From Adoption to Diffusion of a Telehealth Innovation

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Abstract

Telehealth innovations promise to provide extensive medical benefits by increasing access to healthcare services and lowering costs at the same time. However, while many telehealth initiatives are considered technically viable and medically relevant, they often fail to go beyond the status of prototype applications. Motivated by our limited knowledge on how promising telehealth innovations are further diffused, this study offers a longitudinal investigation of a specific telehealth program and analyzes its initial adoption and further diffusion through commercialization initiatives. Framed as a diffusion of innovation study, the paper aims to offer research contributions as well as practical lessons. In terms of research, the paper expands our knowledge of the emerging IS research topic of telehealth innovations with an empirical investigation of a telehealth innovation. It also contributes to process-oriented diffusion of innovation research by challenging and expanding extant theories to a relatively new research context. In terms of practice, the study provides insights by detailing the transition process of a telehealth innovation from initial adoption to further diffusion and by identifying contextual issues that facilitates or challenges the transition.

Key words: Telehealth innovations, diffusion of innovation, commercialization, process model

1. Introduction

Telehealth innovations are considered to have great potential to help resolve important issues in healthcare. The potential benefits include enhanced accessibility to healthcare, reduced cost of care, and enhanced quality of care [U.S. Congress, Office of Technology Assessment, 1, 2, 3]. Despite such potential, however, many telehealth innovations are either not accepted or not successfully implemented [2, 3]. The reasons cited include poor technology performance, organizational issues, and legal barriers [4]. It is also widely acknowledged that users of such innovations, physicians and other medical staff in most cases, are notorious for their non-responsiveness to and resistance to use of information technologies [5, 6].

Telehealth innovations originate from development in the manned space-flight program by the National Aeronautics and Space Administration (NASA) and from pioneering efforts of a few physicians using off-the-shelf commercial equipment [7]. Telehealth projects vary with respect to goals, funding, and technology, but many large scale projects in the 1990s were undertaken by large university hospitals with external funding from government agencies and industry [U.S. Congress, Office of Technology Assessment, 1, 7]. Though telehealth has been practiced for more than 40 years, its status was until recently evaluated as being in the early stages of development [U.S. Congress, Office of Technology Assessment,1]. However, technology advances have now contributed to increased experiments with telehealth innovations that potentially can lead to improved business and product development, commercialization, sales, and job creation, though these impacts have not materialized yet [8]. In a typical life trajectory of telehealth innovations, many die out as they move out of the pilot project status after initial funding is exhausted despite being considered medically and technically viable solutions during the initial adoption stages. Unfortunately, we do not have enough understanding of this paradox. Nor do we understand what it takes for successful innovations to further diffuse into a larger population of healthcare organizations. In other words, the processes from prototype development and initial adoption to further diffusion beyond the original source of telehealth innovations are not well understood. We have found few studies in the information systems (IS) literature that address this important issue directly. Motivated by this research gap, we investigate the following research questions in this study:

- ***Descriptive question:*** How is a telehealth innovation developed from its initial adoption by a small network of hospitals to wider diffusion into a larger population of organizations?
- ***Prescriptive question:*** What lessons can we suggest on how to successfully transition

from initial adoption to wider diffusion of a telehealth innovation?

To that end, we conducted a case study in which we closely followed a telestroke innovation over two and a half years. The telehealth innovation was developed and adopted by the initial network of hospitals and is currently undergoing a commercialization process. By closely following and examining these processes, this study aims at a number of contributions in terms of research and practice. First, it aims to contribute to telehealth innovation research by providing insights into what processes makes such an innovation survive the initial pilot stages and go through commercialization. There exist few studies that followed a longitudinal development of adoption and commercialization of a telehealth innovation. Second, this research aims to contribute to diffusion of innovation research, process-oriented approaches in particular, by examining the telehealth innovation from a diffusion of innovation perspective. The study expands this body of knowledge with an empirical investigation of technology diffusion in the field of healthcare, a relatively recent IS research domain. Finally, this study aims to provide practical insights by identifying and highlighting context-specific issues such as facilitating factors and obstacles for transitioning from initial adoption to wider diffusion of a telehealth innovation.

The study is structured as follows. The next section reviews telehealth innovation and diffusion of innovation research. Then, we discuss the case study design and the analysis framework in the research method section. Subsequently, we present our findings in the results section. We conclude this study with a discussion of its contributions and implications for both research and practice.

2. Theoretical Background

Telehealth innovations

Healthcare has emerged as an increasingly important domain in IS research with a steadily growing body of knowledge as the investments in information technology (IT) lead to increased use of and experiments with IT-based innovations [9]. In this paper, we focus on telehealth innovations as an important subset of IT-based innovations in the healthcare domain. Technology advances related to network technologies, advanced interfaces, and mobile technology have created a renaissance of such innovations since the 1990s [10]. As a result, increased use of IT to deliver healthcare services over distance have created new terminology such as telemedicine, telehealth, and e-health [4, 5, 10]. Although exact definitions and boundaries of these terms are elusive [4], telemedicine is broadly defined as provision of healthcare services, clinical information, and medical education over distance using telecommunication technology, whereas telehealth is seen as being a more encompassing term [10]. Telehealth encompasses the distant delivery of health services including clinical, educational, and administrative services, through transfer of various forms of information (e.g. audio, video and graphics) via telecommunication [11]. Maheu et al. point out that the term telehealth has grown in popularity and is now used as a synonym for telemedicine [10].

Although the major contributions to telehealth innovation research comes from the field of medical informatics [9], the IS field has begun to offer contributions to this research topic [e.g. 12, 13-19]. However, research questions and approaches vary significantly. Adewale and Mbarika discuss the potential and challenges of telehealth innovations in developing countries at national levels [12, 17]. Liang et al.'s study focuses on development of a web-based decision support system to encourage multiple sclerosis patients to continue a specific medication and provides the results of a preliminary evaluation of the system [16]. Brown et al. propose hypotheses on individuals' interpersonal traits and their effect on willingness to collaborate and productivity of the collaboration in the context of telehealth innovations [13]. Hence, these two studies analyze individual level adoption of telehealth innovations. In contrast, studies like Paul and McDaniel [19] and Paul [18] examine organizational performance of virtual collaboration through telehealth innovations. Other organization level studies approach the topic from the point of view of adoption and diffusion of telehealth innovations. For example, studies like Constantinides and Barrett and Chau and Hu investigate various aspects of organizational implementation of telehealth innovations [14, 15]. Constantinides and Barrett investigate the implementation process of a telehealth innovation in Crete with a focus on interrelationships between the context, the manner in which information systems are employed in practice, and the role of different technology artifacts [15]. Chau and Hu [14] analyze implementation of a Hong Kong-based telemedicine program using an IT diffusion model [20, 21]. These two studies analyze adoption of innovation into an initial adopting network of hospitals.

In the current literature, we found few studies which investigate how a telehealth innovation goes beyond its context of origin, how it gains sustainability, and how it migrates from a pilot state to a full-grown product through commercialization. This paper aims to fill this research gap by closely following a telehealth innovation from its initial adoption process through subsequent commercialization. We adopt a diffusion of innovation perspective in combination with a process-oriented perspective, a research approach that matches well the longitudinal nature of our case and the detailed insights we have gained into the various stages of the

process. Hence, drawing on the existing body of knowledge on diffusion of innovation, we seek to answer the posed research questions and contribute with new insights.

Diffusion of innovations

Research on innovation adoption and diffusion has been established as one of the major research streams in the IS field with a large body of knowledge accumulated (refer to summaries of this research stream by Fichman [22] and Gallivan [23]). Definitions on terminology vary among researchers. In his classical model of innovation diffusion, Rogers defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system [24]. In a similar vein, Fichman defines diffusion as the process by which a technology spreads across a population of organizations [22]. We adopt this notion of diffusion with its focus on a larger population of organizations, which is clearly distinguished from the notion of adoption that is focused on innovation adopting entities whether they be individuals, or organizations. For example, Davis' [25] Technology Acceptance model and Rogers' Diffusion of Innovation theory (Rogers' theory covers both individual level adoption and organizational level adoption) are among the most dominant frameworks explaining individuals' adoption and acceptance of technology and this individual-level research focuses on innovation characteristics and other contextual adoption factors [22, 23]. Another approach to innovation adoption research at the organizational level is from a process perspective, which this study subscribes to. Rogers proposed five stages for innovation adoption in organizations and Kwon and Zmud [21] and Cooper and Zmud [20] have suggested another classical six-stage adoption process model.

These dominant theories of diffusion of innovations are criticized for their limited explanatory power [22, 23, 26, 27]. Fichman argues that innovation research based on Rogers' classical model focuses mainly on simple innovations being adopted autonomously by individuals and therefore it is less relevant to technologies adopted by organizations [22]. Motivated by such limitations in the dominant theoretical frameworks, Gallivan argues that to explain more complex technologies and adoption scenarios we need to expand our processual understanding of innovations and he suggests a hybrid framework that incorporates processes and factors related to organizational adoption of innovations [23]. Lyytinen and Damsgaard also recognize limitations of the assumptions underlying Rogers' diffusion of innovation theory which are not aligned with those of complex and networked technologies such as EDI [27]. They argue that complex and networked technologies contain messy, complex problem-solving elements and such technologies are socially constructed as they shape and are shaped by society. Lyytinen and Damsgaard suggest process-based approaches to study complex, networked technologies; such approaches help achieve greater accuracy and deeper insights rather than simplicity and generalizability in traditional diffusion of innovation research [27].

Telehealth innovations exhibit a number of unique characteristics. Some of these characteristics fit well with the characteristics of complex, networked technologies suggested by Lyytinen and Damsgaard [27]. First, telehealth innovations are inter-organizational in nature. Second, telehealth innovations require considerable alignment of organizational procedures and policies by electronically linking multiple organizations and their work processes. Third, telehealth innovations require a considerable user mass to be efficiently deployed. One factor which makes telehealth innovations more challenging is the complex institutional environments governed and strongly influenced by multiple regulatory and government-sponsored agencies [11, 28]. The process-oriented perspective taken in this study is appropriate to explore these technical and social characteristics of telehealth innovations. It is particularly suitable to investigate the transition processes of the innovation from its initial implementation and adoption as a pilot project to further diffusion through commercialization. Process research analyzes sequences of events to explain how particular changes evolve over time [29-31] and it is valuable in investigating the context in which events occur and the causal linkages and temporal relationships unfold [23]. Specifically, this study adopts what Markus and Robey [29] calls an emergent perspective on causal agency in IT and organizational change, which is well suited to the inter-organizational setting of this study. From an emergent perspective, behaviors of organizations emerge through dynamic interactions between diverse external circumstances and internal interests and motives.

3. Research Method

Case Study

An in-depth, longitudinal case study was conducted. Generally, a case study is a preferred way of research when how and why questions are being posed [32, 33] about a contemporary phenomenon in its context [34]. This is well aligned with the themes and phenomena of this process-oriented study focused on understanding the transition of a telehealth innovation from initial adoption as a pilot to further diffusion through commercialization. It is also desirable from the point of view that we as researchers did not have any control over the events and we seek to understand interactions between IT-related innovations and organizational contexts [33]. Single case studies further allow researchers to investigate phenomena in depth to provide rich description and understanding [35].

Focal Innovation

In March 2003, the department of neurology at a large university hospital (referred to as the hub hospital) in the state of Georgia in the U.S. launched a telestroke program named the Remote Evaluation for Acute Ischemic Stroke Program, or REACH. This telestroke system allows neurologists from the hub hospital to participate in real-time stroke assessments of patients in rural hospitals (See Cho et al. for detailed technical description of the innovation [36]). The innovation was first launched in one rural hospital and gradually expanded to a number of hospitals, with initial technical problems being detected and resolved effectively over time

The need for the REACH system was justified by the critical lack of stroke specialist expertise in most rural areas and in many urban areas as well. This contributes to a higher rate of stroke deaths in rural and underserved communities [37]. For the case of non-bleeding, or ischemic, stroke, a blood-clot dissolving agent called tPA (tissue Plasminogen Activator) greatly reduces chances of severe disabilities if it is administered within three hours from the first show of stroke symptoms. However, it is estimated that only a fraction of stroke patients receives its benefits, partly due to a lack of on-site stroke specialists. It is essential that a stroke specialist examines each stroke patient before tPA is applied. It is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA to a bleeding case will have immediate and most likely lethal consequences. Providing the services of stroke specialists over distance can therefore significantly increase the rate of tPA use, save many lives, and reduce the risk of permanent disabilities. Between March of 2003 and May of 2004, doctors had used REACH to evaluate 75 patients and to qualify 12 of them for treatment. In late 2006, more than 400 patients have been evaluated through REACH at 9 rural hospitals with 55 having been treated with tPA.

In January 2005, two entrepreneurs sponsored by a state R&D funding agency joined and formed a company (referred to in the following by the pseudonym *BrainCare Inc.*) to commercialize REACH. The hub hospital and the two entrepreneurs went through several rounds of negotiations, but failed to reach an agreement on licensing and operation terms and conditions. As a result, the sponsorship of the state to *BrainCare Inc.* ceased by the end of 2005. A few months after the first failed commercialization attempt, the REACH initiators (a group of neurologists at the hub hospital) established another company (referred to in the following as the pseudonym *BrainConsult*) to continue commercialization of the innovation. Gaining some momentum from winning a state technology competition, the initiators found their first potential customers in September 2006 and continued expanding their market nationwide.

Data Collection and Analysis

It is typical that case research utilizes multiple data sources [34, 38]. In this study, multiple data sources have been sought to ensure triangulation [34]. Data sources include systems documentation, public articles, stakeholder interviews, and workshops. A total of 26 individuals in five hospitals (hub hospital and four rural hospitals) have been interviewed to examine the initial adoption process of the innovation: seven doctors, six administrative staff, three IT staff, nine nurses, and one radiology technician. Detailed analyses of the initial adoption process of the innovation was reported in two previous studies [39, 40]

Following the commercialization initiatives, the first two authors held 12 workshops and follow-up meetings with the two entrepreneurs of *BrainCare Inc.* to discuss business plans and strategy. The researchers also interviewed five individuals from *BrainConsult* including the CEO and members of the Board of Directors. Individualized interview protocols were developed before interviews through discussions and iterations between the interviewing researchers. All the interviews and workshops were recorded and interviews were transcribed for later analyses.

Interview notes were made during and immediately following each interview and workshop. In most cases, the two authors held debriefing sessions among themselves exchanging their summaries of major points of each interview and workshop. This practice ensured a rounded and multi-faceted understanding of data and enhanced inter-subjectivity in the initial interpretation of data.

The data were further analyzed later focusing on the process of initial adoption and further diffusion. First, events were identified to chronologically chart the process of adoption and diffusion of the innovation. According to Miles and Huberman [38], such a listing of events provides insights in terms of "what led to what and when." Key actors were then identified as well as their actions and implications for further diffusion. Then, a process model to describe and explain the initial adoption and further diffusion was established through rounds of discussions among all three researchers. Differences among the researchers were resolved through discussions that resulted in iterative refinements of the overall analysis. The analysis was hence an iterative process that continued until consensus was established among the researchers. The following are the results of this case analysis.

4. Results

The results are presented in four phases – adoption, implementation, commercialization, and diffusion (Table 1). For each phase, we identify the main actors and describe and analyze their actions. These results provide insights on how the process unfolded.

Adoption

The first phase of adoption covers the initiation of the telestroke system development in 2000 to the roll out of the system to the first rural hospital in 2003. The innovation was driven by a group of four neurologists with one doctor serving as the champion of the innovation. The neurologists had long cherished the idea of a telestroke system that could link them effectively to rural hospitals and they started to implement this idea by hiring a technically skilled medical student for system development in 2000. A year later, after the student left for residency in another hospital, the neurology department employed a full time system developer. The system developer and the four neurologists quickly developed rapport and formed a committed and well-functioning team. In the first phase of adoption, the neurologists played a key role as the primary driving force. They were simultaneously the project champions and end-users, as well as heavily involved in the development process. The neurologists basically controlled the process and interacted constantly with the system developer by sharing their work practices and ideas and by providing feedback to support incremental development of the system. Also, in parallel to developing REACH, the neurologists cultivated relationships with nearby rural hospitals by visiting them and educating the medical staff on how to collaboratively diagnose and treat ischemic strokes. During frequent visits, the neurologists were able to understand the operational conditions at the rural hospitals as well as user (ER physicians) needs. The telestroke initiative was supported by top management at the hub hospital, more specifically the CEO and one vice president for service outreach. The neurologists were actively promoting REACH and were able to get financial support for system development and equipment purchase for rural hospital installation. The first phase of adoption was dominated by the activities of the small group of highly motivated neurologists. Through these activities and close collaboration with a few other stakeholders, they managed to successfully develop REACH as a medically feasible telestroke system.

Phase & Key Events	Actors (who)	Actions (what)
Adoption • Innovation conceptualized • Hire graduate student • Hire full-time developer	• Neurologists • System developer • Hub hospital	• Conceptualized by hub-hospital neurologists • Relationships with target rural hospitals cultivated • Implemented by dedicated developer
Implementation • First roll-out • Gradual inclusion of rural hospitals	• Neurologists • System developer • Rural hospitals	• Roll-out one by one • Tried to resolve technology issues at rural hospitals • Tried to resolve financial issues at hub and rural hospitals
Commercialization • Firm established • Tech competition • Contract for system upgrade • Hire CEO	• Firms (*BrainCare Inc.* and *BrainConsult*) • State funding agency • Hospital administration • Neurologists	• Negotiations between the hub and *BrainCare Inc.* • Establishment of *BrainConsult* • System reengineering • Market development
Diffusion • First customer	• *BrainConsult* • Customers • Competitors	• Further market development • Negotiation between competitors

Table 1. Actors and activities involved in the telestroke innovation

Implementation

The phase of implementation covers the first rollout of the telestroke system in March 2003 and its continued expansion into a network of rural hospitals. During this phase, REACH was gradually rolled out to a total of nine rural hospitals as of December 2006. The neurologists continued to play an important role by negotiating the system launch with nearby rural hospitals. Once a rural hospital agreed to participate in the telestroke network, the system was provided and installed by the hub hospital without any costs shared by the rural hospital. The system developer

played an increasingly important role by almost single-handedly managing system installation in each rural hospital as well as subsequent trouble-shooting and maintenance. As REACH expanded into more rural hospitals, two categories of issues emerged as being important for the involved stakeholders. One was technical issues and the other was reimbursement issues. The limited IT resources at rural hospitals surfaced as a serious problem. Most of the rural hospitals did not have full-time IT staff, and there was therefore no consistent communication interface to address technical issues between the hub hospital and the rural hospitals. As a consequence, the system developer at the hub hospital had to handle even minor technical problems at the rural hospitals, though later a full-time technician was hired by the hub hospital to oversee technical implementation and system trouble-shooting. In some cases, system installation significantly fell behind schedule due to lack of fast internet connection and digital CT scanners in the rural hospitals. Over the process of gradual expansion, the knowledge base about REACH and its use continued to grow; but it remained difficult to leverage these experiences in the context of the rural hospitals. Another group of issues were related to reimbursement. The medical services provided by the neurologists through REACH were not reimbursed because the system configuration did not meet the two-way video link requirement for telemedicine to receive proper reimbursement. Also, the rural hospitals were under-reimbursed for their services through REACH because the majority of their patient base was covered by Medicare and Medicaid - government insurance institutions which were known for under-reimbursement of medical services. Despite these technical and financial issues, the telestroke system continued to expand into more rural hospitals. However, there were no systematic and successful attempts to develop and negotiate sustainable models that would effectively resolve the technical and financial issues related to the innovation.

Commercialization

The beginning of the commercialization phase was dominated by two entrepreneurs who established *BrainCare Inc.* to commercialize the telestroke system. Engaged by the neurologists and funded by a state R&D agency in the state of Georgia, the two entrepreneurs negotiated conditions with the hub hospital and the neurologists while developing a detailed business plan and searching for additional funding sources and potential customers. However, the relationship between the firm and the hub hospital deteriorated over issues of licensing and operation terms and the negotiations ended in failure at the end of 2005. The initial funding ceased and *BrainCare Inc.* was dissolved. As the neurologists ended negotiations with the two entrepreneurs, they started to explore alternative commercialization opportunities themselves. They filed for a Small Business Innovation Research (SBIR) grant from NIH by establishing a firm (*BrainConsult*) on their own. At the same time, the telestroke system almost reached a local saturation point with the single hub hospital covering nine nearby rural hospitals. At this point, the innovation faced funding problems for further local expansion and the neurologists increasingly emphasized diffusion of REACH nationwide based on its success within the local network. Applying for the SBIR grant created momentum for these efforts and required the neurologists to establish *BrainConsult* on March 2006. At the same time, the project initiators won a state-wide technology competition in May 2006, which created wider recognition of REACH and brought in prize money of $100,000. Winning the competition boosted enthusiasm and confidence among the various stakeholders. A new CEO with software development background was hired and the system was reengineered to increase reliability and scalability. Up to this point, the key stakeholders did not have business experience and were mainly driven by solid medical expertise and interest in how technology could become useful in treating ischemic stroke patients. The new CEO, who did not have any healthcare industry experience, brought much needed business experience and solid technological capabilities to the team. As a result, business plans and technology infrastructure were developed and during these activities potential customers started approaching *BrainConsult* in summer 2006. By the end of 2006, *BrainConsult* was still in the process of being shaped. The firm operated virtually without a physical office location, and the stakeholders were still looking for complementary funding. Slowly but surely, *BrainConsult* was being shaped with a solidified technological infrastructure, an emerging organizational structure, and a comprehensive business plan.

Diffusion

The telestroke innovation created attention on its own. Even before the commercialization attempts went into full gear, some hospitals in other U.S. states showed interest in REACH, though their interests did not lead to implementation and formal contracts. Later, while the system was being systematically reengineered, *BrainConsult* started interacting with potential customers. The Surgeon General of a northern state pushed for telemedicine systems for rural areas and REACH was seriously considered. In

September 2006, *BrainConsult* signed a formal contract with this state as its first customer. The scale of the contract was relatively large with five hub hospitals, each of which would cover ten rural hospitals. Gradual development of the five hub-and-spoke systems were planned and by December 2006, two of them were up and running, generating revenue for *BrainConsult*. The first customer and further diffusion of the innovation outside of its originating context was a major milestone for the innovation. To support further diffusion, *BrainConsult* developed flexible business plans facilitating tailored pricing and operating models to individual customers.

5. Discussion

We have conducted a longitudinal case study of the development process of a telehealth innovation by following its transition from initial adoption to wider diffusion through commercialization efforts. We presented the unfolding of the innovation in four phases and identified what actors encountered what issues, how those issues were resolved, and the outcomes of each phase. Through the analysis of the process, we were able to identify for each phase key factors that enabled each phase as well as key challenges that stakeholders encountered (Table 2).

In response to the first, descriptive research question, we have observed a number of context-specific issues that facilitated the transition from initial adoption to wider diffusion through commercialization. For example, the innovation was driven by highly motivated neurologists, who played multiple roles of champions, project drivers, and end-users. Their close involvement throughout the system development process resulted in functional feasibility of the innovation and their relationship-building with rural hospitals created commitments to participate at those hospitals. The pilot stage also created some public awareness of the innovation as well as an initial base of potential customers to support later commercialization. Finally, winning the state technology competition built considerable momentum for further diffusion. At the same time, the innovation faced some challenges during this process. Although system development involved the neurologists as future users and reflected hub-hospital interests and work practices, the rural hospital side was not taken into consideration during development. This turned out to be problematic in later adoption and diffusion stages. For example, technological and business issues in the rural hospitals emerged as important and quite challenging issues. More importantly, the misalignment of the innovation with institutional arrangements became a major issue that needed to be resolved in the later commercialization stage. These context-specific enabling factors and challenges are expressions of important forces that shaped the trajectory of the innovation. These findings provide the basis for answering the research questions posed at the beginning of this paper.

This research makes two distinct theoretical contributions. First, it contributes to the growing body of IS research on telehealth innovations. Many existing studies report cases of initial adoption in a single organization or a network of initial adopting organizations [e.g. 6, e.g. 14, 15, 41, 42]. There are no studies, however, that investigate the transition from initial adoption to wider diffusion into a larger population of organizations. By examining a case of such transition all the way through commercialization, this study answers the question of how a pilot telehealth innovation can successfully develop into a wider diffusion mode through commercialization. Second, the presented study expands the body of knowledge on diffusion of innovation research. Adoption and diffusion of complex, networked and learning-intensive technologies have not been examined from a diffusion of innovation perspective [27]. We argue the telestroke innovation is an example of a complex technology. Dominant theories of diffusion of innovations are criticized for their lack of explanatory power beyond the conditions in which those theories originated [22, 23, 26, 27]. This study explores this research gap by providing initial understandings of the development of a complex, networked telehealth innovation from its initial conception to other conditions, commercialization in this particular example. In particular, we presented our findings in four stages; adoption, implementation, commercialization, and diffusion and we identified for each of these the key enablers and challenges faced in transitioning from adoption to the later stages of development. These insights can be further developed into a evolutionary model covering the stages of adoption to diffusion and they constitute what Markus and Robey call an emergent perspective on causal agency in IT and organizational change [29]. Complex and networked technologies contain messy, complex problem-solving elements that are both socially constructed as well as shaped by context and society at large [27]. By outlining a four-staged model of the transition from adoption to diffusion in the context of telehealth innovations, we contribute to research focusing on such a dynamic process from an emergent perspective.

	Enabling Factors	Challenges Faced
Adoption	• Highly motivated, proactive project initiators • User-driven initiative • Close interactions among doctors	• Alignment with legal issues • Alignment with the insurance schemes • Alignment with rural hospital interests and processes
Implementation	• Rural hospitals lack neurologist expertise • Incremental expansion • Creation of knowledge base	• Rural hospital technical infrastructure • User training • New work practices
Commercialization	• Reengineering of system • Enhanced recognition through winning state technology competition • New independent firm established to commercialize the innovation	• No proven business models • Flexible, scalable business models • Limited funding – passive funding strategy
Diffusion	• Recognition built since pilot stage • Use of knowledge base built from earlier stages	• Aggressive marketing • Settled organization • Aligned interests among stakeholders (complicated medical setting-hospital, university)

Table 2. Enablers and challenges during telehealth innovation

In response to the second, normative research question, this study also offers practical contributions for stakeholders involved in IT-based innovations within the healthcare industry. We can summarize these insights into the following recommendations for organizations to consider as they adopt telehealth innovations with further ambitions to diffuse them through commercialization at later stages:

- *Develop long-term plan for post-pilot stages:* Like many other telehealth innovations, REACH started its life as a pilot system. The project initiators engaged in this effort driven primarily by their medical knowledge and ambitions. To facilitate subsequent diffusion of similar IT-based health innovations, project initiators are advised to develop long-term plans for post-pilot stages including consideration of financial, legal, and technological issues.

- *Position innovation as win-win proposition:* REACH was supported by the hub hospital, but at some point it faced difficulties gaining financial support for further expansion. One reason was that the strategic alignment between hub hospital goals and the innovation were not convincingly explicated to gain sustainable support. The relationship between REACH and strategic rural hospital interests exhibited an even greater misfit. REACH was basically promoted by hub hospital initiatives and sources of funding; no explicit attempts were made to develop sustainable financial models for rural hospital involvement. Hence, telehealth innovators are advised to position their initiatives early on as win-win propositions in relation to both hub and rural hospital interests.

- *Align with rural hospital processes:* REACH was first developed by and at the hub hospital and later "pushed" to the rural hospitals. Because of this early framing, business processes and work processes in the rural hospitals were not actively considered or reflected in the technology during the system development phase, even though the innovation would affect rural hospital processes significantly during system operation. The earlier the that rural hospitals can be involved in the innovation development, the easier it would be to align the innovation with relevant hospital process to facilitate subsequent adoption and further diffusion.

- *Accommodate rural area technology infrastructure issues:* The project initiators encountered unexpected problems with technology infrastructure at the rural hospital sites. In a case report, it took several months for a rural hospital to get fast network connection due to lack of infrastructure in the local area, not

at the hospital, specifically. The lack of IT staff at the rural hospitals also created a bottle-neck effect for further addition of rural hospitals. Training and trouble-shooting became dominant issues for the limited available system development resources. Accommodating rural area technology infrastructure issues, both technically and knowledge-wise will likely facilitate both initial adoption and further diffusion efforts.

- *Consider institutional arrangements and legal issues:* The most commonly cited problems related to REACH were misalignment with institutional arrangements and legal issues. Reimbursement from insurance institutions was at the top of the list. The innovation starting as a pilot did not meet the reimbursement requirement for two-way video streaming. Since the neurologists failed to meet the requirement by designing the innovation one-way, their services were not reimbursed at all. Also, from a reimbursement point of view, REACH was not an attractive proposition for the rural hospitals due to many patients having insufficient insurance coverage. They either lacked insurance altogether, or were covered by government Medicare and Medicaid programs – which reimbursed only a fraction of the service costs. Considering institutional and legal issues as one important design dimension can therefore greatly support successful diffusion of new IT-based healthcare innovations.
- *Build and manage knowledge base from initial adoption:* Since adoption of REACH occurred incrementally, i.e. hospital by hospital, the hub hospital project team had the chance to build a knowledge base through experiential learning. As the innovation expanded to more hospitals, the project initiators developed important knowledge about system trouble-shooting and system configuration, which later turned out to be an asset for wider diffusion through commercialization. Experiences with initial development and adoption can hence be systematically managed and utilized at later diffusion stages.

Although our study only covers one telestroke innovation, our findings may provide useful guidelines for other telehealth initiatives. However, while telehealth innovations share a set of common characteristics, it is always important to understand and take into account the unique contexts in which they unfold. Further research is therefore needed to develop this research, both conceptually and in terms of practical implications.

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