Prospectus

Improving the Ergonomics of GI Endoscopes

(Technical Report)

Telemedicine's Impact and Acceptance within Charlottesville

(STS Research Paper)

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INTRODUCTION

In the rapidly growing field of medicine, innovations in healthcare is no longer limited to the traditional lab-bench and test tubes. Nowadays, the medical devices industry has been projected to sustain an annual growth rate of 5.6% as innovations are driven by leaders like Stryker or Medtronic (Kelly, 2018). Likewise, information and communication technologies (ICTs) are spearheading the widespread telemedicine adoption as evidenced by our country has seen a dramatic increase in research and development, as evidenced by a recent executive order passed by the White House and a recent UN meeting ("ICTs to achieve the United Nations Sustainable Development Goals," 2018; Phull, 2019). Therefore, this project aims to advance device development in both telemedicine and the medical devices market.

Colorectal cancer is the 3rd leading cause of cancer-related deaths in the United States, and in the current standard of care, colonoscopy is the only procedure capable of screening for colorectal polyps and cancers (Marley & Nan, 2016). In the United States alone, approximately 19 million colonoscopies are conducted by gastroenterologists every year and serve as the primary diagnostic tool to identify these otherwise undetectable gastrointestinal pathologies ("An Astounding 19 Million Colonoscopies are Performed Annually in The United States," 2018). Through a survey of 1,353 respondents, Cohen et al., (2006) found that gastroenterologists in the United States often must perform an average of 22.3 colonoscopies per week. A high frequency of colonoscopies has often led to De Quervain's tenosynovitis of the practitioner's left thumb, amongst other related repetitive strain injuries, which is caused by the repetitive "abduction and extension of the thumb to manipulate the dials" of the endoscope (Harvin, 2014). Characterization of this injury typically involves a painful inflammation of two tendons that run between the thumb and the wrist: the abductor pollicis longus (APL) and the extensor pollicis brevis (EPB) ("De Quervain's tenosynovitis," n.d.). Therefore, the technical component of this thesis aims to develop an ergonomic solution to mitigate the frequency of repetitive strain injuries (RSI) contributed by endoscope mechanics. Improving the endoscopy ergonomics of the modern scope not only reduces the risk for repetitive strain injuries (RSI), but also offers a solution to improve the quality of life for the physician.

Smart health encompasses a myriad of initiatives and innovations to help interconnect all community members with health-care practitioners as a means of expanding access to health care. In particular, with advancements in telemedicine and remote patient monitoring, physicians have been able to establish meaningful relationships with members of isolated communities. Nowadays, strides in telemedicine and smart health have been developed locally and abroad as a means to ensure healthy living within various communities across the world. For instance, China, amongst other world leaders, has paved the way in establishing ground-breaking technology designed to improve the patient and healthcare provider experiences. However, due to challenges with widespread implementation across America, especially in Charlottesville, the magnitude of the impact of telemedicine has been reduced ("Challenges Facing the Telehealth Industry | UIC Health Informatics," 2017). Therefore, I plan to characterize how the Charlottesville community has embraced this healthcare platform and what the Charlottesville population considers are the factors influencing people's tendencies to interact with this form of healthcare.

TECHNICAL PAPER: IMPROVING THE ERGONOMICS OF THE ENDOSCOPE

Gastroenterologists who frequently perform a high volume of colonoscopies risk musculoskeletal overuse injury due to the mechanical challenges posed by operating the scope. Current endoscopes often require the physician to use their left thumb and forearm muscles to exert and sustain forces on a system of dials to control and maintain its position of the scope during the procedure. The current design allows the physician to deflect the distal end of the scope so that the tortuous bends of the gastrointestinal tract can be navigated (K. Chang, personal communication, September 25, 2019). The repetitive abduction and extension of the left thumb often leads to De Quervain's tenosynovitis which accounts for 19% of common musculoskeletal overuse pathologies affecting up to 89% of the colonoscopists surveyed (Byun et al., 2008). Though various strategies have been proposed to address these issues include self-propelling scopes (Vucelic et al., 2006), joy-stick controlled scopes (Woo, Choi, Seo, Kim, & Yi, 2017), and robotic systems (Lee & Chung, 2013), highly-skilled gastroenterologists are reluctant to exchange their years of experience and training operating the dials on the traditional endoscope for the sake of learning an entirely different system.

Many studies that attempt to identify the root cause of these musculoskeletal injuries find that poor ergonomic design of the modern endoscope is a likely risk factor. There is a strong hypothesis that hand injuries resulting from the practice of colonoscopy are caused by some combination of the following three risk factors: prolonged strain on the thumb, repetitive action of the thumb, and high forces being exerted on the thumb to operate the dials (Harris-Adamson et al., 2015, p. 33). Shergill, Harris-Adamson, Lee, McQuaid, & Rempel, (2016) found over a cohort of 12 endoscopists that while they were performing colon insertion, their hands exerted an average peak thumb force of 15 Newtons (N) on the left thumb and spent 17% of their procedure time exerting high pinch forces above 10 N (Shergill et al., 2016). A separate study also found that those with occupations that require them to spend more than 11% of their work exerting high pinch forces increased their risk of overuse injury (Harris-Adamson et al., 2015). Therefore, this technical project aims to address this problem by reducing at least 2 out of the 3 identified risk factors that frequently lead to repetitive strain injuries. By putting the health of the physician first, our team aims to potentially reverse any loss of productivity from endoscopy-related injuries, allowing more patients to be seen in a day and streamlining the patient experience in the endoscopy suite.

UNDERSTANDING AND APPLYING ERGONOMICS TO ENDOSCOPY

The technical project will involve the design of an experiment and the design of a device solution. The experimental approach will prioritize validating the underlying cause of musculoskeletal injury in endoscopists by evaluating the left hand activation of the muscles associated with the abductor pollicis longus (APL) tendon and the extensor pollicis brevis (EPB) tendon as well as the forces exerted by the thumb while performing a colonoscopy. The study will compare data collected before and after the implementation of our proposed design. The experiment may require Institutional Review Board (IRB) approval to gather a cohort of endoscopists for the experiment. These endoscopists will be tasked to perform a simulated colonoscopy on a training model of the colon commonly used in gastroenterology fellowships. During the procedure, force sensors and electromyography (EMG) will be used to measure the force exerted by the thumb and the muscle activity in the hand, respectively. Insights gathered in this study will help guide the device design phase.

The space used to conduct research on hand muscle activity and force exertion for the first phase of the technical project has yet to be determined, but will ideally take place in an endoscopy training suite that supplies a model colon capable of simulating a colonoscopy. Muscle activity will be measured using the BioRadio electromyogram (EMG), and the forces exerted by the thumb will be measured using a force sensor. My team will consist of two other Biomedical Engineering Students, Vincent Sciortino and Kevin Ly Chang, and will occur over several years. The technical advisor, Professor William Guilford, has generously provided access to a three-dimensional (3D) printer, as well as an estimated budget of $4,000, so that prototypes from the second phase of the technical project may be produced and iterated. By the end of the year, the technical project team hopes to produce a working prototype that alleviates these musculoskeletal overuse injuries for the physicians, followed by a technical paper publication on the comparative study elucidating the efficacy of our proposed design.

STS THESIS: CAN TELEMEDICINE WORK?

INTRODUCTION: WHAT IS TELEMEDICINE?

According to the World Health Organization, telemedicine is holistically considered "the delivery of health care services, using technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers" (World Health Organization, 2010). Telemedicine is accessed by over 150 facilities and healthcare physicians across Virginia and is essential to impacting a broad variety of community members (Drees, 2019). For rural Virginia, telemedicine has been one of the primary ways of combating various epidemics in these rural communities. Programs, such as the Remote Access Medicine (RAM) clinic, have worked diligently to expand access to these healthcare initiatives and help bridge the gap between the development of such projects and their respective designs.

The example by the various international leaders has catalyzed a widespread adoption of various initiatives at the UVa health system utilizing these ICTs to create programs for underserved people Thus far, the UVa health system has been able to point to some immediate successes from the implementation of their telemedicine system as well as exploring the possibility for growth. In the current hepatitis C epidemic, UVA has developed a technology-led initiative that have set-up teleconferences with several members of the rural communities to increase personalized treatment. By setting up this program, "the people that we've gotten all these medicines for, would not have had access to it without having to drive over 300 miles to get it," per a UVA clinical research Manager (Paschall, 2019). This initiative has been crucial for administering healthcare to otherwise isolated communities and has proven how telemedicine can be essential to the betterment of health in Virginia.

Despite the reported successes of the program, the experience of the outer community hasn't been quite as positive, and seems to have According to Mark Rugarber, a registered nurse, while much innovation that has been implemented within the health system, the average patient often times has difficulty navigating the process. Particularly within the realm of healthcare, people struggle to understand what resources are available to them, and often are unfamiliar with telemedicine as a whole. These disparities are further exacerbated with people of lower financial backgrounds who lack access to the necessary resources to adequately navigate this system (Rugarber, 2019). In addition, given the local presence of issues such as Broadband access impeding technological adoption, regulatory issues with misdiagnoses, and institutional concerns with remaining compliance have impeded with the scale of measurable impact in the implementation of these programs. This project intends to address the following research question:

1. Is telemedicine perceived as a solution to equalize accessibility for health care across various diverse communities in Charlottesville?
2. What factors enable or impede telemedicine's acceptance within Charlottesville?

LITERATURE REVIEW

Furthermore, considering the advancement of treatments and incidence of various pathologies, telemedicine plays a key role in broadening the impact of health-care in tackling regional epidemics (Paschall, 2019). A similar impact can be seen within the realm of mental health, a new and burgeoning field in rural medicine (Noguchi, 2019). Physician perspective on the support and access from telehealth is essential to establishing public support.

Since it's initial implementation, telemedicine has often been considered the future of primary medicine and health care. As discussed in a breadth of research in medicine, telemedicine has been considered "broadly inconsistent" with an unclear understanding of measurable impact. (Ekeland, Bowes, & Flottorp, 2010). Though some studies cite accessibility and improved medical compliance as promising signs of a bright future, others cite an underlying lack of broadly applicable evidence to support any consistent and valuable impacts for regional communities. In particular, one area frequently cited as a necessary area for further exploration is the social and cultural presence of telemedicine from the patient perspective (Ekeland et al., 2010; Tachakara & Rajani, 2002).

Currently, the social and cultural presence, several communities that mimic some of the disenfranchised communities of Charlottesville have responded to telemedicine.
In some communities, telemedicine has been showed to be an effective way of empowering the patient. In a study exploring the nature of patient interactions through various telemedicine platforms, patients were found to be more engaged and "ask more questions" during the visit to take better advantage of these given initiatives (Tachakara & Rajani, 2002).

One such instance includes the current challenge for many rural community members is the differences in access to the various means of telemedicine. For instance, despite the widespread adoption of healthcare in the rural communities, 660,000 Virginia residents lack broadband access, which leaves them unable to participate in UVA's remote patient monitoring services (Drees, 2019). Likewise, rural communities, such as those in the Midwest, cite a plethora of concerns that have hampered the widespread adoption of telemedicine in many communities (Bareiss, 2001). Despite the presence of broadband challenges, telemedicine and smart health is amongst the various new initiatives destined to advance people's access to healthcare. For instance, a new 100,000,000$ pilot program was launched with the goal of improving broadband access, but is still unable to benefit the broader rural community (Drees, 2019).

Furthermore, these initiatives are key to allowing community centers to triage patients to fast-track the administration of life-saving vascular and cardiac healthcare (Wicklund, 2018). By offering opportunities for smaller hospitals to contribute to the administration of healthcare associated with larger research centers, like UVA, increases the span of reach for healthcare programs. Telemedicine is essential for building trust in the healthcare for community hospitals to ensure rural isolated communities can get the help they need with fewer obstacles to success.

Accordingly, these programs have allowed for local emergency health care to grow as an industry, which implies room for growth for other community healthcare centers (Batson, 2019).

STS FRAMEWORK

To gain further context into the status quo of healthcare in Charlottesville, this project adopts Social Construction of Technology (SCOT) as the framework to better break down all of the relevant stakeholders affected by the implementation of telemedicine initiatives. Specifically, this framework will be important in understanding how the social interests of the various stakeholders can be used to better understand the major takeaways from the literature review and how it influences the design and implementation of these initiatives in Charlottesville and the University of Virginia.

METHODOLOGY

This project will apply the following three methods to collect research data, summarize as follows:

1. Document/Policy analysis: The document analysis will be conducted in a two-prong effort. First, the aforementioned literature review will continue with an added emphasis on the regional impact in Charlottesville and the surrounding affected communities. Better understanding the policies, reports and patient testimonials for its implementation in Virginia, we will be able to illustrate the value embedded in the design implementation of telemedicine through the University and regional healthcare systems. Therefore, this analysis can then be used to create solutions to better address the successes and shortcomings for the various communities in Charlottesville.

2. Interview: A series of interviews including health-care providers, technology leaders, and community leaders, will be conducted to both validate the volume of collected literature and gain a more interpersonal understanding on how telemedicine is viewed in Charlottesville by it's affected base, and further elucidate how the impact of telemedicine is perceived differentially across all of the involved actors within the field of telemedicine. The focus of this analysis will be to explore members from the various communities identified in the preliminary interviews with health care provider Mark Rugarber and health care administrator Yafel Valera such as members from the hispanic community or rural communities (Rugarber, 2019; Valera, 2019). Ultimately, the goal of this investigation will be to elucidate how the various Charlottesville communities interact with Telemedicine. More importantly, this interview series will provide a diverse perspective and an honest glimpse into the successes and failures of telemedicine in Charlottesville, Virginia.

Collectively, both the series of interviews and the expansive policy search will allow us to understand all pertinent actors and their associated problems and solutions from the various applications of telemedicine within the framework of a Social Construction of Technology (SCOT).

CONCLUSION & FUTURE WORK

Finally, the contributing research from this specific initiative will also be evaluated in the scope of the Smart Cities Projects started in STS 4500, this project will be presented to various leaders within Charlottesville that will be able to add their own perspectives and insight to further develop this project. In combination, these two frameworks will allow us to better structure and understand the interplay of the various conflicting social groups.

Ultimately, this paper will employ various frameworks to better characterize and understand the implementation of telemedicine initiatives in Charlottesville. Accordingly, it will aim to not only explore how it's been successful, but also evaluate the more immediate impacts it has had on the regional communities in Charlottesville. The conclusions from this analysis will provide the groundwork to build upon pillars of success within this program and build upon gaps between the infrastructure of the initiatives and the affected demographics.

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