visiting patients. Phase II started at the end of 1994 and focuses on achieving two goals: (1) to provide applications systems in the ward, and diagnostic and therapeutic services at the department level within the hospital-wide communication networks and (2) to establish communication networks at the specialist outpatient clinics. The emphasis of Stage III will be placed on integrating island systems in the hospitals and clinics, and the development of decision support systems for medical services.

4.1. Data communication infrastructure

Currently, the backbone of the network is established via T1 lines that connect the HA database center and the 39 public hospitals. At the end of 1994, more than 100 datalines and 95 LANs have been established throughout 37 hospitals and 38 outpatient clinics. A recent announcement by the HA includes the upgrade of major inter-hospital links to ATM and 100 Mb Ethernet for intra-hospital LANs.

The HA maintains an integrated patient administrative system (IPAS) that keeps the database of patient demographics and episodic data for all patients that use the HA’s facilities. The major upgrade of the backbone network among the hospitals and clinics will enable the introduction of image-based telemedicine applications and video-conferencing among medical staff and patients.

4.2. Telemedicine Applications

Limited telemedicine applications for public hospitals have recently developed and been used. For instance, MICATS (the medical imaging capture, archive, and transfer system) developed by the Medical Development Technology Center (MDTC) has been used in the neurosurgery department to capture diagnostic images. The captured images at MICATS can be coupled with patient database from the HA and transmitted through inter-hospital networks for remote diagnosis and consultation. Also fabrication of three-dimensional models for the captured image can be made [1].

Using MICATS as a prototype, an additional telemedicine system, called Neurosurgical Medical Record & Imaging System (NMRIS), has been in development under the HA’s initiative. NMRIS is based on MS Windows platform. It can integrate the patients’ records, diagnosis, procedures summary, and image capturing and storage. The interchange of patient information and images between hospitals becomes possible with the NMRIS. It is also connected to the patients’ database of the Hospital Information System (HIS), which contains more detailed patient information. Through the integration of different functions, the system is intended to support the consultation with clinical information and film images as well as relevant medical research, analysis, and training. Currently, the NMRIS links the neurosurgical units of three public hospitals. A new version of NMRIS has been installed at one hospital, and over 8,000 patient records and 200 medical images have been entered into the NMRIS database.

The two current telemedicine systems, MICATS and NMRIS, mostly focus on capturing patients’ demographic and longitudinal information, and their medical images in databases. Transmission of images and patient information among the hospitals is beginning to increase. The established infrastructure, however, provides a potential for more advanced form of telemedicine such as remote diagnosis, mobile clinics, video-conferencing, and remote patient care that can greatly improve the efficiency and effectiveness of the health care in Hong Kong.

Data transmission can be made either in real-time or as a store-and-forward mode. The store-and-forward is slowly gaining attention in telemedicine because of its established technology and low cost. In fact, transmission of medical images in real-time is extremely costly and transmission cost itself becomes a major roadblock of telemedicine dissemination. One additional advantage of store-and-forward approach for medical applications is that there is a standard for this type of transmission, EDI 275 [22]. Therefore, existing EDI software that follows the standard can be easily applied to the medical domain.
5. Conclusion

Hong Kong has legitimate reasons for the active promotion of telemedicine. As an effort to lay a foundation for the future research on telemedicine in Hong Kong, we discussed the health care industry in Hong Kong based on the stakeholder analysis and the current development of telemedicine in the region. The monopoly of health services, especially secondary and tertiary services, by public hospitals governed by the HA and, accordingly, the lack of competition are pinpointed as the significant roadblock for telemedicine development in Hong Kong. As an alternative for the competitive pressure, we proposed that the HA take more active role in adopting telemedicine to improve organizational effectiveness. The top-down initiative from the HA to promote the new innovation has made some gains for the use of telemedicine. With the development of NMRIS, HA has taken the first step into the world of telemedicine. It will take years of further effort for system development and research before the real impact of telemedicine in the region can be understood. However, with its well established information infrastructure, Hong Kong is ready to take advantage of telemedicine the in near future. The proposed causal model for telemedicine in Hong Kong will continue to evolve over time and is intended to be used for a longitudinal study. Adoption of telemedicine in Hong Kong has just begun.

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