Abstract
While prior research has examined how telemedicine projects can be successfully implemented, how these operational projects evolve and change, and therefore increase and expand their impact on healthcare delivery, has received little attention. This paper addresses this research gap by examining telemedicine from a knowledge management perspective. Knowledge management projects are organizational efforts to leverage the application of their knowledge assets. Telemedicine is framed as a form of virtual collaboration, placing particular emphasis on the application of knowledge to improve healthcare delivery outcomes. Teleconsultations, a particular type of telemedicine involving complex collaborative activities, are studied in order to provide insights into how these virtual collaboration efforts can evolve and improve over time. Findings from a study of sixteen teleconsultation projects from four different telemedicine networks highlight the key characteristics of and critical challenges faced by teleconsultation projects as they attempt to evolve and expand their impact on healthcare delivery.

1. Introduction
In the knowledge age, collaboration is an efficient and effective means to apply the ever more varied and specialized knowledge required in today's rapidly changing environment. Collaboration involves two or more parties working together to achieve outcomes none could on their own [11, 24] and is a means to apply the varied and specialized knowledge required in today's rapidly changing environments. Advances in information and communications technology (ICTs) have made possible collaboration in virtual settings, where the use of information technology as the primary means of connection has overcome geographical barriers. Collaboration in virtual settings have significantly expanded the knowledge network available, providing increased access to even more specialized knowledge more rapidly and at a lower cost [1, 27].

The potential benefits of and challenges to collaboration in virtual settings are in full force in the case of telemedicine. Telemedicine is "the use of electronic information and communications technologies to provide and support healthcare when distance separates the participants" [14, p. 2]. It involves two or more geographically separated healthcare providers working together via information technology to provide value added healthcare delivery. Healthcare delivery is fundamentally a collaborative process [13, 14, 18], and telemedicine involves collaboration in virtual settings [22]. Telemedicine has the potential to increase the access to and the quality of healthcare delivery while simultaneously lowering costs [14, 5, 9]. Yet the early utilization rates of installed telemedicine projects were disappointingly low [18].

Since that time, telemedicine projects targeting rural healthcare delivery have received significant financial support [23], and there have been major advances in the capability, usability, and affordability of ICTs. Further, the efficacy and efficiency of telemedicine for a variety of clinical applications has been established [10]. Yet telemedicine utilization rates remain low [8].

While prior research has examined how telemedicine projects can be successfully implemented [10, 8], there appears to be a dearth of studies on how these operational telemedicine projects evolve and change, and therefore increase and expand their impact on healthcare delivery. This research partially addresses this gap in the literature by examining telemedicine from a knowledge management perspective. Knowledge management projects are organizational efforts to leverage the application of their knowledge assets [1, 3]. A knowledge management perspective frames telemedicine as a form of virtual collaboration and places particular emphasis on the effective and efficient application of knowledge to improve healthcare delivery outcomes. Teleconsultations, a particular type of telemedicine typically involving one healthcare provider—usually a primary care provider seeking advice from another—usually a specialist or sub-specialist—who has specialized expertise regarding the health problem at hand [14], are studied in order to provide insights into how these virtual collaboration efforts can evolve and improve over time. Teleconsultations were selected because they tend to involve more complex collaborative activities relative to the other major types of telemedicine (distance learning and teleradiology) [20]. Evidence from a study of sixteen teleconsultation projects from four different
telemedicine networks is presented. The findings highlight the key characteristics of and critical challenges faced by teleconsultation projects as they attempt to evolve and expand their impact on healthcare delivery.

This work extends previous research by furthering the understanding of an increasingly important phenomenon—knowledge-based collaboration in virtual settings—by examining how such activities evolve over time. It contributes to practice by demonstrating how the evolution of collaboration in virtual settings can be facilitated and how the critical challenges to such activities can be addressed. It does so in the context of an increasingly important and contentious area—that involving healthcare delivery.

2. Telemedicine As Virtual Collaboration: A Knowledge Management Perspective

Knowledge management projects are organizational efforts to leverage their knowledge assets [1, 3]. Knowledge assets are leveraged when they are used, and the focus of collaboration is not the articulation and capture of knowledge, but the application of knowledge. Viewed from a knowledge management perspective, the value of collaboration results from the communication, integration, and application of both the explicit and tacit knowledge needed to address the situation at hand [28, 29]. Collaboration enables the application of knowledge because it can be an efficient and effective means by which knowledge can be made more readily available in an understandable form. Collaboration has both a personal and collective component. It is personal in that it is dependent on the knowledge, experiences, and absorptive capacity of the individuals involved. It is collective in that knowledge is interpreted, converted and applied through the interactions of individuals in a situated context [12, 17].

Collaboration involves continuous learning processes by which knowledge workers increase both the breadth and depth of their expertise, depending on the absorptive capacity of the individuals involved. The resulting growth in their knowledge bases enables them to handle new, even more complex situations [24]. Effective collaboration efforts result in improved decision-making that adds value relative to the alternatives. Collaboration is not necessary if one can accomplish one’s goals by oneself; therefore, the measure for collaboration is whether it added value in terms the outcome relative to what would have been done without collaboration [24, 11]. As a result, collaboration, viewed from a knowledge management perspective, involves the management not only of data, information, and knowledge, but of the social context as well.

Healthcare delivery is fundamentally a knowledge-based collaborative process having both explicit and tacit knowledge aspects. In healthcare, explicit knowledge is the scientific basis of medical knowledge that has been published and widely accepted. It is based on clinical studies, recommended treatment protocols for various health conditions, and epidemiological studies of risk factors for disease. Healthcare also involves considerable amounts of tacit knowledge that is difficult to test scientifically and/or articulate. This is exhibited in the subjective or intangible nature of healthcare, which is often referred to as the "art of care" [25].

Collaboration results in the building of a collective capacity greater than that of individuals acting independently. This enables healthcare providers to simultaneously cope with an ever expanding medical knowledge base in the context of increased complexity in the diagnosis and treatment of patient health problems under increasing cost and time constraints. The three standard measures of healthcare delivery outcomes are access, quality, and cost [13], and collaboration potentially can have a significant impact on healthcare delivery outcomes.

The potential benefits of and challenges to collaboration in virtual settings are in full force in the case of telemedicine. Telemedicine has the potential to increase the access to and the quality of healthcare delivery while simultaneously lowering costs. Despite being successfully implemented, telemedicine has not had a significant overall impact on healthcare delivery. A knowledge management perspective highlights telemedicine as a form of virtual collaboration and draws attention to the application of knowledge to improve healthcare delivery outcomes. As a form of collaboration, the measures for telemedicine’s effect on remote site healthcare delivery prior to the introduction of telemedicine and the extent to which access to and quality of healthcare available is increased, and the change in the cost of delivering such care.

As previously discussed, teleconsultations, a particular type of telemedicine tending to involve more complex collaborative activities, are studied in this research. Teleconsultations may be knowledge transferring, discovering, or creating, depending on the situation [20]. Knowledge transferring consultations involve one care provider giving his or her opinion of a patient’s illness based on the care provider’s specialized expertise. Knowledge discovering consultations are those consultations that,
for example, result in the discovery of a new diagnosis based on a new interpretation of the available information. Knowledge creating consultations are the rarest. An example of one is the creation of a new treatment protocol for an illness or disease by combining different therapeutic drugs. Furthermore, the knowledge conversion processes of these different types of consultations may vary [20].

Prior research on telemedicine has demonstrated the efficacy and efficiency of numerous types of clinical applications in teleconsultations. Prior research using a knowledge management perspective has furthered the understanding of how collaboration in telemedicine affects the impact such projects have on remote site delivery. The importance of the social context in which collaboration in virtual settings occurs has been highlighted [20, 22]. Telemedicine projects that are successfully implemented have developed a virtual social environment that is supportive of collaboration. This paper builds on this prior research. By using a knowledge management perspective of telemedicine, and by presenting the findings of a study of successfully implemented telemedicine projects, a better understanding of how this process of evolution and change impacts healthcare delivery is obtained.

3. Method

Four telemedicine networks (sites) involving a total of sixteen teleconsultation projects were studied at different times. Each of the networks had at its hub a university-affiliated health sciences center (HSC), and the spokes of the networks were located in relatively isolated rural areas. HSCs were selected because the vast majority of telemedicine projects involve university-affiliated health sciences (or medical) centers [14, 18]. They also tended to have certain characteristics that naturally accounted for alternative explanations for the impact or the lack thereof of installed telemedicine projects [21].

Four operational teleconsultation projects from three telemedicine networks were initially studied in 1996/1997. Table 1 presents an overview of these four teleconsultation projects. A status update for Site W was received in 2005 by their Associate Director of Telemedicine. Sites X and Y were revisited in 2007. Data about the status of the operational telemedicine projects in 1996/1997 and additional teleconsultation projects implemented since then were collected. In 2007, Site Y had three additional teleconsultation projects while Site X had none. In addition, a fourth telemedicine network, Site Z, was included in the study in 2007. Nine teleconsultation projects involving three different clinical applications were studied at Site Z. Table 2 presents an overview of these additional teleconsultation projects.

Note that this is a multi-period study in that telemedicine networks were studied in 1996/97 and 2007. However, this study is not a multi-period study at the project level because the majority of the teleconsultation projects studied in 2007 did not exist in 1996/97, and a number of projects that existed in 1996/97 were discontinued prior to 2007.

### Table 1. Overview of 1996/1997 Teleconsultation Projects

<table>
<thead>
<tr>
<th>Site</th>
<th>Project</th>
<th>Teleconsultation Activities</th>
<th>Information Technology Configuration</th>
<th>Utilization per month (approx.)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td></td>
<td></td>
<td>Videoconferencing</td>
<td>2 to 3 times</td>
<td>Discontinued</td>
</tr>
<tr>
<td>X</td>
<td>X1</td>
<td>Infectious Diseases, Bone Marrow Transplant (BMT)</td>
<td>Videoconferencing + Attachments</td>
<td>1 to 2 times + 10 times by telephone</td>
<td>Rural hospital closed in 2000. Different primary care physician in remote area took over.</td>
</tr>
<tr>
<td>Y</td>
<td>Y1</td>
<td>Multiple Medical Specialties</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z</td>
<td>Z1</td>
<td>Hepatitis C, Early Childhood Developmental Disabilities (ECDD)</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z2</td>
<td>Z2</td>
<td>Drug Abuse and Behavioral Counseling (DABC)</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z3</td>
<td>Z3</td>
<td>Medical Specialties, Nurse Practitioners</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z4</td>
<td>Z4</td>
<td>Therapists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z5</td>
<td>Z5</td>
<td>Specialist, Therapists, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z6</td>
<td>Z6</td>
<td>Specialist, Therapists, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z7</td>
<td>Z7</td>
<td>Early Childhood Developmental Disabilities (ECDD)</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z8</td>
<td>Z8</td>
<td>Drug Abuse and Behavioral Counseling (DABC)</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
<tr>
<td>Z9</td>
<td>Z9</td>
<td>Medical Specialties, Nurse Practitioners</td>
<td>Videoconferencing + Attachments</td>
<td>1 time</td>
<td>Rural hospital now has many specialists.</td>
</tr>
</tbody>
</table>

* Before the rural hospital closed in 2000. ** After the rural hospital closed in 2000.

### Table 2. Overview of Newer Teleconsultation Projects

<table>
<thead>
<tr>
<th>Site</th>
<th>Project</th>
<th>Teleconsultation Activities</th>
<th>Information Technology Configuration</th>
<th>Utilization (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Y3</td>
<td>Burn Unit, Subspecialists, Therapists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>1 hour every other week</td>
</tr>
<tr>
<td>Y4</td>
<td>Oncology</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>As needed</td>
</tr>
<tr>
<td>Z1</td>
<td>Hepatitis C</td>
<td>Subspecialists, Therapists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + as needed</td>
</tr>
<tr>
<td>Z2</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z3</td>
<td>Early Childhood Developmental Disabilities (ECDD)</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z4</td>
<td>Early Childhood Developmental Disabilities (ECDD)</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z5</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z6</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z7</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z8</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
<tr>
<td>Z9</td>
<td>Drug Abuse and Behavioral Counseling</td>
<td>Subspecialists, Nurse Practitioners, Nurses, Counselors</td>
<td>Videoconferencing + Attachments</td>
<td>2 hours per week + 2 hours behavioral per week (total)</td>
</tr>
</tbody>
</table>
Issue-focused, semi-structured interviews of key informants provided thick and richly textured data [19] and eliminated the problem of item non-response which plagued earlier telemedicine studies [18]. Key informants were members of one of three groups—healthcare providers (physicians, physician assistants, nurse practitioners, nurses, residents, therapists, or counselors), administrators, and IT professionals—who had been directly involved in their organization’s telemedicine projects. A total of 90 healthcare professionals were interviewed face-to-face as part of this study, and the interviews were audiorecorded and transcribed. 48 were interviewed in 1996/1997. Of these, one was reinterviewed in 2005 and six were reinterviewed in 2007. 42 additional healthcare professionals were interviewed for the first time in 2007.

The transcribed interviews were analyzed and coded. Internal validity was enhanced through the use of pattern matching [31], and the reliability of coding of the qualitative data was enhanced by the use of computer aided qualitative data analysis software [15]. Construct validity and reliability were enhanced by triangulated data collection [31]. This was achieved by interviewing multiple key informants and collecting multiple types of data. Teleconsultations or videotapes of teleconsultations were observed when possible, and documentation and archival data such as grant proposals and follow-up, needs assessments, and strategic plans were collected when available.

4. Results


As exhibited in Table 1, two of the four teleconsultation projects active in 1996/1997 were still operational in 2007. The two discontinued teleconsultation projects ended due to changes in personnel. In the case of the bone marrow transplant teleconsultation project, the bone marrow specialists at HSC W relocated to a HSC in a different state. The multiple medical specialties teleconsultation project with the rural health clinic ended as a result of a combination of the physician assistant (PA) leaving the clinic and the supervising physician from the rural hospital dying and being replaced by a physician who was not interested in telemedicine.

In the infectious diseases teleconsultation project, the remote site, remote personnel, and technology utilized changed as a result of the rural hospital closing in 2000. Consultations via the telephone and fax machine with a different physician at his office replaced a combination of videoconferences and telephone calls with a physician at the rural hospital. As the infectious diseases specialist affiliated with the HSC X stated:

HSC X Infectious Diseases Specialist: What has replaced that is I’ve continued to do consultations…But those are done basically via telephone with sharing of information over fax machines. X-rays, radiographs are mailed in…So our concept of what we did in telemedicine has sort of evolved. I don’t know if it’s quite as satisfying as the telemedicine experience without being able to look at and see patients. But I think with that being no longer available we’ve found a way to continue and expand that initial service.

While telephone consultations were not perceived as being as good as the teleconsultation sessions because of issues relating to the transfer of x-rays, they were perceived as being sufficient. Part of the reason for this may have been that, around the time the rural hospital closed, a physician with significant training in infectious diseases moved to the rural area. He became the primary contact in the remote area for HSC X’s infectious diseases specialist. Previously, the teleconsultation project involved rural primary care physicians with little or no training in the treatment of infectious. The infectious disease specialist felt that the new physician had quite a bit of expertise which made it easier to adjust to giving consultations via the telephone and facsimile.

HSC X Infectious Diseases Specialist: You know, he has considerable expertise, I mean, really a lot of expertise. And so we’ve been talking with one another for a long time. And we’re at a different plane in discussing [infectious diseases] patients (than) some doctor who maybe just calls in for the first time.

The frequency of teleconsultation sessions at the multiple medical specialties project with a rural hospital operational in both 1997 and 2007 dropped dramatically. In 1997, on average eight to twelve teleconsultation sessions were held per month. In 2007, the average was just one teleconsultation session per month. There were a number of reasons for this. First, in 1997, there were two physicians at the rural hospital who were very active in the teleconsultation project. One of those physicians (the supervising physician with the remote health clinic mentioned above) died in 2001 and was replaced by a physician who was not interested in the teleconsultation project. Second, and more importantly, a new hospital had been built and a number of specialists moved to the rural area. Therefore, there was no longer the need to consult with the HSC specialists and subspecialists as...
frequently. As the surviving rural physician from 1997 stated in 2007:

Y1 Rural Physician: I guess how it’s changed is now we have more specialists here. In the old days it was just family practice guys. So we tend to consult the guys that we have here first... And part of it was so many doctors have kind of come and gone. [Other Y1 Physician from 1997] used to be here, and he died in a plane crash... and he was a big user of it.

4.2. Evolution of Collaboration in the Newer Teleconsultation Projects

Table 2 presents a brief description of the additional teleconsultation projects studied in 2007. A particularly interesting finding was that the teleconsultations had evolved in a manner such that they were truly a form of collaborative healthcare delivery. These teleconsultation projects were collaborative in two ways. First, they brought together multiple types of expertise. As a rural physician involved with the hepatitis C teleconsultation project stated:

Z1 Remote Physician: [The Hepatitis C] team (at HSC Z) is quite comprehensive, in the sense that on the panel of the experts, there is the gastroenterologist or the hepatologist. There are two psychiatrists, there’s one addiction specialist, and then there are nurse practitioners, nurse specialists for substance abuse, depression, and hepatitis C that sit around the table. And so when you talk to them, there are all these people that can hear you and help the patient. So I think that’s real good.

Individuals with different types of expertise were also part of the early childhood developmental disabilities (ECDD) and pediatric teleconsultation projects. The ECDD project included not only physicians at the HSC but speech, occupational, and physical therapists as well, while the pediatric teleconsultation included multiple pediatric specialists and subspecialists. Second, the teleconsultations involved collaboration between the specialists at the HSC and the rural healthcare providers. This collaboration empowered the remote healthcare providers and enabled them to handle more healthcare problems on their own. An HSC psychiatrist involved in the drug abuse and behavioral counseling (DABC) teleconsultation project explained:

HSC Z Psychiatrist: I work with you actively with the idea that your competence and confidence gradually increases over time and I play much more of a consultative secondary role. But that’s different from either if you assign me a caseload and I’m a direct provider of service, or we never interact directly with the patients that you see... essentially it’s like a systems consultation interview.

This empowerment, made possible by leveraging the expertise of the HSC specialists, increased the number rural patients who had access to care. For example, the DABC teleconsultation project sessions were held weekly and lasted approximately two hours. The DABC HSC psychiatrist described the difference between him treating patients directly versus what they were currently doing:

HSC Z Psychiatrist: One is that when they think of the direct service model they quickly realize that they would—if I’m available let’s say two hours a week, if they gave me a caseload then I'd manage then I would touch the lives of very few people, I mean with that length of time. But if I do case discussions, some of which can be very brief and some of them are these collaborative interviews which might be an hour, an hour-and-a-half, I’m touching a whole lot of patients and their families and other professionals. And so I'm just more useful to them. You know, sort of like they're extending the utility input someone like me could provide.

An additional benefit of the teleconsultation project was that they were a means to address the professional isolation many of the remote care providers often felt. A rural PA involved with the hepatitis C teleconsultation project stated:

Z4 Rural PA: (This) is just bringing this knowledge to all of us who would never have it otherwise, you know. And I just feel like so connected to a bigger medical community that way. And I feel—I’d feel awful if this kind of service wasn't around here. I’d feel like medicine was failing. Do you know what I mean because we just wouldn't be giving the right care to people if that makes sense.

This was important because not only does this feeling of connectedness potentially increase the quality of care available in the remote sites, but it also potentially increases the access to care by removing a major barrier to healthcare providers staying in rural communities. The turnover in healthcare professionals in remote areas is very high. Finding healthcare providers who will commit to staying in the rural community for even two years is often a challenge. Many of the sites studied had trouble finding and keeping healthcare providers for their rural communities. The connectedness that resulted from these teleconsultations potentially helped reduce the feeling of isolation that many of these rural healthcare providers had.

The teleconsultation projects also increased access to healthcare delivery in that it resulted in process improvements. The HSC burn specialist felt that he could see around twice as many patients in the
teleconsultation sessions as he could in the same amount of time in his clinic. He explained:

HSC Y Burn Specialist: Well I think the reason is, is that I'm stable and the patients move, versus the patient's stable and me move. And so me just sitting there, it's just an assembly line...But the fact that they bring a patient in, we get through everything and they move them out and bring the next patient in, it just makes it much more efficient. So I can see 9, 10 patients in an hour where it's hard for me to get through 4 or 5 in a clinic where the patient's physically present.

Other teleconsultation projects were also able to see quite a few number of patients in a relatively short amount of time. A PA involved in the hepatitis C teleconsultation project described their last session:

Z4 Rural PA: And just last Wednesday, there were like 23 patients presented within two hours. So it is like crazy.

Yet the increase in the number of patients seen for a given amount of time did not have a negative impact on the quality of care. In fact, it was argued that the combination of the generalists at the rural site and the specialists at the HSC resulted in a quality of care that was equal if not better than what was being achieved at the HSC itself. As the rural PA involved in the hepatitis C teleconsultation project stated:

Z4 Rural PA: And that's what [HSC Hepatitis C specialist] is trying to closely monitor, is are our outcomes in these rural communities the same as his in the big university using the teleconferencing? And they are. They've done studies that show—as a matter of fact, they might be better....At their Hep C clinic, you know, that's all they do, Hep C. But I see that whole entire patient. You know, I'm not seeing just their Hep C. I'm seeing their entire person and so- and I'm dealing with their entire person. And even then at [HSC], we'll probably say for this, "I need you to see your PCP (primary care provider). Well, I see him as a PCP too." And I think that happens in a lot of rural clinics because we're trying to do all of it for them.

Another interesting finding in the evolution of collaboration in teleconsultation projects was that these projects tended to be very successful in addressing chronic conditions or illnesses involving a treatment regimen that lasted weeks or months. The hepatitis C teleconsultation project treatment period ranged from six months to one year, depending on the genotype of the hepatitis C being treated. The oncology teleconsultation project enabled many of the patients to receive their follow-up chemotherapy treatments at the local hospital, and the burn unit teleconsultation project enabled the patients to receive their follow-up care locally as well. This was important in the case of the burn unit teleconsultation project because it increased the likelihood of patient compliance to the treatment regimen, thus increasing treatment outcomes. Patients no longer had to drive 300 miles to the HSC on a weekly, biweekly, or monthly basis for a thirty minute follow-up appointment.

The hepatitis C teleconsultation project often meant the difference between patients undergoing treatment or not being treated. Persons infected with hepatitis C often showed no symptoms for many years and therefore often were unwilling to undergo what is an unpleasant and long treatment regimen. The treatment regimen involves shots on a weekly basis (in addition to pills). Many of the patients were already reluctant to receive treatment locally. Without the teleconsultation project, it was unlikely they would agree to make the weekly trip to the HSC that would be necessary for treatment.

The ECDD teleconsultation project went even further. Using a small video device that plugged into an analog landline, the remote site developmental specialists had the option of going to the home of the child if the parents were unable or unwilling to travel to the clinic. The quality of the images using the landline was not ideal, but the collaborative efforts of the developmental specialist at the child’s home and the specialists and therapists at the HSC enabled quality care to be provided. As a remote site developmental specialist described the impact of being able to go to the child’s home:

Z6 Remote Developmental Specialist: Well, it's not so much that they don't have transportation, but when I take the phone to them they don't—“oh, I forgot, or oh I, you know”--and we have a lot of that. “Oh, I forgot,” and then just won't show up. It's just too much trouble. But, if it's taken to them, it's not as much trouble.

Interviewer: So, there's really a compliance issue? Roughly what percent (of your patients) do you think you have to deal with that compliance issue?

Z6 Remote Developmental Specialist: About 75%...You'll have very few who would come. You know, you'll have the parents that are real gung-ho about the therapy, they will come. But, otherwise they won't come.

Interviewer: What is their reason for not coming?

Z6 Remote Developmental Specialist: There really isn't a reason, you know. It's just like, the therapies are free, but yet they're not there for them. They're not home or they don't answer the door. There's not a reason, it's just, unfortunately, you know, most of the time their children are not their top priority. There's other things that are top priority.

While teleconsultation projects can significantly increase the access to care in remote communities, resource constraints in terms of time in addition to money are severe. As exhibited in Table 2, teleconsultation projects only had the HSC specialists
available for very short amounts of time, and it was unlikely that the number and duration of teleconsultation sessions held could increase. The teleconsultation projects generally represented only a small proportion of both the remote site healthcare professionals and the HSC specialists’ responsibilities. Even if they wanted, they did not have the time or resources available to increase their involvement in the teleconsultation projects.

However, as the teleconsultation projects evolved, an opportunity to further leverage the impact of the teleconsultation projects without an increase in the frequency or duration of the teleconsultation session was created. As the expertise of the remote healthcare providers was increased through the teleconsultation sessions, the remote care providers were able to handle more complex problems on their own without having to refer to the HSC for assistance. As the head of the hepatitis C teleconsultation project explained:

HSC Z Hepatitis C Specialist: If we can, through these knowledge networks, help them manage their patients, that is co-managing patients, not them managing themselves but we manage them together by use of disease management protocols, which they already have. And you see how we were following the protocol. And by using case based learning, then they will rapidly become experts in these diseases. And that’s what you probably saw, how they were becoming better and better, you know? They were all listening to each other, and so they were learning rapidly. And what we have shown is they rapidly become experts so that we can enhance capacity to care for these common problems and that’s the whole idea here…we can set up these knowledge networks and train their own people to manage their own patients.

This expanded and geographically distributed expertise had the potential to further increase remote site access to quality healthcare delivery in two ways. First, even more remote sites could be added to the telemedicine network without increasing the time allotted to the teleconsultation sessions. The ability of the remote care providers to handle more situations on their own resulted in even fewer teleconsultations between them and the HSC. This freed up teleconsultation session time that could then be used assisting newer, less experienced remote sites.

Second, this provided the opportunity to further leverage the impact of the teleconsultation projects by having them evolve into what were in effect multtier telemedicine networks. The IT support function (help desk) provides an imperfect but useful analogy as to how this multi-level network might function. When someone calls the IT help desk for support, they are first assisted by a level I technician who possesses a general level of expertise. If the level I technician is not able to provide the necessary assistance, then a more specialized level II technician is brought in to assist. In the teleconsultation projects, the remote sites that had developed additional expertise over time would become in effect the level I technicians to the newer remote sites. If the experienced remote sites could not address the issue, then the situation would be forwarded to the more specialized level II technicians—the specialists at the HSC. As the head of the hepatitis C teleconsultation project explained when asked about how he expected the volume of teleconsultations to change over time:

HSC Z Hepatitis C Specialist: Our hope is that over time less and less, each [remote site] needs to bring less and less to us over time, because that would mean to us that our model is working and capacity is being created. But so happens that, because we choose complex areas, there’s always nuances, there’s enough—because each of these areas, people are developing what we call centers of excellence in each of their areas. So it’s not only that they’re just managing their own patients. After some time what is happening is their peers around the state are starting to see them as experts. So they refer to them. So then they may not know some of those things.

A few of the existing remote sites were already collaborating outside the scheduled teleconsultation sessions. As a remote PA involved with the hepatitis C teleconsultation project stated:

Interviewer: Do you ever talk to the other remote sites?
Z4 Rural PA: Like just me and them?
Interviewer: Yes.
Z4 Rural PA: With [Z1 Rural Physician], I have because now that I’ve met him on the teleconference, he is just an amazing guy. So I’ll—like on the teleconference, they’ll also bring up things like, "Oh [Z1 Rural Physician] had a great hepatitis day out in [Z1]. So now I'm like "Oh." So I call [Z1 Rural Physician] and say, "Tell me all about it."
The PA felt she could handle the role of the first level expert. She gave an example of her reaction to a question asked in a teleconsultation session by a newer remote site.

Z4 Rural PA: Even our M.D. over in [new remote site], I'm like, "Wow, he could have dialed me and I would know what to do." Absolutely. And I think that's why our organization is starting to be comfortable with the idea of using grant money to get video conferencing in some of our farther north clinics so that I can do some initial stuff with those Hep C patients, you know. And then it would be the same thing like, "Ooh... this is beyond me. Let's got to [HSC Z] again." And it would just be this constant back and forth, you know.

A barrier to the implementation of the multitier telemedicine networks may be that it increases the time commitment required by the more experienced...
remote site healthcare providers. The time these remote site healthcare providers may spend collaborating with the HSC may decrease, but it is quite possible this may be more than offset by the increased time needed to collaborate with the newer remote sites. Fortunately, cost effective solutions to this problem exist. Many of the remote site healthcare providers complained about the administrative overhead associated with the teleconsultation projects. As three remote providers involved in the ECDD teleconsultation project described:

Z7 Rural Developmental Specialist: The other major problem that they really need to look at is the paperwork that people are demanding because in telehealth, the other end (HSC) wants something of information... (Initially) we’re doing like a three-page referral giving that person (at the HSC) some information about the family and the child. Well, when we finally get the parent in front (of the teleconsultation equipment) we’re having to do forms all over again. Like our program collects release and HIPAA, we have them sign all of these forms for our program. We have to do a whole other set just to do a [teleconsultation session] with the family, that’s a lot of paperwork for a family to go through. And then, surveys, evaluations, how did that call go, that’s another paper. I don’t know, how many forms would you say before a family can...

Z7 Rural Site Coordinator: About ten, nine or ten.
Z7 Rural Developmental Specialist: Nine or ten additional forms. We’re doing things double. And that’s the hardest thing to talk a parent into.
Z7 Rural Site Director: Because that’s dead time. You have to do it but it’s not really productive. Because the paperwork is the killer... We all ready have referral forms in our words, in our forms. It just seems like double work. Our staff actually fills them out. We try not to bug the parent as much as possible, but there’s ten forms, easy.

Interviewer: How many hours does that take?
Z7 Rural Developmental Specialist: About an hour sitting with the parents, and then a little bit longer to get them faxed and then all punched together. A couple of hours.

There were a number of possible solutions to address this problem. Reducing the redundancies in paperwork was one. Another was to streamline the administrative process by transferring information by the internet instead of using the facsimile. An additional possibility was to provide a relatively small amount of funding to the remote sites so they could contract nurses or administrative personnel on an hourly basis to deal with the paperwork. This was already happening at some of the hepatitis C remote sites. A rural physician involved in the hepatitis C teleconsultation project stated:

Z1 Rural Physician: Well, I have a nurse. Fortunately, [Site Z] gave me a nurse who comes to help out. And she comes twice a week for 16 hours. And she will fax all of the things I need. And then she will talk about a patient, I will fax this in advance, at least a day in advance to them. So I send it, in the format, they have a format that we use. And then I use the lab. The labs that we use will also send it to them. And I think that’s how it takes care of it. We’re supposed to view this through the computer. But I guess, you know, I belong to a different company, and they are in a different company. And I think they have trouble sending the things. So for now, we fax everything. Though the plan is that someday this will be done by the internet.

5. Discussion and Conclusion

The purpose of this research was to utilize a knowledge management perspective to better understand how successfully implemented teleconsultation projects evolve and change, and therefore increase and expand their impact on healthcare delivery. Findings from a study of sixteen teleconsultation projects from four different telemedicine networks highlighted the key characteristics of and critical challenges faced by teleconsultation projects as they attempt to evolve and expand their impact on healthcare delivery.

Table 3 presents a summary of the findings. The findings suggest the evolution and sustainability of these teleconsultation projects are significantly challenged by changes in the personnel involved in the teleconsultation project. This finding is consistent with research on the relationship between organizational membership stability and organizational performance [6, 16, 30].

Table 3. Summary of Findings

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The findings also highlight the predominant reason for the existence of teleconsultation projects: the lack of availability of needed specialist expertise. The primary reason the utilization of the multiple medical specialties teleconsultation project with the rural hospital had decreased was that the needed expertise was now available locally.

An argument can be made that an effective teleconsultation project will die a natural death as the expertise and capabilities of the remote site healthcare providers increase. Teleconsultation projects are a form of a virtual organization. Virtual organization membership is not likely to be stable over time; indeed one of the more important advantages of virtual organizations is their temporary nature [7, 27]. However, there is a significant shortage of most types of specialty care, physical and speech therapies, and psychiatric care in many rural areas, and the demand for the services offered in the teleconsultation projects continued to significantly exceed the resources available.

The availability of healthcare is necessary for rural communities to remain economically competitive [4, 2], and this research may contribute to sustaining the availability of healthcare in remote settings. Teleconsultation projects face a significant issue of sustainability because their continued utilization is dependent on individual healthcare providers. Rural healthcare provider turnover is a relatively common event, and the performance of a teleconsultation project should not be dependent on having the same personnel in the same role. Regulatory guidelines regarding healthcare personnel training and licensing means that roles should be stable, even if personnel are not. It may be that roles in teleconsultation projects are so intimately tied to a specific person that, if a person leaves, the project falls apart because it is so dependent on that person. In effect, this may be an issue of creating and sustaining organizational memory that survives remote site health care provider turnover. This issue may in part be addressed by the use of IS [26].

Financial considerations were another major challenge to the sustainability and evolution of teleconsultation projects. None of the teleconsultation projects studied were financially self-supporting. They were all dependent on grants or financial support from the HSC, and it is unlikely that these teleconsultation projects will generate enough revenue in and of themselves to support even their operational costs—yet alone their capital costs. There are two main reasons for this. First, the number of potential patients is limited by the small population sizes of the remote sites. Second, these patients tend to be poor. At best, they are covered by Medicare, Medicaid, or another government program. At the teleconsultation sites studied, a significant number of the patients did not have any insurance at all.

The challenges the teleconsultation projects face in sustainability are indicative of the problems facing the healthcare delivery market in general, and these findings may have important implications for the healthcare debate currently raging. Under the current healthcare delivery model, many of these teleconsultation projects may not be perceived as major successes because they are not self-financing and they do not provide additional revenues to the HSCs. However, under a model based on preventive care and lowering the overall cost of providing healthcare as a whole, these teleconsultation projects can play an important role in healthcare reform by reducing the cost of diagnosing and treating illnesses and disease. Remote care providers are empowered and can handle more problems locally, saving travel costs and keeping money in the local economies. Unnecessary emergency transportations, which are expensive, can be reduced.

More importantly, teleconsultations can play a major role not only in preventive care but in assisting patient compliance for chronic conditions. Previously, patients would have to travel to the HSC on a regular basis for follow-up. The end result was that many patients did not bother to follow up because it was too much of a bother, too expensive, or they could not afford the time away from work. These teleconsultation projects facilitate patient compliance in because going to the local primary care provider rather than having to travel many hours to the HSC makes it more likely that patients will follow up. More radically, patient compliance can be made even more likely by the provider going to the patient's location. This is the idea behind school-based clinics. The clinics, being in schools, are where the children are. This eliminates the need for the parents to have to take time off from work to take their children to a healthcare provider. Standard childhood illnesses are treated earlier and at a lower cost than they might otherwise be. These findings suggest that teleconsultations can play a major role in the move towards a lifecycle approach to healthcare delivery that emphasizes preventive care and disease management, and away from the current focus on treating conditions when they become acute and more expensive and difficult to treat.

10. References

Successful knowledge management projects


