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CROSSING THE CHASM: 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, many telehealth initiatives fail to go beyond the status of prototype applications despite being considered technically viable and medically relevant. Based on a longitudinal investigation of a successful telehealth program, we identify a chasm between the initial adoption mode of the innovation as a prototype within a network of hospitals and the subsequent diffusion mode of the innovation as a commercialized product. Subsequently, we analyze how key actors negotiated the chasm to successfully diffuse the innovation beyond the initial hospital setting. In terms of research, the paper presents a longitudinal, empirical investigation of a successful telehealth innovation. Drawing on the metaphor of “crossing the chasm,” we explain why many telehealth initiatives fail to go beyond prototype application status. In terms of practice, the paper provides lessons on how key actors can negotiate the chasm to transition from adoption mode to diffusion mode.

Keywords

Telehealth innovations, innovation adoption, innovation diffusion, process models, chasm

Please use the following format when citing this chapter:

Cho, S., Mathiassen, L., and Gallivan, M., 2008, in IFIP International Federation for Information Processing, Volume 287, Open IT-Based Innovation: Moving Towards Cooperative IT Transfer and Knowledge Diffusion, eds. León, G., Bernardos, A., Casar, J., Kautz, K., and DeGross, J. (Boston: Springer), pp. 361-378.

1 INTRODUCTION

Telehealth innovations have great potential to enhance accessibility to healthcare, reduce cost of care, and enhance quality of care (Bangert and Doktor 2003; Institute of Medicine 1996; Office of Technology Assessment 1995). Despite such potential, many telehealth innovations are either not accepted or not successfully implemented (Bangert and Doktor 2003; Institute of Medicine 1996) due to poor technology performance, organizational issues, and legal barriers (Bashshur 2000). It is also widely acknowledged that physicians and other medical staff are notorious for their nonresponsiveness to and resistance to use of information technologies (Anderson 1997; Lapointe and Rivard 2005).

Telehealth innovations originated from 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 (Zundel 1996). Telehealth projects vary with respect to goals, funding, and technology, but most major projects in the 1990s were undertaken by large university hospitals with external funding from government agencies and industry (Office of Technology Assessment 1995; Zundel 1996). Although telehealth has been practiced for more than 40 years, its status was until recently evaluated as being in the early stages of development (Office of Technology Assessment 1995). 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, although these impacts have not materialized yet (Jennett and Watababe 2006). In a typical life trajectory of telehealth innovations, many die out after initial funding is exhausted despite being considered medically and technically viable solutions.

In this research, we explain this paradox between the high potential of telehealth innovations, on the one hand, and the slow diffusion of telehealth innovations, on the other hand, by investigating gaps and collaboration patterns across innovation processes. The concept of an innovation gap is not new in the field of information systems. Fichman and Kemerer (1999) identify an assimilation gap between acquisition of an innovation and its actual deployment and use in an organization; and Moore (1999, 2004) uses the phrase “crossing the chasm” to denote a gap between early adopters and the early majority of innovation adopters in the marketplace. In framing this research, we rely on this notion of a gap in the process of market uptake of an innovation; however, the gap we investigate has a different focus and is framed differently than in previous studies. Specifically, we draw on Moore’s concept of chasm to analyze the disrupted path to commercialization and diffusion of a telehealth innovation.

We have found few studies in the information systems literature that address the transition from adoption mode to diffusion mode of IT-enabled innovations. Moreover, in the particular context of telehealth innovations we know little about this transition. Against this backdrop, we investigate the following research questions:

- **Descriptive question:** How can we use the metaphor of *crossing the chasm* to characterize the transition of a telehealth innovation from adoption-mode to diffusion-mode?
- **Prescriptive question:** How can key stakeholders successfully cross the chasm between adoption mode and diffusion mode for a telehealth innovation?

Over a period of four years, from 2003 to 2007, we conducted a longitudinal case study in which we followed a telestroke innovation closely (Cho et al. 2007; Cho and Mathiassen 2007; Cho, Mathiassen, and Robey 2007). The innovation was initially developed and adopted by a network of hospitals and, following initial adoption, it was successfully commercialized as a new telestroke innovation. By closely examining this process, we identified a chasm between the initial adoption mode and the subsequent diffusion mode of the innovation. Moreover, we found that this chasm presented a major obstacle for the actors involved in the attempt to commercialize the innovation. As a consequence, we chose to analyze in detail how key stakeholders successfully negotiated the chasm.

The resulting analysis offers a number of contributions to research and practice. First, few studies have offered a longitudinal analysis of a telehealth innovation from initial adoption to successful diffusion in the market. Hence, we aim to contribute to telehealth innovation research by providing insights into the processes and conditions that make such innovations transcend the initial pilot stages. Second, we aim to challenge existing assumptions and boundaries of diffusion of innovation research, process-oriented approaches in particular, by identifying and characterizing the chasm that innovators face in seeking to diffuse the innovation to a broader market. Finally, we provide insights on how key actors crossed this chasm by detailing the transition process and by identifying contextual issues that facilitated or challenged it. The presentation 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 with a discussion of the contributions of the study and its implications.

2 THEORETICAL BACKGROUND

2.1 Telehealth Innovations

Healthcare has emerged as an increasingly important domain in IS research with a steadily growing body of knowledge (Chiasson and Davidson 2004). In this paper, we focus on telehealth innovations as an important subset of IT-based healthcare innovations. Advances in the form of network technologies, advanced interfaces, and mobile technology have created a renaissance of such innovations since the 1990s (Maheu et al. 2001). Increased use of IT to deliver healthcare services over distance has created new terms such as telemedicine, telehealth, and e-health (Anderson 1997; Bashshur 2000; Maheu et al. 2001). Although exact definitions and boundaries of these terms are elusive, telemedicine is broadly defined as provision of healthcare services, clinical information, and medical education over distance using telecommunications technology, whereas telehealth is seen as being a more encompassing term (Maheu et al. 2001).

Although the major contributions to telehealth innovations are often credited to the field of medical informatics (Chiasson and Davidson 2004), the IS field has begun to offer contributions in this area as well. However, within the IS literature, research questions and approaches vary a great deal. Adewale (2004) and Mbarika (2004) discuss the potential and challenges of telehealth innovations at the national level in developing

countries. A study by Liang et al. (2006) focuses on development of a web-based decision support system to encourage multiple sclerosis patients to continue a specific medication. Brown et al. (2004) examine individuals' interpersonal traits and their effect on willingness to collaborate and resulting outcomes in the context of telehealth innovation. Hence, the latter studies analyze individual-level adoption of telehealth innovations. In contrast, other authors (e.g., Paul 2006; Paul and McDaniel 2004) examine how telehealth innovations (tele-radiology, distance learning, and tele-consulting) affect performance in collaborative relationships. Other organization-level studies focus on the process by which a telehealth innovation is adopted into a hospital network. For example, Constantinides and Barrett (2006) investigate implementation of a telehealth innovation in Crete with a focus on relationships among the context, the manner in which a system is used in practice, and the role of various technology artifacts; and, Chau and Hu (2004) analyze implementation of a Hong Kong-based telemedicine program using a conventional IT diffusion model (Cooper and Zmud 1990; Kwon and Zmud 1987).

We found no studies that investigate how a telehealth innovation goes beyond its context of origin, how it gains sustainability in the broader marketplace, or how it migrates from a pilot initiative to a full-blown commercial product. This paper aims to fill this gap.

2.2 Adoption and Diffusion of Innovations

Research on innovation adoption and diffusion has been established as a major research stream in the IS field (refer to summaries of this research stream by Fichman (2000) and Gallivan (2001)). Definitions of terminology vary among researchers. In his classical model of innovation diffusion, Rogers (2003) defines diffusion as the process in which an innovation is communicated through certain channels among the members of a social system over time. Fichman (2000) defines diffusion as the process by which a technology spreads across a population of organizations. We adopt this notion of diffusion with its focus on a larger population of organizations, in contrast to the notion of adoption that focuses on single innovation adopters—whether they are individuals or organizations. For example, Davis' (1989) technology acceptance model and Rogers' diffusion of innovation theory (Rogers' theory covers both individual level adoption and organizational level adoption) are among the dominant frameworks that explain individuals' adoption behavior focused on innovation characteristics and contextual factors (Fichman 2000; Gallivan 2001). Another approach to innovation adoption research at the organizational level is from a process model perspective, which we employ in this study. For organizational-level adoption and diffusion, Rogers proposed a five-stage model and Kwon and Zmud (1987) and Cooper and Zmud (1990) have suggested a similar six-stage model.

These dominant theories of innovation adoption and diffusion are often criticized for their limited explanatory power. Fichman (2000) argues that innovation research based on Rogers' classical model focuses mainly on simple innovations being adopted autonomously by individuals and it is, therefore, less relevant to technologies adopted by organizations. Gallivan (2001) argues that to explain more complex technologies and adoption scenarios we need to expand our process-oriented understanding of innovations and he suggests a hybrid framework that incorporates both processes and factors related

to organizational adoption of innovations. Lyytinen and Damsgaard (2001) also recognize limitations in the assumptions underlying Rogers' diffusion of innovation theory. They argue that complex, networked technologies contain messy, complex problem-solving elements and such technologies are socially constructed as they shape and are shaped by society. For such innovations, Lyytinen and Damsgaard argue that process-oriented approaches provide greater accuracy and deeper insights into the phenomenon, as opposed to simplicity and generalizability, which are the goals of traditional innovation diffusion research.

Telehealth innovations fit well with the characteristics of complex, networked technologies suggested by Lyytinen and Damsgaard. First, they are interorganizational in nature. Second, they require considerable alignment of organizational policies and procedures by electronically linking multiple organizations and their work processes. Third, they require a sizeable critical mass of adopters in order to be effectively deployed. Finally, they unfold in complex institutional environments governed and strongly influenced by multiple regulatory and government-sponsored agencies (Bali and Naguib 2001; Bashshur et al. 1997). The process-oriented approach they advocate is, therefore, especially suitable to investigate the transition processes of a telehealth innovation from its initial pilot implementation to subsequent commercialization and throughout a broader market. Process models can explain how particular changes evolve over time (Markus and Robey 1988; Mohr 1982; Newman and Robey 1992) by investigating causal linkages and temporal relationships between key events and the context in which they unfold (Gallivan 2001). Specifically, this study adopts what Markus and Robey (1988) label an emergent perspective in which collaboration and networking among organizations emerge through dynamic interactions between diverse external forces and internal interests and motives.

Anchoring our theoretical framing on the process-oriented approach to diffusion of a complex, networked technology, we draw on, in particular, Moore's (1999, 2004) concept of chasm for the analysis of the study. Moore describes the common delay that accompanies diffusion of an innovation, following an initial period of rapid uptake. He describes this plateau in the diffusion process as a chasm that needs to be crossed—from the early adopter cohort to the much larger "early majority" in the technology adoption life cycle. His focus on identifying this chasm is to explain why many innovations fail to achieve more large-scale diffusion (i.e., the early majority), after being adopted enthusiastically by early adopters. We borrow the chasm metaphor to describe the problematic gap that can occur between the initial adoption of a telehealth innovation as a prototype within a network of hospitals and subsequent large-scale diffusion, which we regard as a commercial product generating revenues for the inventor across a broader market base.

3 RESEARCH METHOD

3.1 Case Study

Our study is based on an in-depth, longitudinal case study. Generally, a case study is a preferred mode for conducting research when *how* and *why* questions are posed (Benbasat et al. 1987; Darke et al. 1998) about a contemporary phenomenon in its context

(Yin 2003). These attributes are reflected in our process-oriented study. Moreover, a case study is also appropriate because, as researchers, we had no control over the events. Finally, a case study is appropriate because we seek to understand interactions between an IT-related innovation and the organizational contexts of various organizations in which it was developed, adopted, and subsequently diffused (Darke et al. 1998). Case studies allow researchers to investigate phenomena in depth to provide rich description and understanding (Walsham 1995).

3.2 Focal Innovation

In March 2003, the department of neurology at a large university hospital (labeled the hub hospital) in the U.S. state of Georgia launched a telestroke program named 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. The innovation was launched 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 paucity of stroke specialists contributes to a higher mortality rate due to stroke in rural and underserved urban areas (Casper et al. 2003). 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 evidence of stroke symptoms. However, it is estimated that only a fraction of stroke patients receive the benefits of tPA, partly due to a lack of on-site stroke specialists. It is essential that a stroke specialist examine each stroke patient before tPA is administered. It is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA inappropriately (i.e., to a case of bleeding stroke) will trigger immediate and likely lethal consequences. Providing the services of stroke specialists over distance can, therefore, significantly increase the ability to diagnose whether a stroke is bleeding or non-bleeding, thus allowing tPA to be properly administered—saving many lives and reducing the risk of permanent disabilities. Between March 2003 and May 2004, doctors in the initial network of adopting hospitals used REACH to evaluate 75 patients and to qualify 12 of them for tPA treatment. By late 2006, more than 400 patients had been evaluated through REACH at 9 rural hospitals with 55 having been treated with tPA.

In January 2005, two entrepreneurs with funding from a state government research and development agency met and formed a company (labeled *BrainCare Inc.*, a pseudonym) to commercialize REACH. The first attempt at commercialization ended in failure as various stakeholders could not reach agreement on licensing and operation terms and conditions. As a result, the state's financial sponsorship of *BrainCare Inc.* ceased by the end of 2005. A few months after the first failed attempt, the REACH initiators (a team of neurologists at the hub hospital) established a second company (labeled *BrainConsult*, another pseudonym) to again attempt commercialization of REACH. Gaining some momentum from winning a state technology competition, the initiators found their first paying customers in September 2006 (a network of rural hospitals in the state of New York) and continued expanding their market nationwide.

3.3 Data Collection and Analysis

It is common for case study research to utilize multiple data sources (Miles and Huberman 1994; Yin 2003). Data sources for our study include interviews with key stakeholders, systems documentation, publicly available news articles, and observation at workshops. A total of 26 individuals in five hospitals (hub hospital and four rural hospitals) were interviewed to examine the initial pilot adoption process for REACH: nine nurses, seven doctors, six administrative staff, three IT staff, and one radiology technician. Detailed analyses of the initial adoption process of the innovation have been reported in previous studies (Cho et al. 2007; Cho and Mathiassen 2007; Cho, Mathiassen, and Robey 2007). During the commercialization process, the first two authors attended 12 workshops and follow-up meetings with the two entrepreneurs from *BrainCare Inc.* to discuss their business plans and strategy. We also interviewed five individuals from *BrainConsult* (the second firm founded to commercialize REACH) including the CEO and members of the Board of Directors. Data collection was conducted over the period from October 2004 to November 2007.

The first two authors developed customized interview protocols prior to each interview. Interview notes were recorded during and immediately following interviews and workshops and all interviews were transcribed for later analyses. In most cases, the authors held debriefing sessions in order to exchange and compare notes. This practice ensured a balanced and multifaceted understanding of data and enhanced intersubjectivity in the initial interpretation of data.

The data were later analyzed by all three authors through multiple sessions of discussion, focusing on the stages of initial adoption and subsequent commercialization and diffusion. First, events were listed to develop a chronological timeline for REACH's adoption and diffusion processes. According to Miles and Huberman (1994), such a chronology of events provides insights in terms of "what led to what and when." Such a listing provides the basis for depicting the sequence by which key events unfolded. Key actors were then identified as well as their actions and implications for further diffusion. Then, active discussions among all three authors took place to formulate a process model describing the initial pilot adoption, commercialization, and diffusion of REACH. Initially, the authors had different opinions on the number of stages and the definitions of the various stages. Disagreements among the authors were resolved through discussions that resulted in iterative refinements to the overall process model. The analysis was hence an iterative process that continued until consensus was established. The following are the results of this case analysis.

4 RESULTS

In this section, we describe the process of initial adoption and subsequent diffusion of REACH through four phases: adoption, implementation, commercialization, and diffusion (Table 1). For each phase, we identify the main actors and analyze their actions. These results provide insights in terms of how the process unfolded.

Table 1. Actors and Activities Involved in the Telestroke Innovation

Phase (When)	Actors (Who)	Actions (What)
Adoption	<ul style="list-style-type: none"> • Neurologists • System developer • Hub hospital 	<ul style="list-style-type: none"> • Innovation conceptualized by hub hospital neurologists • Dedicated systems developer hired • Relationships with target rural hospitals cultivated • Innovation implemented by systems developer
Implementation	<ul style="list-style-type: none"> • Neurologists • Systems developer • Rural hospitals 	<ul style="list-style-type: none"> • Innovation roll-out one rural hospital at a time • Technology issues addressed at rural hospitals • Financial issues addressed at hub and rural hospitals
Commercialization	<ul style="list-style-type: none"> • Firms (<i>BrainCare Inc.</i> and <i>BrainConsult</i>) • State funding agency • Hospital administration • Neurologists 	<ul style="list-style-type: none"> • Negotiations between hub hospital and <i>BrainCare Inc.</i> • <i>BrainConsult</i> established and CEO hired • Participation in technology competition • System reengineered • Market further developed
Diffusion	<ul style="list-style-type: none"> • <i>BrainConsult</i> • Customers (early adopters) • Competitors • Neurologists 	<ul style="list-style-type: none"> • Market penetrated • First customers engaged • Product expanded • Company renamed • Operation expanded and a Chief Operating Officer hired • Business models developed further

4.1 Adoption

The first phase, adoption, includes events starting with initiation of telestroke systems development in 2000 to roll-out of REACH in the first rural hospital in 2003. In terms of telemedicine systems, the hub hospital had a digitized tele-radiology system by the summer of 2004. It planned to fully migrate to the new system, which was being used in tandem with conventional film images. By the time REACH was initiated and launched, the tele-radiology system was the only telemedicine innovation in use in the hub hospital. Development of REACH was driven by a group of four neurologists, with one doctor serving as innovation champion. The physicians had long cherished the idea of a telestroke system that could link them effectively to rural hospitals. They began to implement this idea by hiring a technically savvy medical student to develop software in 2000. A year later, after the student left the area for his residency, the neurology department hired a full-time developer. During the adoption phase, the four neurologists played a key role as the primary driving force. They were simultaneously the project champions,

the end-users, and the overseers the software development process. The neurologists basically controlled the process and interacted constantly with the developers by sharing their work practices and ideas and by providing necessary feedback to facilitate incremental development of the system. Also, in parallel to developing REACH, the neurologists cultivated relationships with rural hospitals in the state, visiting them and educating their medical staffs on how to leverage telehealth to collaboratively diagnose and treat ischemic strokes. During frequent visits, the neurologists gained insight into the operational conditions at the rural hospitals as well as requirements of the prospective users (ER physicians). The overall initiative was supported by top management at the hub hospital, specifically the CEO and a vice president responsible for service outreach. The neurologists actively promoted REACH and were able to secure financial support for software development and purchase of hardware for rural hospitals. The adoption phase was dominated by the activities of this small group of highly motivated neurologists. Through their leadership and close collaboration with a few other actors, they managed to develop REACH as a feasible telestroke system.

4.2 Implementation

The second phase, implementation, includes events starting with the first roll-out of REACH in March 2003, through continued expansion into a network of rural hospitals by December 2006. During this phase, REACH was gradually rolled out to a total of nine rural hospitals. The neurologists continued to play a key role by negotiating the system launch with rural hospitals in Georgia. The necessary hardware and software was provided and installed by the hub hospital without any costs incurred by the rural hospitals. As REACH expanded into more hospitals, two sets of issues emerged as critical: technical issues and financial reimbursement issues. The limited IT resources at rural hospitals surfaced as a serious problem, since most rural hospitals lacked full-time IT staff. As a result, there was no consistent process and manpower to address technical issues between the hub hospital and rural hospitals. As a result, the full-time developer at the hub hospital had to handle even minor technical problems at the rural hospitals. Later on, a second, full-time technician was hired by the hub hospital to focus on implementation problems and system trouble-shooting in the rural hospitals. Implementation of REACH in the rural hospitals often fell behind schedule due to lack of high-speed Internet connections or digital CT scanners in the rural hospitals. The knowledge base about REACH, its uses, and potential problems continued to accumulate as the system was gradually implemented in the nine hospitals. A second set of issues related to financial reimbursement. Any services provided by the hub hospital neurologists using REACH were not reimbursed by private or government insurance because the system configuration did not meet the two-way video link requirement for telemedicine to be reimbursed. Also, the rural hospitals were under-reimbursed for all REACH services because most of their patient base was covered by Medicare and Medicaid, government insurance plans that were well-known for low reimbursement rates. Despite the various problems, REACH continued to expand into more hospitals; however, there was no systematic or successful attempt to develop and negotiate sustainable business models that would effectively resolve the technical and financial issues described above.

4.3 Commercialization

Phase three, commercialization, was dominated by two entrepreneurs who established *BrainCare Inc.* to commercialize REACH. Engaged by the neurologists and funded by a government R&D agency, the entrepreneurs negotiated conditions with the hub hospital and the neurologists while creating a detailed business plan and searching for additional funding sources and customers. Unfortunately, the relationship between these entrepreneurs and the hub hospital deteriorated over issues of licensing and operation terms. The negotiations ultimately were aborted in December 2005 and *BrainCare Inc.* was dissolved right after. As the neurologists ended negotiations with *BrainCare*, they started to explore other ways to commercialize REACH, as the system had reached a local saturation point: a single hub hospital overseeing nine nearby rural hospitals. At this point, REACH's champions faced barriers to further local expansion. The neurologists increasingly sought nationwide diffusion, relying on the fact that they had proven REACH to be technically feasible within one U.S. region. The neurologists created momentum for nationwide diffusion by applying for a Small Business Innovations & Research grant and by founding a firm (*BrainConsult*) in March 2006.

At the same time, the project initiators won a state-wide technology competition, which created wider recognition of REACH and secured an award of \$100,000. Winning the competition boosted the neurologists' enthusiasm and confidence. A CEO with a systems development background was hired, and the software was reengineered to increase reliability and scalability. Up to this point, these stakeholders lacked business experience and were mainly driven by their medical expertise and passion for using technology to treat ischemic stroke patients. The new CEO, who lacked healthcare industry experience, brought software experience and solid technology skills to the team. As a result, he helped formulate a new business plan and technology infrastructure, and he had generated enthusiasm among several interested hospitals by summer 2006. By late 2006, *BrainConsult* was still in a formative stage: it still lacked a physical office location and a dependable stream of revenue. On the other hand, the company had developed a solid technological infrastructure, an emerging organizational structure, and a comprehensive business plan.

4.4 Diffusion

The final phase, diffusion, began with the first commercial contract. Even before the commercialization attempts shifted to high gear, some hospitals in other regions showed interest in REACH, although their interests did not immediately lead to formal contracts and implementation. The Surgeon General of a northern state was promoting telemedicine in rural areas and he urged that REACH be considered. In September 2006, *BrainConsult* signed a contract with this state as its first paying customer. By November 2007, REACH was up and running in about 30 hospitals. Moreover, a total of 44 hospitals spread across four different states had contracted to install REACH, relying on eight hub hospitals among them. As a result, *BrainConsult* started to enjoy a steady stream of revenue, but it also faced a new set of challenges and decisions. The company defined itself as an application service provider but continued to debate the nature and scope of business. The firm eventually changed its name in late 2007 (although we

continue to use the pseudonym *BrainConsult* to refer to it here). At that point, the firm still lacked any dedicated marketing plan, and its employees were entirely focused on technology and systems development. Although assured a stream of revenues, the company had limited financial resources to create a comprehensive portfolio of capabilities. Key actors debated whether to seek outside funding, although they acknowledged the potential loss of control over the company's fate that this might necessitate. As a result of this ongoing process of shaping *BrainConsult* to become a more mature business, the founding group of neurologists relinquished some control, while still maintaining their roles and positions within the original hub hospital.

5 DISCUSSION

We have presented a longitudinal case study of a telehealth innovation, describing its transition from pilot adoption within one state (Georgia) to wider commercialization and diffusion from a process-oriented research perspective. The field of IS has little understanding of such a transition process despite a large body of knowledge on the diffusion of innovation process. The overall process of the particular telehealth innovation unfolded through the four phases we described, explaining what issues the actors encountered, how those issues were resolved, and what outcomes ensued. While REACH was eventually commercialized, major challenges were faced during the transition from the early stages (the adoption and implementation phases, which were limited to an initial network of hospitals) to the later stages (commercialization of REACH and its subsequent diffusion to the broader marketplace). In this section, we characterize this *chasm* between the early stages (adoption and implementation) and later stages (commercialization and diffusion), and we discuss how REACH's champions were able to successfully cross the chasm (at least, when evaluated at this time).

5.1 Characterizing the Chasm

Our analysis reveals the existence of minor gaps at each stage of our process model. For example, new stakeholders (rural hospitals) emerged during stage two (implementation), which brought additional skills and resources—but also problems and constraints—to the original stakeholders (the neurologists and system developers). In transitioning from phase two to three, the focus shifted to resolving problems that had not previously existed—problems with technological infrastructure and financial reimbursement policies and regulations. Similarly, in transitioning from phase three (commercialization) to phase four (diffusion), we observed a realignment among many stakeholders. *BrainConsult* (the second company founded by the neurologists) became the most prominent actor while other stakeholders, including some of the REACH inventors and the original hub hospital, receded into the background to some degree. In stage four, the critical activities were focused on preparing REACH for the market and building appropriate organizational capabilities and structures. While the CEO and board members of *BrainConsult* addressed these gaps in a way that was ultimately successful, they also faced considerable challenge in progressing from the limited, initial adoption in the state of Georgia alone to a much broader pattern of diffusion in the market.

These challenges describe the problematic gap that can occur between the initial adoption of a telehealth innovation as a prototype within a network of hospitals and subsequent large-scale diffusion as a commercial product generating revenues for the inventor across a broader market base. They called for step-function changes in terms of skills, resources, and capabilities, which can be characterized in terms of four development trajectories: from a single hospital network to the marketplace; from prototype to a complete product; from government funding to market-based revenue generation; and from medical expertise to business leadership.

From a single hospital network to the marketplace: In this development trajectory, we observe that the type of target adopters changed significantly. The primary adopters in adoption mode had close ties with the hub hospital. They were all included in a restricted set of nearby rural hospitals, geographically and medically connected to the hub hospital. Each rural hospital was hand-picked by the hub hospital and the relationship between them did not involve financial transactions. The number of rural hospitals was limited by the financial resources and physician manpower available at the hub hospital. For diffusion mode, conversely, the adopting hospitals are true consumers in a marketplace. These entities have no ties of loyalty to the hub hospital, nor are they geographically close to the original hub. Hence, the relationships among the actors changed from one of collaboration within a network of hospitals to transactions involving buyers and sellers in a marketplace.

From prototype to complete product: Second, the REACH system had to undergo a transformation from a situated prototype to a commercial product. REACH was initially created to meet specific needs of the original hub hospital and associated rural hospitals. During diffusion mode, REACH had to be reengineered to meet general market requirements for a commercial product, which required enhancing reliability and scalability. Later, it was upgraded to allow two-way video streaming, hence overcoming barriers to full insurance reimbursement. As *BrainConsult* matured as an application service provider, it was essential that REACH become a complete product (Moore 1999), including the basic telestroke application and other value-added services such as training, installation, maintenance, and operational support.

From government funding to market-based revenue generation: Third, the financing mechanism for REACH completely evolved from an academic type of R&D project that relied on outside government funding to market-based revenue streams. Funding for development, implementation, and support in the initial set of rural hospitals was tied to the hub hospital's neurology department and its ability to secure research grants. With subsequent diffusion, financing options changed dramatically. As *BrainConsult* was founded and matured, the operational funds came in the form of customer revenues. By the end of our case study, the customer portfolio was large (consisting of 8 hub and 44 rural hospitals), and *BrainConsult's* board was considering outside investors and owners. As a result, *BrainConsult* had evolved to become self-sustaining based on customer revenues.

From medical expertise to business leadership: Finally, the capabilities evolved significantly between the adoption and diffusion phases. Initially, key leadership was provided by a group of neurologists with expertise in medicine—but not business—during adoption mode. These neurologists championed the innovation, locating funding sources and seeking potential adopters. This leadership was grounded in humanitarian motives and medical expertise, and the mode of operation was focused on meeting the

needs of the initial hub and set of rural hospitals. In contrast, a new firm, *BrainConsult*, oversaw most core activities during the later diffusion phase. Commercial success occurred as a result of hiring business leadership—namely, a CEO and, subsequently, a chief operating officer who were able to build the necessary structures and processes to ensure a viable business.

5.2 Crossing the Chasm

The good news is that the chasm was successfully negotiated and crossed. REACH was led by highly motivated neurologists, who played multiple roles of champions, project managers, and end-users. Their close involvement throughout the initial phases ensured that a stable technology existed and necessary relationships were established with rural hospitals, generating a solid network of initial adopters. More importantly, these champions also became a driving force in diffusion mode as well by establishing the business (*BrainConsult*) on which diffusion relied. The successful pilot stage helped to ensure that the chasm could be traversed, as it generated public awareness of REACH among a broader set of potential adopters. Another key event, REACH winning a state technology competition, helped to facilitate creation of *BrainConsult* and helped build momentum for further diffusion. Finally, the set of capabilities that ensured a successful adoption mode were also critical to diffusing REACH to the broader market.

While the chasm dividing phases two (implementation) and three (commercialization) was successfully crossed, substantial effort, resources, and ingenuity were required. Constraints associated with the rural hospitals (in the form of limited bandwidth, CT scanners, and barriers to insurance reimbursement) were not adequately considered during development. This oversight became a potential barrier to successful implementation in the rural hospitals. Misalignment of REACH's technical features with the institutional arrangements (specifically, reimbursement regulations), was a problem that had to be resolved in order to ensure successful implementation (in phase two) and the possibility of commercialization (in phase three). *BrainConsult* had to fundamentally alter REACH's technical specifications to allow for two-way video streaming, as required for insurance reimbursement. Next, there was insufficient awareness of economic issues (i.e., the capability for the first company, *BrainCare*, to negotiate contracts to which both hub and rural hospitals could agree). As a result, the REACH champions had to undergo complex negotiations with multiple potential business partners before a viable business plan and commercial entity emerged.

We summarize our learning and reflections from this study into the following recommendations in the hope that they can be of help to other entrepreneurs and managers who want to adopt telehealth innovations with the goal of subsequently diffusing them as commercial products:

- *Develop a long-term plan for post-pilot stages:* Like many other telehealth innovations, REACH started out as a pilot system. Its inventors were motivated by their medical expertise and humanitarian goals. To facilitate subsequent diffusion of similar IT-based health innovations, we encourage champions of other innovations to develop long-term plans for what they hope to achieve post-pilot—including consideration of financial, legal, and technological issues.

- *Position innovation as win–win propositions from the start:* REACH was supported by the hub hospital, but at some point it faced difficulties gaining financial support for further expansion. The strategic alignment of REACH capabilities with the hub hospital's goals was better than that with rural hospital goals. REACH was promoted by the hub hospital, on which it relied for its funding; no attempt was made to develop a sustainable business model that explicitly considered rural hospitals' motives, capabilities, and constraints. Hence, it is critical that telehealth champions seek to position any innovation early on as win–win propositions with regard to the origination entity and other partner institutions.
- *Align with rural hospital processes:* REACH was developed by the hub hospital and then “pushed” out to the rural hospitals. Due to its origins, the processes and constraints of the rural hospitals were not actively considered when the technology was designed and created. The sooner partner institutions can be involved in design and development of a telehealth innovation, the easier it is to align the innovation with relevant partner capabilities in order to ensure subsequent adoption and diffusion.
- *Accommodate rural area technology infrastructure issues:* The project initiators encountered unexpected problems with technology infrastructure at the rural hospital sites. For example, the lack of IT staff, high-speed Internet connections, and CT scanner equipment in the rural hospitals served as barriers to adoption of REACH by these hospitals. As a result, training and trouble-shooting began to consume significant IT staff resources at the hub hospital. Recognizing partner constraints, both in terms of technology and expertise, will facilitate adoption among partner institutions, and pave the way for successful diffusion within the broader marketplace.
- *Accommodate institutional arrangements and legal issues:* The most commonly cited problems related to REACH were misalignment with institutional arrangements and legal issues. Since the neurologists failed to meet the two-way video streaming requirement by designing the flow of data one-way, the services of hub hospital physicians were not reimbursable. In addition, REACH was not an attractive proposition for the rural hospitals due to many patients having insufficient insurance coverage. Considering institutional and legal issues as key design dimensions can, therefore, greatly facilitate successful diffusion of new IT-based healthcare innovations.
- *Involve business leadership from early stages.* The evolution of REACH was driven purely based on medical leadership until the difficult transition leading to diffusion. Early involvement of business leadership can provide complementary skills needed to prepare the innovation itself and the business model for subsequent commercialization and diffusion into the market (Moore 1999). In the case of REACH, business leadership could have opted to build a useful knowledge base through experiential learning since adoption occurred incrementally (i.e., hospital by hospital). Such a knowledge base could involve developing a set of guidelines to facilitate implementation at rural hospitals related to training, maintenance, trouble-shooting, and possible system configurations. Experiences with initial development and adoption could hence be systematically managed and utilized at later diffusion stages.

6 CONCLUSION

This research makes two distinct theoretical contributions. First, it contributes to the growing body of IS research on telehealth innovations. Many studies report cases of initial adoption in a single organization or network of adopter facilities (e.g., Chau and Hu 2004; Constantinides and Barrett 2006; Davidson and Chismar 1999; Lapointe and Rivard 2005; Lau et al. 1999). 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 where the necessary transitions occurred all the way to commercialization and diffusion, this study provides important insights about why many technically viable and medically useful innovations fail to go beyond prototype applications. Observing that there is a chasm between initial adoption mode of a telehealth innovation and subsequent diffusion as a commercial product in the market, we offer lessons from our study of REACH regarding how stakeholders can successfully negotiate and cross this chasm.

Second, our case study expands the body of knowledge on diffusion of innovation research. We believe that REACH fits the definition of a complex, networked technology for which conventional innovation diffusion models are inappropriate (Lyytinen and Damsgaard 2001). Dominant theories of innovation diffusion have been criticized for their lack of explanatory power beyond the conditions in which those theories originated, that is, independent adopters evaluating a simple innovation for their own use (Fichman 2000, 2004; Gallivan 2001; Lyytinen and Damsgaard 2001). We agree with this criticism that traditional innovation diffusion models (e.g., Kwon and Zmud 1987; Rogers 2003) do not fit the context of REACH or the challenges involved in commercializing and diffusing it. This study explores this research gap of little processual understanding by providing insight into the creation of a complex, networked telehealth innovation from its initial conception to commercialization. In particular, we identified a potential barrier that was nearly fatal, in terms of obstructing progress from adoption mode to diffusion mode, and we framed it as a point of disruptive change. We presented our case study results as a process model consisting of four stages (adoption, implementation, commercialization, and diffusion) with each stage demarcated by specific actors and key activities. We framed the disruptive transition between adoption mode and diffusion as a chasm, borrowing the metaphor from Moore (1999, 2004). The study details the nature of the chasm as well as the context-specific enabling factors and challenges that the REACH champions faced in successfully negotiating the chasm. The four-phase model and our description of the events and resources required to cross this chasm constitute what Markus and Robey (1988) label an emergent perspective with regard to how IT and organizational change occurs. Theoretically identifying and framing the chasm between initial conception and commercialization in a telehealth innovation context and characterizing the attributes of the chasm are a major contribution of this study.

Although our study deals with just one telestroke innovation, our findings provide useful insights for other telehealth initiatives. However, while telehealth innovations share a set of common characteristics, it is always important to take into account the unique contexts in which they unfold. Further research is therefore needed to develop the insights we have provided, both conceptually and in terms of practical implications.

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