Thesis Project Portfolio

Designing an Affordable Distal Radius Fracture Reduction Simulator for Medical Training

(Technical Report)

Telehealth and Its Effect On Access to Healthcare in Urban and Rural Communities

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Greer Matthias
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Department of Mechanical Engineering

Designing an Affordable Distal Radius Fracture Reduction Simulator for Medical Training

(Technical Paper)

Telehealth and Its Effect On Access to Healthcare in Urban and Rural Communities

(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Mechanical Engineering

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Prospectus

Introduction:

The Covid pandemic disrupted our culture and society like nothing seen in recent history. In addition to shutting down schools and hospitalizing thousands, the aggressive push for social distancing rendered the traditional office workplace environment difficult to impossible to maintain. As a result, remote working from home became the new standard for employment, reaching a point where, during the calendar year 2020, around 50% of all hours worked were remote (Dalton and Groen, 2022). This newfound flexibility allowed workers to spend more time at home, and gave them a higher degree of control over their lives. They could spend more time with family as well as adopt a schedule that eliminated the typical 9-5 workday. As a result, the years of the pandemic saw a significant increase in population of rural areas, as opposed to dense urban centers. The work from home dynamic created an environment where employees could live somewhere further away from where their actual office was, allowing for opportunities to live in places that were less stressful financially and socially. Smaller, rural towns became increasingly appealing for their lower cost of living and distance from the larger, more hectic urban centers. However, for all the positive attributes of moving to more rural locations, there are also negatives, specifically with regard to healthcare. This issue ties indirectly with my technical project, which involves constructing a medical device to better assist physicians with routine procedures. Inspired by this technical project and personal experience, I decided to try and answer the question of how the trend towards rural living has affected people's access to quality healthcare. This paper will establish how my STS and technical project are related, as well as lay the groundwork for answering my proposed research question.

Technical Project:

Several years ago, UVA orthopedic surgeon Dr. Aaron Fraelich and Associate Professor Jason Forman designed and built a prototype device to help simulate the closed reduction of wrist fractures. This prototype, while functional, was rudimentary and difficult to mass produce. Our group is tasked with designing our own mechanism which ideally would be cheaper and easier to mass produce.

Distal radius wrist fractures are extremely common, composing about a quarter of all pediatric fractures, and close to a fifth of fractures in geriatric patients (Chung, 2012). These fractures occur in the radius, one of the two bones that comprise the forearm, at the distal end, referring to the end of the bone further from the body.

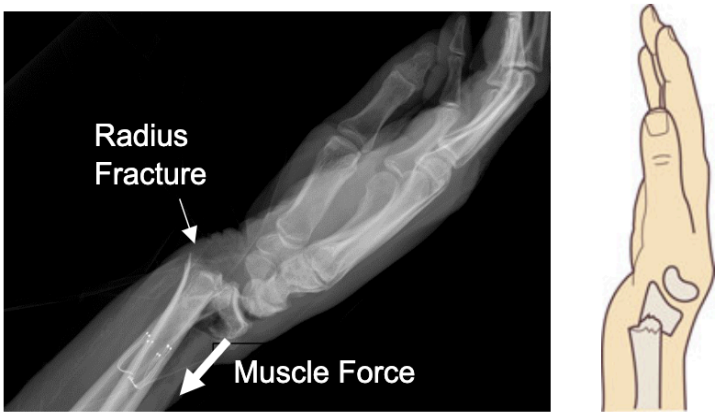


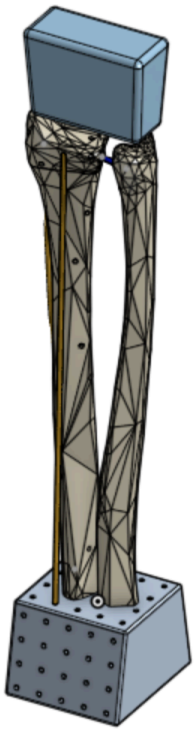
Diagram of Colles' fracture

This fracture often occurs from a patient falling and bracing themselves with their hand, leading to a high energy impact in the wrist, resulting in an injury similar to the one seen above. When this occurs, due to natural tension in the forearm from tendons and muscle, the bone fragment is displaced and pulled towards the elbow. Doctors treat this injury by giving patients a splint that stabilizes the injury and holds it in place so that it can heal. However, in order to

realign the bone fragments, they must perform what's known as a closed reduction. Essentially, this procedure requires doctors to pull the bone fragments back into place, a task made more difficult by the previously mentioned forces applied by muscles. For medical students, the primary way that they are trained in this procedure is to practice on an actual patient, which obviously comes with inherent risk. Our group is seeking to create something that can mitigate this risk and allow med students to practice the procedure before applying it to live patients.

We began by doing in depth research on the physiology of this type of fracture and meeting with Dr. Fraelich to determine what factors of a closed reduction were most important to emulate. We also researched some of the existing practice devices. From there, as part of an assignment for our design class, we created a number of proposed designs that we later went through and discussed which would be the most viable option. The primary design points we needed to meet were creating a model with a lifelike feel and ensuring that the tension applied to the bone fragment mimicked the actual tension in the arm. To do this, we decided on trying to create a silicone mold that could slide over the inner workings of our device. This would create a skin-like feel while also being easily removable to access the inner workings of the mechanism. Additionally, we settled on using elastic bands to simulate muscle tension. The elastic would stretch from the base of the model to the hand, and would be adjustable both in strength and placement. The goal with these design criteria was to be able to quickly change the “muscle force” based on physician feedback. As engineers, we have no experience in what a closed reduction actually feels like, and will be relying on feedback to create as accurate a device as possible. By being able to quickly adjust both the strength and direction of our elastic bands, we hope to quickly iterate through different configurations without having to make an entire new product.

A current rendering of our design is shown below. The hand part has been simplified to a cubic block, but we plan to redesign it to be more anatomically correct. The hand, along with the ulna and radius are to be 3D printed out of ABS plastic. Medical grade elastic, as mentioned above, will be used to apply tension. The base where the bones will be attached, shown with numerous holes in it, will be made out of wood and provide a stable platform for when the reduction is being performed. The holes are where the elastic will be anchored.



STS Project:

The Covid pandemic ushered in a new work style, working from home. In an effort to limit physical contact, over 27.5 million people gave up the office lifestyle to instead create home offices (US Census, 2022). This newfound work flexibility contributed to the first net increase in rural area populations in a decade (Cromartie, 2024). However, this increase in

population draws attention to a clear discrepancy in healthcare access between rural and urban populations.

One reason that urban healthcare has an advantage over rural healthcare comes from financial reasons. Rural towns are often poorer, which means that not all residents have insurance, or that some residents must choose between buying groceries and seeing a physician. Additionally, there tends to be less physicians practicing in rural areas, because there is a small and less lucrative customer base. As a result, urban centers tend to have a higher concentration of qualified doctors. Another factor that makes healthcare access difficult in rural settings is that on average, residents live more spread out, sometimes with inferior infrastructure and roads, making it difficult to access the healthcare that is available.

These issues that plague rural residents in turn affect what hospitals do exist to serve rural areas. About 700, or ⅓, of rural hospitals face financial trouble (Hunter, 2024). When the few hospitals that do exist are forced to shut down, this only exacerbates the issues that already exist. Patients must drive further, take more time off work, and otherwise take more time out of their day than what the average urban resident would need to.

However, while the overall discrepancy between rural and urban healthcare seems glaring, there have been efforts to reduce it. The Biden administration approved a 75 million dollar legislation (HRSA, 2024) intended to help fight opioid abuse as well as provide financial support to rural hospitals. This indicates that people in power are aware of issues affecting rural communities and are committed to helping them.

With regard to my research question about how the trend towards rural living has affected people's access to quality healthcare, these examples highlight that there is certainly a discrepancy between rural and urban healthcare. Moving forward, in order to answer this

question, I plan to analyze more news articles, which I believe assist in contextualizing information pertaining to my research question within the scope of recent events. Additionally, I intend to look at more quantitative data on population fluctuation for specific rural areas, which will help to establish and understand how people were relocating. I also plan to look for anecdotal evidence from residents who moved from an urban area to rural during or following Covid, or vice versa. Finally, I'd like to examine political data trends, both past and current, to learn and infer how legislation might affect rural areas, for better or worse, in the near future.

While examining this variety of sources, an important STS framework I aim to use is technological determinism, the idea that technology drives and has a direct impact on social outcomes. With this in mind, I intend to look for examples of this in rural communities, such as infrastructure maintenance and resource distribution, which would also contribute to answering my research question.

Overall, I believe there is a plethora of data and news that will allow me to answer my research question, which questions how the rural migration due to Covid affected residents' access to quality healthcare. By examining this data through a specific STS framework, I hope to be able to establish a clear answer to this question in my STS paper during the spring semester.

Conclusion:

Quality healthcare is something that all Americans should be able to access, regardless of where or how they live. Unfortunately, that isn't the case currently. People living in rural communities have higher mortality rates and are unable to receive the same caliber of care that their urban counterparts do. Devices such as the one that my technical project group are working

on could help alleviate this issue by creating a low cost, easily replicable medical asset which could be used at any medical facility, both urban or rural. In addition, by creating a mechanism which replicates a real world medical procedure, the quality of healthcare that patients receive would increase as well. If doctors can practice a maneuver prior to performing it on a live patient, patients will experience a higher success rate.

Overall, my technical project looks to contribute a small amount to what is an overwhelmingly larger issue. However, it has provided invaluable insight into how engineers must take into account the overarching challenges their intended user group might face, and how best to provide a solution.

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