

**Prospectus**

**Human Powered Vehicles**  
(Technical Topic)

**Patient Access to Elective Surgery**  
(STS Topic)

By

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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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## **Technical Topic Introduction**

Human powered vehicles (HPV's) are environmentally friendly and cost-effective alternatives to commuter vehicles. They are defined by the American Society for Mechanical Engineering (ASME) as any bike or trike that is powered solely by muscular strength (Archibald, 2016). These vehicles primarily include semi-recumbent bicycles, upright bicycles and trikes. According to Archibald (2016), human powered vehicles are used for a variety of reasons including, exercise, socializing with friends, sightseeing, commuting to work, minimizing cost, and competition. Assuming average HPV maintenance, gas, and insurance costs, users who live about 7 miles from their daily commute can save more than \$50,000 over the course of 10 years (Archibald, 2016). Additionally, using HPVs to commute provides exercise. HPVs can also benefit the health of the environment, "greenhouse gas emissions are reduced by about two orders of magnitude" when commuters use HPVs (Archibald, 2016). In theory, the use of HPVs in place of traditional transportation methods greatly benefits the rider's well-being and the environment.

A less common factor that influences the use of HPVs is sports. However, use in sports and competition can not only test the design of the vehicle but also assess the strength of the rider, and the mechanical advantage of their HPV as a result of the engineers' design. With improved mechanical advantage, comes an increase in efficiency in other aspects of the HPV use. If you are able to travel in an HPV that optimally performs for the task at hand, greenhouse emissions are minimized and the cost effectiveness of the vehicle are maximized. Overall, creating a HPV of optimal efficiency will maximize the vehicles utility and practicality for everyday use.

## **Technical Capstone Project**

My technical capstone project is to create a human powered vehicle. I am currently on a team of 14 people. As a team, we will work to design and build a recumbent bike that will be used to compete in the ASME Human Powered Vehicle Challenge on April 24-26, 2020, in Perry, Georgia. In order to effectively divide the tasks necessary to complete the project, we have broken the team into sub team that focus on various aspects of the HPV. The categories of work divided into sub teams are, Frame, Fairing, Drivetrain, Steering and Innovation. Each sub team has a leader that reports back to the team lead. Positions of team and sub team leads are reelected every four weeks.

As a team, we decided to base our design on market research, available resources and biomechanical analysis of riders. In order to conduct market research, we created a survey that asks questions to confirm assumptions made in the initial design process. This survey was made publicly accessible through the use of social media. We decided that using a random subject group was best in order to prevent our own subconscious bias in choosing a sample population that would answer the survey in accordance with the assumptions we made about the holistic societal need for our product. Using a select population would hinder our research's ability to represent the entire market. This survey will remain open until our design process is completed. The findings from our market research will be recursively used to adjust our design so that it best meets the needs of the market for HPVs.

Another design constraint is our team's financial budget. The University has allotted us \$2000 for the completion of our project. An additional \$4500 was acquired through various grants making our total budget \$6500. Prior to building the HPV, our team must identify each part or material necessary for construction and then determine what parts or materials are worth

the expense of higher quality based on our design. After prioritizing and defining our budget we will continue to apply for grants and scholarships that will allow us to reach our financial goals.

The current tentative categorized budget is listed below.

<b>Subteam</b>	<b>Cost</b>
Frame	\$390.00
Drivetrain	\$1,112.00
Fairing	\$1,312.90
Steering	\$411.88
Tires & Wheels	\$700.62
Innovation	\$184.54
Safety	\$88.00
<b>Total</b>	<b>\$4,199.94</b>

**Table 1:** Capstone Budget per Subteam (Created by Ross Bonnin, 2019)

To assess the mechanical advantage of a HPV, you must first understand the biomechanical efficiency of the rider. Our team will conduct is biomechanical analysis of riders.

This analysis will rely upon the Biodex in Dr. Shawn Russell's Motor Performance and Motion analysis lab, see Figure 2. A Biodex is a medical device used to isolate and test various muscle groups that causes the movement of the machine's instrumented arm for the purpose of understanding a patient's power output. These muscle groups are theoretically isolated based on the position of the patient's body when acting to move the Biodex's instrumented arm. Patient body positioning can be manipulated using the adjustability of the seat in which they are sitting and the positioning of the instrumented arm. From this data we will determine the optimal rider distance from the pedals, seat angle and rider joint angles for maximum power output of each rider. We will also be able to understand what gear ratios between the front gear ring and the rear cassette will be maximize rider power output potential.



Figure 1. Biodex machine. (Image source: Sarah Glenn, 2012)

Once our design is completed, we purchase supplies necessary and begin construction. Meanwhile, we will continue necessary research required in order to complete the design. A tentative project schedule can be seen below. This project schedule is subject to change depending on delays or setbacks that we may experience.

	Week							
Items	8	9	10	11	12	13	14	15
<b>Biomechanics Research</b>								
<b>Full CAD Design and Manufacturing Plan</b>								
<b>FEA+CFD Testing</b>								
<b>Generate Purchase List and BoM</b>								

**Table 2:** Projected project schedule. (Created by Ross Bonnin, 2019)

With the completion of this project, we believe that we will have constructed a vehicle that is designed to benefit the lives of potential consumers. We will ensure that its production has a small carbon footprint. Additionally, the HPV that we design will be a practical alternative to other short distance commuter vehicles.

## **STS Topic Introduction**

Last summer, I worked in Dr. Shawn Russell's Motion Analysis and Motor Performance Lab at UVA. The mission of Dr. Russell's lab is to use motion capture to evaluate walking gait of patients with motor control issues or recovering from injury. From my work in the lab, I had the opportunity to interact with patients and see, first hand, their progress through recovery. Additionally, I had the opportunity to shadow Dr. Stephan Brockmeier in the UVA Sports Medicine Clinic. This orthopedic clinic sees patients that range widely in age, background and socioeconomic status. Dr. Brockmeier's patients consisted not only of athletes but also men and women who suffer from shoulder and knee ailments. He then advises his patients on whether they are suitable candidates for surgery to correct these ailments based on pain and function limitations to everyday life.

These surgeries are deemed by the healthcare industry as elective surgeries. Elective surgeries are any surgery deemed unnecessary for survival. Even though a patient may be experiencing a great deal of pain, the surgery required to fix their ailment is still considered elective. In reflecting on my exposure to the healthcare system this past summer. It was evident that there are defiant sociological and cultural factors that affect patient access to an elective surgery that could potentially alleviate pain.

## **Human, Social and Technical Implications of Elective Orthopedic Surgery**

I will examine the factors that influence patient care using Latour's Actor Network Theory. This is the idea that, "artifacts can be deliberately designed to both replace human action and constrain and shape the actions of other humans" (Latour, 1992). The theory analyzes

a sociotechnical system by the interactions of actors and artifacts. Actors are the people, organizations and institutions that shape technology. Artifacts are the technology that results in interactions between actors. Artifacts have the ability to perform tasks beyond human control yet barriers to access them can also dictate who is allowed to use the artifacts (Latour, 1992).

The category of actor with sociotechnical system can be further broken down into human and nonhuman actors (Latour, 1992). Human actors are any person that influences the use of technology. This includes any medical professional related to healthcare that gives healthcare technologies action. They influence the use of medical technology and therefore have the power to control the population of its use. Non-human actors are any entity that replaces or restricts technical human action. Within the context of medicine, surgery procedures, medical devices and medications perform tasks that the doctors could not perform on their own and therefore are non-human actors. Non-human actors do not always have to be technical in nature. They can also come in the form of cultural values, political views that constrain the use of a technology. Non-technical actors play an important role in delegating the standards through which technology is used (Latour, 1992).

In a paper written by Kristina Manderbaka and her research team, it was concluded that socioeconomics plays a key role in the accessibility to elective surgery. Manderbaka and her research team examined all public and private records of elective surgeries between the years 1992 and 2003 on patients between the ages of 25 and 84. They then focused on coronary revascularization, primary hip replacement, primary knee replacement, lumbar disk operation, hysterectomy, prostatectomy and cataract surgeries. Each patient was then segmented based on socioeconomic factors such as employment and disposable income. Additionally, surgeries were



standardized by age and categorized by gender. Researchers on this project also hoped to evaluate gender equality in the accessibility to elective surgery. From the analysis, it was concluded that those of higher socioeconomics generally had better access to elective surgery. This paper is vastly important to my understanding of factors that can affect patient accessibility to treatment. Even in a system where there is universal healthcare, other factors associated with socioeconomics can affect accessibility.

Cultural norms also have a significant impact in the access patients have to medical care. According to a study conducted by Shin-Lin Chiu and his research team, cultural beliefs surrounding lunar events in Taiwan affect patient participation in elective orthopedic surgeries. These lunar events include, the Chinese New Year, the Dragon Boat Festival, the Ghost Month and the Moon Festival. The Chinese New Year occurs from the 16th day of the 12th lunar month to the 15th day of the 1st lunar month of the New Year and it is believed that it is bad luck to begin the year with an illness. The Ghost Month occurs during the 7th month and is believed to be a month of misfortune. Therefore, during these months, surgery is deemed an unnecessary risk in accordance with Taiwanese customs (Chiu, 2018). In order to determine this phenomenon, they decided to examine total knee replacement (TKR) and proximal femur fracture (PFF) surgeries between the years 2000 and 2011. It was then further categorized by geographical residence and gender of patients. Chiu and his team hoped to not only see a trend in sociocultural impact on scheduling surgery but also what demographics were most affected by Taiwan's cultural beliefs. Findings from this study confirmed that there was a significant dip in the amount of elective TKR surgeries during the 7th and 12th months, but not in the amount of PFF surgeries. It was also noted by researchers that there was a significant decrease in TKR surgeries for the 1st lunar month for females.

In analyzing these results, it was determined that PFF surgeries are more time sensitive and therefore cannot be delayed without further health concerns. It was also speculated that there was a steeper decrease in female participation of TKR surgery during the Chinese New Year due to their customary responsibility to carry out chores during this time. Social norms in Taiwan actually limit accessibility to the care that women receive. Although there are many factors that affect the scheduling of elective surgery, Chiu and his team proved that it is statistically probable that Taiwanese customs are a strong influence in elective surgery (Chiu, 2018). Cultural factors can dictate patient motivation to seek care. Despite the fact that this was a choice made by the patient, ingrained cultural beliefs are non-technical actors that prevent patients from allowing themselves to receive treatment and alleviate the pain that they experienced. This study shows how the complexity of social interaction can influence a deviation from what scientists and doctors believe to be logical. Culture has the ability to dictate perception of logic when deciding whether or not to use a technology.

### **Research Question and Methods**

The research question that I will focus on will be: What cultural or socioeconomic barriers exist that contribute to a patient's decision to forgo an elective orthopedic surgery that would alleviate chronic pain?

From my experience shadowing Dr. Brockmeier, I observed many instances where patients needed a joint replacement or fusion and were unable to receive the care that they needed. As seen in the research by Manderbaka (2009) and Chiu (2018), socioeconomic and cultural values are two very influential non-human and non-technical actors. They dictate the use

of health insurance and patient motivation for surgery. By further understanding these barriers, I will gain insight into non-human actors influenced by culture and socioeconomics that limit accessibility to elective orthopedic surgery.

In order to answer my research question, I will develop a list of interview questions for both practicing physicians in the UVA sports medicine clinic, and former patients that uncover social and cultural factors that influence care. These interviews will be conducted in person. Interview questions are subject to change based on the direction of the conversation. The interview questions will be primarily qualitative about their care and recovery from their condition but will also include optional questions to indicate socioeconomic status, gender and race. My sample will be subjects that are afflicted arthritis but have received a variety of treatments. In order to do so, I will focus on former patients and current practitioners of a clinic that specializes in treatment or elective surgery to relieve painful conditions that are not time sensitive or life threatening. To find these sample groups for my research, I will conduct interviews with orthopedic clinics affiliated with the UVA Hospital or other teaching hospitals. It is important that I collect data from teaching hospitals because they will be more sympathetic and lenient to the collection of data that could potentially breach doctor-patient confidentiality due to the fact that it is for educational use. It is also important that I chose a sample that is widely diverse so that my findings are more statistically relevant to universally understanding society as a whole.

Once interview data is collected, it will be segmented into patient and practitioner responses. I will then find common themes in these responses that could indicate, social and cultural non-human actors that impacted patient care. After I have analyzed that data that I have collected, I will compare my findings to existing literature on the actor network theory and

elective surgery in hopes that what I have found is accurate and unbiased of my own options of the healthcare system. Below is a chart that describes the timeline I will follow in completing my thesis.

	Month						
Tasks	November	December	January	February	March	April	May
Complete prospectus and get signed	■	■					
Create interview questions and conduct interviews		■	■	■			
Conduct analysis of data				■	■		
Finalize thesis				■	■	■	■

**Table 3.** Research schedule.

### Conclusion

The healthcare system has many barriers that make it difficult for patients to receive care that they need. These barriers are the result of socioeconomic status, and sociological factors that ultimately culminate into an uneven distribution of medical technology and services that effect the system as a whole. From my research, I will understand how patients who experience pain are unable to receive the care they need.

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