Crossing the diffusion chasm: from invention to penetration of a telehealth innovation

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Abstract

Purpose – The purpose of this paper is to help explain the paradox between the high potential of telehealth innovations and their slow diffusion by investigating the challenges involved in a successful case.

Design/methodology/approach – The paper is based on a longitudinal study of a telestroke program from 2003-2007 seen from the point-of-view of the inventors. The program was initially used by a network of hospitals; it faced several challenges when the inventors sought to diffuse it to a broader marketplace; but, the inventors eventually succeeded to create a viable technology and business model.

Findings – The authors offer a process model of this telehealth innovation consisting of four phases: invention, pilot test, commercialization, and penetration – with each phase demarcated by specific actors and activities. In addition, a chasm between the pilot test within a network of hospitals and the subsequent commercialization of a product aimed for the market is identified. Finally, the authors reveal how key actors negotiated the chasm to successfully diffuse the innovation beyond the initial hospital setting.

Originality/value – The paper offers two contributions. First, it contributes a new model of IT-enabled innovation processes seen from the inventor’s perspective and emphasizing the diffusion chasm as a key challenge. Second, it contributes a longitudinal, in-depth analysis of a telehealth innovation from initial invention to successful market penetration.

Keywords Innovation, Generation and dissemination of information, Hospitals

Paper type Research paper

1. Introduction

Telehealth innovations have great potential to enhance accessibility to healthcare, reduce cost of care, and enhance quality of care (Office of Technology Assessment,

The authors would like to thank the inventors of REACH and other stakeholders involved in its diffusion for participating in interviews and workshops. They also want to thank the editors and reviewers of the IFIP 8.6 conference in 2008 for valuable comments on an earlier version of this paper and the editors of the special issue for helping them develop this final version of this research.
Despite such potential, many telehealth innovations are either not successfully implemented or not accepted (Bangert and Doktor, 2003; Institute of Medicine, 1996) due to poor technology performance, organizational issues, and legal barriers (Bashshur, 2000). Also, it is widely acknowledged that physicians and other medical staff in most cases are notorious for their non-responsiveness to and resistance to use of information technologies (IT) (Anderson, 1997; Lapointe and Rivard, 2005; Timmons, 2003). In a typical life trajectory of telehealth innovations, many therefore die out after initial funding is exhausted despite being considered medically and technically viable solutions.

The objective of this research is to explain this paradox between the high potential of telehealth innovations and their slow diffusion by investigating the challenges involved in a successful telestroke program. We followed the innovation process closely over a period of four years, from 2003-2007 (Cho et al., 2007a, b; Cho and Mathiassen, 2007). The telestroke program was developed by four neurologists and initially used by a network of hospitals. When the inventors sought to diffuse the innovation to a broader marketplace, they struggled with several challenges. However, they eventually succeeded in creating a viable technology and business model. Other studies have identified difficulties of implementing telehealth innovations from the adopters’ perspective (e.g. Aarts and Peel, 1999; Berg, 2001; Davidson, 2000; Lorenzi and Riley, 2003; Lorenzi et al., 1997), but we found no longitudinal studies of telehealth innovation processes from the perspective of the inventor. Against this backdrop, this paper investigates the following research question: “How can we characterize and explain the path from invention to market penetration of a telehealth innovation from the perspective of the inventor?”

By closely examining the innovation process, we identified a gap between the initial prototype and the subsequent commercial product. This gap presented a major obstacle for the involved actors in their attempts to diffuse the innovation. The concept of an innovation gap is not new in studies of IT-based innovations. Fichman and Kemerer (1999) identified an assimilation gap between acquisition of an innovation and its actual deployment and use in organizations. Moore (1999, 2004) used the phrase “crossing the chasm” to denote a gap between early adopters and the larger population of “early majority” adopters in the marketplace. While the gap we identified has a different focus and is framed differently than in these studies, our research builds on the notion of a disrupted innovation process. Specifically, we draw on Moore’s concept of crossing the chasm to analyze the path from invention and pilot test to commercialization and penetration of the considered telestroke innovation.

The resulting analysis offers two contributions. First, existing information systems (IS) research rarely investigates how inventors develop new IT-based innovations and subsequently seek to diffuse them widely into a market. In response, we develop a process model that explicates innovation challenges from the inventors’ perspective. Second, few studies have offered longitudinal analyses of telehealth innovations from initial invention to successful market penetration. In response, we provide a detailed analysis of how a telestroke innovation successfully went beyond the pilot stage and penetrated the market. In doing so, we identify a chasm between the pilot phase of the innovation and its subsequent commercialization, and we reveal how key actors crossed this chasm by analyzing issues that facilitated or challenged the diffusion process.
2. Theoretical background
2.1 Telehealth innovations
Healthcare has emerged as an increasingly important domain in IS research (Chiasson and Davidson, 2004). Focusing on telehealth, advances in the form of network technologies, user-friendly interfaces, and mobile technology have created a renaissance of such innovations since the 1990s (Maheu et al., 2001). This has resulted in new terms such as telemedicine, telehealth, and e-health (Anderson, 1997; Bashshur, 2000). Although exact definitions and boundaries of these terms are elusive (Bashshur, 2000), tele-medicine is broadly defined as provision of healthcare services, clinical information, and medical education over distance using telecommunications technology, whereas telehealth is a more encompassing term.

Our understanding of telehealth innovations is increasing (e.g. Adewale, 2004; Chau and Hu, 2004; Constantinides and Barrett, 2006; Liang et al., 2006; Mbarika, 2004; Paul, 2006; Paul and McDaniel, 2004), but research questions and approaches vary a great deal. Adewale (2004) and Mbarika (2004) discuss the challenges of telehealth innovations at the national level in developing countries. Liang et al. (2006) focus 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.

While these studies analyze individual-level adoption, other authors have an organization-level focus. Paul (2006) and Paul and McDaniel (2004) examine how telehealth innovations affect performance in collaborative relationships. Constantinides and Barrett (2006) investigate implementation of telehealth 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. Finally, Chau and Hu (2004) analyze implementation of a telemedicine program using a conventional IT diffusion model (Cooper and Zmud, 1990).

We found no studies, however, that investigate how telehealth innovations go beyond their context of origin, how they migrate from pilot initiatives to full-blown commercial products, or how they gain sustainability in the broader marketplace. This paper aims to fill this gap.

2.2 Innovation adoption and diffusion
Innovation adoption and diffusion has been established as a major research stream within the IS field (see Fichman, 2000; Gallivan, 2001). We embrace Fichman’s (2000) definition of diffusion as the process by which a technology spreads across a population of organizations, in contrast to the notion of adoption, which focuses on the uptake of an innovation by a single adopter – whether an individual or organization. Davis’ (1989) TAM model and Rogers’ (2003) diffusion of innovation theory are the dominant frameworks that explain adoption behavior by focusing on perceived innovation characteristics and contextual factors (Fichman, 2000). Another approach is to formulate process or stage models that explain how an adopting organization gains exposure to and experience with an innovation over time (Prescott and Conger, 1995).

There are several process models in the IS literature that take the perspective of the adopting organization: Rogers (2003) proposed a five-stage model, while Cooper and...
Zmud (1990) and Fichman and Kemerer (1997) have each suggested similar six-stage models.

Dominant theories of innovation adoption and diffusion have been criticized for their limited explanatory power. For example, research based on Rogers’ classic model emphasizes simple innovations being adopted autonomously by individuals and it is therefore less relevant to how organizations adopt complex technologies (Fichman, 2000; Gallivan, 2001). Lyytinen and Damsgaard (2001) recognize these limitations in the assumptions underlying Rogers’ theory, claiming 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, process models 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. First, they are inter-organizational in nature. Second, they require considerable alignment of organizational policies and procedures by 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 influenced by multiple regulatory and government-sponsored agencies (Bali and Naguib, 2001; Bashshur et al., 1997). The process-oriented approach is therefore especially suitable to investigate the diffusion of a telehealth innovation from its initial pilot implementation to subsequent commercialization and market penetration.

Taking the inventors’ perspective, there are several process models of entrepreneurship, technology strategy, and new product development literature. For example, entrepreneurship research has proposed a three-stage process model of venture creation and growth (Bhave, 1994), as well as a four-stage model (Bygrave, 2004), while the technology strategy literature features a five-stage model (Schilling and Hill, 1998). Such process models can explain how a given invention evolves through investigation of causal linkages and temporal relationships between key events and the broader context (Newman and Robey, 1992). We subscribe to what Markus and Robey (1988) label an emergent perspective whereby change emerges from the interaction of people and events over time – rather than from external forces (the technology imperative), or from people’s deliberate actions only (the organizational imperative). From this perspective, telehealth collaboration and networking among organizations emerge through dynamic interactions between diverse external forces and internal interests and motives.

Finally, we incorporate Moore’s (1999, 2004) understanding of a common delay in diffusion of high-tech innovations following an initial period of rapid uptake. Moore describes this as a chasm in the diffusion process that needs to be crossed between the small “early adopter” cohort and the much larger cohort of “early majority” adopters. Various attributes of the chasm explain why many innovations fail to achieve large-scale diffusion in the marketplace, after being adopted enthusiastically by early adopters. Specifically, Moore notes that the large and desirable “early majority” target market are pragmatists who must be convinced that the invention is appropriate for their specific industry. These individuals look to the adoption behavior of peer firms when they make adoption decisions. In contrast, early adopters are visionaries who
embrace new inventions because they are “driven by a dream” (Moore, 1999). The challenge for inventors is to move from the visionaries to the pragmatists without losing momentum. We use Moore’s chasm metaphor to describe the problematic gap that can occur between the initial invention and prototype of a telehealth innovation and subsequent large-scale diffusion as a commercial product generating stable revenues across a broader market base.

3. Research method

Our study is based on an in-depth, longitudinal case study. A case study is appropriate because we had no control over the events and because we seek to understand interactions between an IT-based innovation and the organizational contexts in which it was invented, used, further developed, and subsequently diffused (Darke et al., 1998). Case studies allow researchers to investigate phenomena in depth to provide rich description and understanding (Walsham, 1995).

3.1 Focal innovation

In March 2003, the department of neurology at a large university hospital (labeled the hub hospital) in the US state of Georgia launched a telestroke program named Remote Evaluation for Acute Ischemic Stroke Program, or REACH. The program 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 REACH was justified by the critical lack of stroke specialist expertise in most rural areas and in many urban areas, which contributes to a higher stroke mortality rate 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 tissue Plasminogen Activator (tPA) greatly reduces chances of severe disabilities if administered within three hours from the first evidence of stroke symptoms. However, it is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA inappropriately 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 disability. Between March 2003 and May 2004, doctors in the initial network of 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 nine rural hospitals with 55 having been treated with tPA.

In January 2005, two entrepreneurs with funding from a government R&D agency formed a firm (labeled BrainCare, a pseudonym) to commercialize REACH. The attempt ended in failure as various stakeholders could not reach agreement on licensing and operation terms and conditions and government sponsorship of BrainCare ceased by the end of 2005. A few months later, REACH’s inventors established a second firm (BrainConsult, another pseudonym). 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.
3.2 Data collection and analysis

Data were collected by the first two authors from October 2004 to November 2007 based on multiple sources including interviews with key stakeholders, systems documentation, publicly-available news articles, and observation at workshops. We interviewed a total of 26 informants from five hospitals (hub hospital and four rural hospitals) to examine the initial pilot process for REACH: nine nurses, seven doctors, six administrative staff, three IT staff, and a radiology technician. Detailed analyses of the pilot innovation are reported in previous studies (Cho et al., 2007a, b; Cho and Mathiassen, 2007). During the commercialization process, we attended twelve workshops and follow-up meetings with the two entrepreneurs from BrainCare to discuss their business plans and strategy. We also interviewed five individuals from BrainConsult including the CEO and members of the Board of Directors.

All interviews were transcribed and data were analyzed by all three authors in multiple discussion sessions. First, we listed key events in order to develop a chronological timeline for REACH’s diffusion process. According to Miles and Huberman (1994), such a chronology helps depict the sequence by which events unfolded by describing “what led to what and when.” We identified key actors, as well as their actions and implications for further diffusion. Next, we formulated a process model describing REACH’s diffusion process. We consulted similar models in the literature – process models that took the perspective of adopting firms (e.g. Cooper and Zmud, 1990; Rogers, 2003) and also the inventor’s perspective (Bhave, 1994; Bygrave, 2004; Schilling and Hill, 1998). We resolved disagreements regarding the number and definitions of phases through discussions. Our analysis was hence an iterative process that continued until we reached consensus.

4. Results

The diffusion of REACH progressed through four phases – invention, pilot test, commercialization, and market penetration. For each phase, we identify the main actors and analyze their actions, and in doing so we describe the disrupted path from invention and pilot test to commercialization and penetration of the innovation. As summarized in Table I, these results provide insights into how the process unfolded and reveal the nature of the chasm between the pilot and commercialization phases.

4.1 Invention

The first phase, invention, covered events from initiation of telestroke systems development in 2000 to rollout in the first rural hospital in 2003. By the time REACH was initiated and launched, a teleradiology system was the only telemedicine innovation in use in the hub hospital. Development of REACH was driven by four neurologists, with one serving as innovation champion. The neurologists had long cherished the idea of a telestroke system that could link them effectively to rural hospitals. They hired a technically-savvy medical student to develop software in 2000. A year later, after the student left for his residency, the neurology department hired a full-time developer. During the invention phase, the neurologists were the primary driving force.

The neurologists were simultaneously project champions, end-users, and also managers of the software development process. They controlled the process and interacted constantly with the developer by sharing their work practices and ideas and
by providing necessary feedback to facilitate incremental development. Also, the neurologists cultivated relationships with rural hospitals, visiting them and educating their medical staff 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 as described by one of the neurologists:

There was a large amount of the administrative staff throwing their support in for the REACH program as well as the general type medicine program. So, REACH got attention and management seems to perceive the rewards that are reaped by the system and the patients.

The neurologists promoted REACH and secured financial support for software development and purchase of hardware for rural hospitals. The invention 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 Pilot test
The second phase, pilot test, covered events starting with the first rollout 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 nine rural hospitals. The neurologists continued to play a key role by negotiating system launch with the rural hospitals. The necessary hardware and software was provided and

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<td>Innovation conceptualized by hub hospital neurologists</td>
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<td>Firm renamed</td>
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<td>Operation expanded and a Chief Operating Officer hired</td>
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<td>Business models developed further</td>
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Table I. Actors and activities involved in the telestroke innovation
installed by the hub hospital with minimal costs incurred by rural hospitals as
described by the Senior Vice President for Ambulatory and Network Services of the
hub hospital:

It was the monthly cellular fee and the internet expense which most were already bearing, but
to be sure, the contract was written making it clear that we would be providing the
maintenance and support associated with the software and the equipment for I believe, a two
year period.

The limited IT resources at rural hospitals surfaced as a serious problem, since most
lacked full-time IT staff. As a result, there was no consistent process or manpower to
address technical interface issues between the hub hospital and rural hospitals. The
full-time developer had to handle even minor technical problems at the rural hospitals.
Later, a second, full-time technician was hired by the hub hospital to focus on
implementation problems and system trouble-shooting in the rural hospitals. Also,
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.
However, the technological knowledge base about REACH, its uses, and potential
problems continued to accumulate. This included a new set of issues related to
financial reimbursement: The services provided by the hub hospital neurologists were
not reimbursed by private or government insurance because the system configuration
did not meet the two-way video link requirement for telemedicine. 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 with low
reimbursement rates.

Despite these problems, REACH continued to expand into more hospitals. However,
there was no systematic attempt to develop sustainable a business model that would
effectively resolve the technical and financial issues.

4.3 Commercialization
Phase three, commercialization, was dominated by two entrepreneurs who established
BrainCare 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
new funding sources and customers. Unfortunately, the relationship between the
entrepreneurs and the hub hospital deteriorated over issues of licensing and operation
terms. The negotiations were ultimately aborted in December 2005 and BrainCare was
then dissolved. As the system had reached a saturation point – a single hub hospital
overseeing nine nearby rural hospitals – the neurologists began to explore other ways
to commercialize REACH. The neurologists increasingly sought nationwide diffusion,
relying on the fact that they had proven REACH to be medically and technically
feasible within one US region. The neurologists created momentum for nationwide
diffusion by applying for a Small Business Innovations and Research grant and by
founding the firm BrainConsult in March 2006.

REACH was awarded a state-wide technology competition, which created wider
recognition and secured an award of $100,000. The award also boosted the key
stakeholders’ enthusiasm and confidence as described by the Associate Vice President
of the hub hospital:
So that created a lot of interest. The prize and just the notoriety and the fact that they were able to capture the prize in spite of some heavy competition from Georgia Tech which is pretty famous for having these glorious start-ups and being the world's experts on start-ups... Sometimes you need a milestone event to help percolate technology through the health care community and I think that prize was a milestone event that captured a lot of interest.

A CEO with a systems development background was hired, and the software was reengineered to increase reliability and scalability. Up to this point, the key stakeholders lacked business experience and were mainly driven by medical expertise and passion for using technology to treat ischemic stroke patients. The new CEO lacked healthcare industry experience, but he brought business experience and solid technology skills to the team. As a result, he helped formulate a new business plan and technology infrastructure, and he generated enthusiasm among several interested hospitals by summer 2006. Yet, by late 2006, BrainConsult was still in a formative stage. It lacked a physical office location and a dependable stream of revenue; however, it had a solid technological infrastructure, an emerging organizational structure, and a comprehensive business plan.

4.4 Penetration
The final phase, penetration, began with the first commercial contract. Even before the commercialization attempt shifted to high gear, some hospitals in other regions showed interest in REACH, although this did not immediately lead to formal contracts. The Surgeon General of the state of New York was promoting telemedicine in rural areas and he urged that REACH be considered. In September 2006, BrainConsult signed a contract with New York State as its first paying customer. By November 2007, about 44 rural hospitals including eight hub hospitals spread across four states had contracted to install REACH and REACH was up and running in about 30 hospitals. As a result, BrainConsult started to enjoy a steady stream of revenue, but it also faced a new set of challenges and decisions.

The firm defined itself as an application service provider, but continued to debate the nature and scope of business. The name changed in late 2007 (we continue to use the pseudonym BrainConsult). At that point, the firm still lacked any dedicated marketing plan, and its employees were focused on technology and systems development. Although assured a stream of revenues, it 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 that this might necessitate. As a result of this ongoing shaping of BrainConsult to become a more mature business, the founding neurologists relinquished some ownership control, while still maintaining their roles and positions within the original hub hospital. Said the key neurologist:

So you almost have to choose between either leaving and going with the firm or staying. No middle ground. And I've chosen to stay in academics obviously so I'm parting from the firm.

5. Discussion
Drawing on a process-oriented perspective, we have presented a longitudinal study of a telehealth innovation, describing its transition from its invention and pilot test in a network of hospitals to wider commercialization and diffusion across several networks of
hospitals. In this section, we discuss our results in terms of the stated research question. We emphasize the underlying model of the diffusion process, the key characteristics of a chasm between the pilot and commercialization phases, as well as lessons from the case that can help inventors of other telehealth innovations to cross the chasm.

5.1 The diffusion model
Creation and diffusion of REACH unfolded through four phases that together explain the challenges the actors encountered, how these challenges were resolved, and what outcomes ensued. The resulting four stage diffusion model complements analogous models of innovation implementation that have appeared in the IS literature from the perspective of adopters (e.g. Cooper and Zmud, 1990; Fichman and Kemerer, 1997; Rogers, 2003).

Our inventor-centric model differs from existing adopter-centric models, as we specifically address how an invention is first developed and a viable business is subsequently created around it. Our model also complements other stage models that appear in the entrepreneurship literature (Bhave, 1994; Bygrave, 2004) and the technology strategy and new product development literature (e.g. Schilling and Hill, 1998). Our model differs from these prior stage models with its focus on distinct stages of technology development, which the entrepreneurship models neglect to do as they are not specific to technology inventions. Similarly, our model differs from stage models in the technology strategy and new product development literatures, because those models consider new products created by an existing business, whereas our model recognizes that a new business entity must be created to market and support the invention.

5.2 The diffusion chasm
Our analysis revealed several transitions in the unfolding of REACH. In terms of key actors, new stakeholders (rural hospitals) emerged during phase two which added skills and resources – but also problems and constraints – to the original stakeholders the neurologists and system developers. In moving from phase two to three, focus shifted toward solving problems related to technological infrastructure and financial reimbursement. Similarly, in moving from phase three to four, we observed realignment among many stakeholders. BrainConsult became the most prominent actor while other stakeholders, including some of REACH’s inventors and the original hub hospital, receded into the background. Similarly, we observed important transitions in terms of key actions across the four phases as summarized in Table I.

However, our analysis reveals a major delay in terms of REACH’s diffusion into the market, after an initial period of rapid uptake of the pilot into the nine rural hospitals. This delay represents a chasm (Moore, 1999, 2004) in the diffusion of REACH between the initial prototype within a network of hospitals and commercialization of a product that was capable of generating revenues across a broader market base. To successfully cross the chasm, the CEO and Board members of BrainConsult needed to develop new skills, resources, and capabilities in response to four specific transitions:

1) From a single hospital network to the marketplace. First, the type of target adopters changed significantly. The early adopters who comprised the pilot test phase all had close ties with the hub hospital. They belong to a restricted set of nearby rural hospitals, geographically and medically linked to the hub hospital. The number of rural hospitals was limited by the financial resources and
physician manpower available at the hub hospital. In contrast, later adopters were true consumers in a marketplace. These hospitals had no ties of loyalty to the hub hospital, nor were 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.

(2) **From prototype to complete product.** Second, REACH 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 its partner rural hospitals. During commercialization and penetration, REACH was 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 became a complete product (Moore, 1999), including additional, value-added services such as training, installation, maintenance, and operational support.

(3) **From government funding to market-based revenue generation.** Third, the financing mechanism evolved from an R&D project which relied on outside government funding to market-based revenue streams. Initial funding was tied to the hub hospital’s neurology department and its ability to secure research grants. With subsequent diffusion, financing options changed dramatically, with customer revenues becoming the key operating funds. By the end of our case study, the customer portfolio was large consisting of eight hub and 44 rural hospitals, and BrainConsult’s board was considering outside investors and owners. As a result, Brain-Consult had evolved to become self-sustaining based on customer revenues.

(4) **From medical expertise to business leadership.** Lastly, the capabilities evolved significantly between the pilot test and commercialization phases. Initially, key leadership was provided by a group of neurologists with expertise in medicine but not business. 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 oversaw most core activities during the later diffusion phases. 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.

These four transitions characterize the diffusion chasm as it presented itself to the actors involved in REACH’s diffusion. Building on the notion of a disrupted innovation process, this characterization of a chasm has a different focus and is framed differently than similar observations in earlier studies. Fichman and Kemerer (1999) identified a gap between adopters’ acquisition and actual use of an innovation, while Moore (1999, 2004) identified a chasm between the early adopters and the early majority of adopters. The identified diffusion chasm is framed by the four phase diffusion model hence distinct from Fichman and Kemerer’s adoption framing and it focuses on the difficult transition from pilot test to commercialization hence distinct from Moore’s focus on
shift from early adopters to early majority. Our process model is new to the telehealth literature as prior studies have either focused on investigating individual-level adoption issues (e.g. Adewale, 2004; Liang et al., 2006; Mbarika, 2004) or have focused on organization-level issues from the perspective of adopting institutions (e.g. Chau and Hu, 2004; Constantinides and Barrett, 2006; Paul, 2006; Paul and McDaniel, 2004). Our four phase process model and the notion of diffusion chasm offer new insights into how a telehealth innovation went beyond its context of origin, how it migrated from pilot initiative to full-blown commercial product, and how it eventually gained sustainability in the broader marketplace.

5.3 Crossing the chasm
REACH was led by highly motivated neurologists, who played multiple roles of champions, project software managers, and end-users. Their close involvement throughout the initial phases ensured the development of a stable technology and the necessary relationships with rural hospitals to generate a viable network of initial adopters. These neurologists also became a driving force in the latter phases by establishing the business on which diffusion relied. The successful pilot test phase helped ensure that the chasm could be traversed, as this pilot generated public awareness of REACH among a broader set of potential adopters. Another key event, REACH winning a state technology competition, helped create BrainConsult and build momentum for further diffusion. Finally, the set of capabilities that ensured successful early adoption in the initial network of hospitals were also critical to diffusing REACH to the broader market.

While the chasm that separated pilot test and commercialization was successfully crossed, substantial effort, resources, and ingenuity were required. Constraints associated with the rural hospitals in the form of limited bandwidth, lack of CT scanners, and barriers to insurance reimbursement were not adequately considered during the early phases. These constraints became a barrier to further implementation in rural hospitals. Also, misalignment of REACH with institutional arrangements specifically reimbursement regulations was a problem that had to be resolved for commercialization to occur. BrainConsult therefore had to fundamentally alter REACH’s technical specifications to allow for two-way video streaming. Finally, there was insufficient awareness of economic issues, i.e. the inability of BrainCare to negotiate contracts that both hub and rural hospitals could accept. As a result, REACH’s champions had to undergo complex negotiations with multiple potential business partners before a viable business plan and commercial entity emerged.

We summarize these insights from the REACH program into the following recommendations for crossing the diffusion chasm:

- **Develop long-term plan for post-pilot phases.** Like many other telehealth innovations, REACH began 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 to develop long-term plans for the outcomes they hope to achieve post-pilot – including consideration of financial, legal, and technological issues.

- **Position innovation as win-win proposition.** REACH was promoted by the hub hospital, on which it relied for it’s funding. No attempt was made to develop a sustainable business model that explicitly considered rural hospitals’ motives,
capabilities, and constraints. It is critical that champions seek to position telehealth innovations early on as win-win propositions for both hub and rural hospitals.

- **Align with rural hospital processes.** REACH was developed by the hub hospital and then “pushed” to the rural hospitals. The processes and constraints of the rural hospitals were not actively considered when the technology was designed and created. The sooner rural hospitals are involved in design and development of a telehealth innovation, the easier it is to align the innovation with their goals and capabilities to ensure subsequent diffusion.

- **Accommodate rural area technology infrastructure issues.** The project initiators encountered unexpected problems with technology infrastructure at the rural hospitals. The lack of IT staff, high-speed Internet connections, and CT scanner equipment served as barriers to adoption of REACH by these hospitals. As a result, training and trouble-shooting consumed significant IT staff resources at the hub hospital. Recognizing rural hospital constraints, both in terms of technology and expertise, will facilitate adoption during the pilot test phase and pave the way for successful diffusion within the broader marketplace.

- **Accommodate institutional arrangements and legal issues.** The most commonly cited problems were misalignment with institutional arrangements and legal issues. Since the neurologists failed to meet two-way video streaming requirement, 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 greatly facilitate successful diffusion of new telehealth innovations.

- **Involve business leadership from early phases.** Invention and pilot test of REACH were driven purely based on medical leadership until the difficult chasm leading to diffusion. Early involvement of business-savvy leaders can provide complementary skills needed to prepare for commercialization and penetration into the market (Moore, 1999). In the case of REACH, business leadership could have opted to build a knowledge base through experiential learning since adoption occurred “one hospital at a time.” Such a knowledge base could involve developing a set of guidelines related to training, maintenance, trouble-shooting, and possible system configurations at the rural hospitals.

6. **Summary**

This study offers two distinct theoretical contributions. First, our study expands the body of knowledge on diffusion of IT-based innovation. Dominant theories have been criticized for lack of explanatory power beyond the conditions in which they 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. In fact, the traditional models (e.g. Rogers, 2003; Cooper and Zmud, 1990) do not apply well to analyzing the particular challenges related to commercializing and diffusing IT-based innovations like REACH into a broader population of potential adopters. This study explores this gap and offers an alternative conceptualization for the process of creating and diffusing complex, networked innovations (Lyytinen and Damsgaard, 2001) from initial invention to market
penetration. Specifically, we offer a process model consisting of four phases: invention, pilot test, commercialization, and penetration – with each phase demarcated by specific actors and activities. In addition, we characterize the disruptive transition between the pilot and commercialization phases as a diffusion chasm (Moore, 1999, 2004). We described the nature of this chasm, as well as the context-specific enabling factors and challenges that REACH’s champions faced in successfully negotiating it.

Second, our study contributes to the growing body of research on telehealth innovations. We investigate telehealth innovation from the perspective of the inventor and entrepreneur. Such a shift in perspective facilitates understanding the challenges that accompany the transition of telehealth innovations from invention and initial pilot testing to broader diffusion throughout a larger population of potential adopters. By examining a case where the necessary transitions occurred all the way through to commercialization and market penetration, we provide key insights about why many technically viable and medically useful telehealth innovations often fail to move beyond the prototype phase. Observing and characterizing the diffusion chasm between the initial prototype and the subsequent commercial product, we offer lessons on how telehealth inventors can identify and successfully cross the chasm. Although our study deals with one specific telehealth innovation, our findings provide useful insights for other initiatives. However, while telehealth innovations share a set of common characteristics, it is 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.

References


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