REDESIGNING THE MEDICAL EXAM TABLE

EVALUATING PRENATAL CARE FOR PHYSICALLY DISABLED PATIENTS

A Thesis Prospectus
In STS 4500
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The Faculty of the
School of Engineering and Applied Science
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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

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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The medical exam table is a staple of any examination room; it provides a platform for physicians to interact with patients who may be in a variety of different positions during a medical exam. Despite the medical exam table's importance, its design is typically the same at each doctor's office; this stagnancy in its design has subsequently excluded many groups from the medical exam's table functionality. For example, patients who are disabled, elderly, or obese often have difficulty getting onto a medical exam table, due to its height and narrow structure (Maragh-Bass et al., 2018). One specific field of medicine where the medical exam table is a barrier to access is in prenatal care; many obstetricians are uncertain of how to maneuver physically disabled patients onto the table, which is needed for routine checkups during pregnancy (Iezzoni et al., 2015b, Getting onto Examination Tables section). Unfortunately, the medical exam table is just one example of how prenatal care is not adequately tailored towards physically disabled patients. There are several systemic barriers that prevent disabled patients from receiving proper prenatal care, and these barriers must be identified and mitigated to improve the outcomes of prenatal care for physically disabled patients. (Mitra et al., 2017).

The technical project and the tightly coupled sociotechnical thesis proposed in this prospectus aim to address the disparities in healthcare for mobility-limited patients. Specifically, the technical project will consist of the redesign of the medical examination table, in hopes of creating a table that is accessible to physically disabled, elderly, and obese patients, as well as a table that is more lightweight and flexible for physician use. The proposed new table will in turn help physically disabled patients gain increased access to general medical care and prenatal care. Further evaluation of prenatal care practices for women with physical disabilities in the sociotechnical project will also highlight the numerous types of barriers that prevent women with physical disabilities from receiving the same standard of prenatal care that their able-bodied

counterparts receive, and in turn identify potential ways to better meet the needs of these patients. The technical work, in addition to the sociotechnical thesis work, will be accomplished in the Fall 2021 and Spring 2022 semesters for a total of roughly 35 weeks, including winter break, as seen in Figure 1 below.

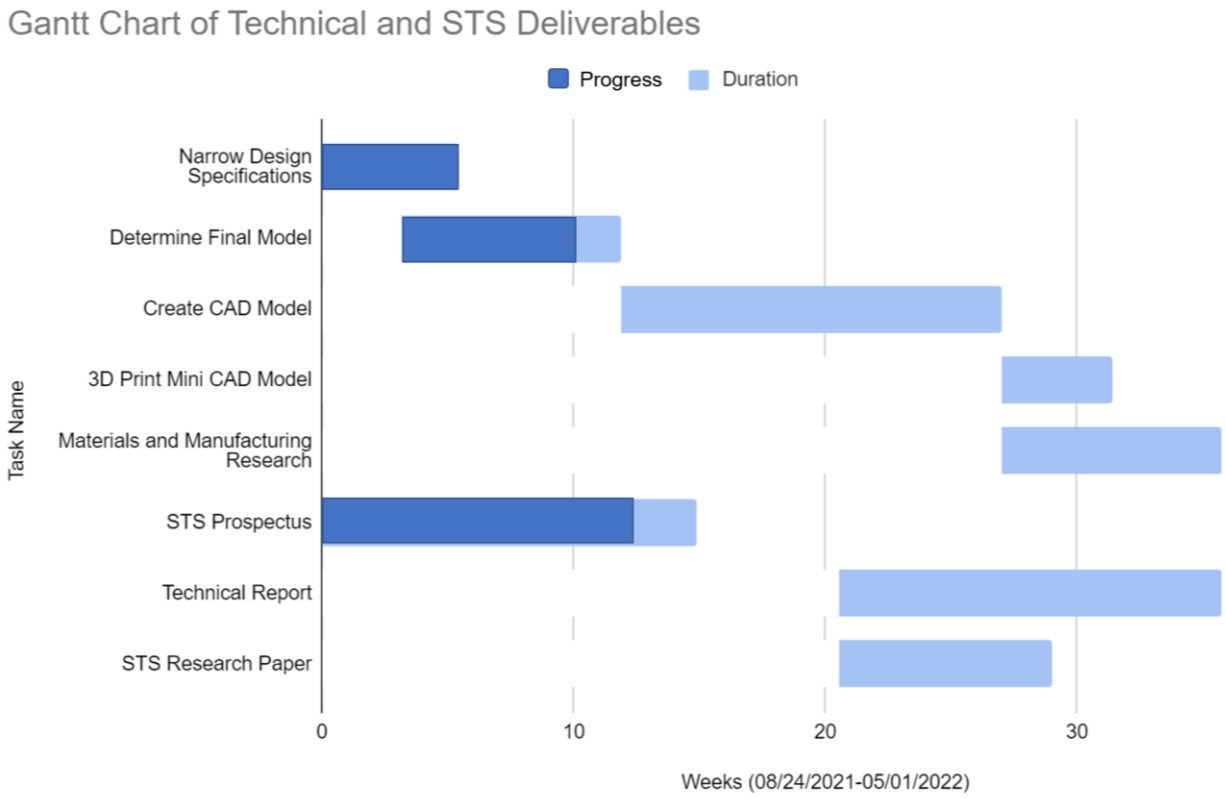

Figure 1: Gantt chart of technical and STS deliverables. This figure visualizes the expected timeline for the major due dates and accomplishments for the technical and STS projects. (Harvey, 2021)

REDESIGNING THE MEDICAL EXAMINATION TABLE

The technical project will be completed amongst undergraduate biomedical engineering students Clara Bosworth, Sarah Cobb, Victoria Harvey, and Lauren Louw, under the guidance of technical advisor Dr. Masahiro Morikawa, M.D., a doctor in family medicine at University of Virgnia Health who has expressed the need for a more accessible medical examination table in

clinical practice. The typical medical exam table stands at height of thirty-two inches, which is over 2.5 feet tall (*Accessible Medical Examination Tables and Chairs | ADA National Network*, n.d.). For most young and able-bodied patients, mounting a table by stepping on the table's retractable step, rotating 180 degrees, and sitting down at the edge of the table is unchallenging. However, for some patients, specifically the elderly and disabled, this act is cumbersome and painful, or simply not possible at all. A 2004 survey titled "A National Survey of Accessibility of Medical Instrumentation" asked disabled Americans about their experiences with fifteen categories of medical equipment, one of which being the medical exam table. The survey found that of the 93% of participants who had used medical examination tables before, 34% found them moderately difficult to use, and 33% found them extremely difficult to use. Additionally, eight percent of participants said that current medical exam tables were impossible to use, given their disability (Story et al., 2004, Results section) . With these complications, many patients may be evaluated while sitting in a wheelchair, which hinders doctor-patient interaction during a medical exam (*Access To Medical Care For Individuals With Mobility Disabilities*, n.d.). Thus, the technical project seeks to reduce accessibility limitations to medical exams through the redesign of the medical exam table, which will in turn improve the standard of care that patients with mobility limitations receive.

Both advice from the technical advisor as well as existing research will be consulted for the technical project's design constraints. Dr. Morikawa has named several features that he would like to see in the redesigned table, such as a light-weight, non-bulky design that allows for the physician to easily reposition and examine the patient as needed, as shown in Figure 2. In addition to these features, Dr. Morikawa hopes to remove the accessibility limitations of the current medical examination table, for which current literature has been consulted. A 2017 study

by Guy Fragala, senior advisor for ergonomics at the Patient Safety Center of Inquiry in Tampa, Florida, explores the benefits of using a height-adjustable medical exam table by recording patient exertion, difficulty, and feelings of safety when mounting both a fixed-height and adjustable height medical exam table. Fragala et al. found that when using a height adjustable medical exam table compared to a fixed height exam table, patient exertion decreased by 72%, difficulty decreased by 64%, and patients felt 42% safer, indicating that it may be desirable to include a motorized adjustable height component in the technical project's redesign of the medical examination table (Fragala et al., 2017, Results section). In addition to height-adjustability, Allysha Maragh-Bass, Adjunct Professor at the Duke Global Health Institute, found through interviews with healthcare professionals that increased wideness of the exam table was a beneficial feature for multiple patient demographics, such as the elderly, obese, gait-impaired, and even pediatric patients (Maragh-Bass et al., 2018, "Theme 1: Ease" section). Thus, both height-adjustability and increased width of the table, alongside other design specifications as designated by Dr. Morikawa and the capstone team, will be key design goals of the technical design project, as shown in Figure 2 below.

Need #	Design Constraint	Unit of Measure	Marginal (Acceptable) Value	Ideal Value
1	Minimum Height	Inches (in)	17-19	18
1	Maximum Height	Inches (in)	31-35	33
2	Range of Motion of Foot and Head Rests	Degrees (º)	90 - 180	90 - 180
3	Bacteria Removed after Sanitization	Percentage (%)	> 95%	> 99%
4	Width	Inches (in)	28-32	30
4	Length	Inches (in)	71-75	73
5	Total weight	Pounds (lbs)	< 250	200
6	Weight limit	Pounds (lbs)	> 350	400
7	Total Cost	Dollars ($)	< $2000	< $1500
8	Aesthetically Pleasing	N/A	N/A	N/A
9	Product Lifespan	Years	8-15	10

Figure 2: Design specifications table. Visual representation of a prioritized list of design specifications for the redesign of the medical examination table. (Harvey, 2021)

After finalizing the design specifications, the team will decide on a final model for the table from which to produce a to-scale, functional computer aided design (CAD) prototype. Finite element analysis will then be conducted on the model to determine how a physical prototype would respond to various forces. As seen in the timeline in Figure 1, preliminary design and research will be conducted for most of the Fall 2021 semester, while CAD design will begin in late 2021 and continue into the Spring 2022 semester. In addition to creating a CAD prototype of the redesigned table, materials and manufacturing research will be conducted during the Spring 2022 semester to determine cost efficient, durable, and sterile materials for a physical

prototype of the table. For example, recent considerations for environmentalism and sterility have indicated that examination table paper may not be functional or necessary; thus, materials research on easily cleanable plastics or cushions to line the examination table will be investigated for a physical model of the table (Waters, 2020). By May 2022, a completed CAD prototype and miniature 3D printed model of the table as well as a thorough material and manufacturing analysis will be complete, all of which will be detailed in a scholarly article for the technical report.

EVALUATING PRENATAL CARE FOR PHYSICALLY DISABLED PATIENTS

Despite the introduction of the Americans with Disabilities Act in 1990, which requires that privately-owned and government-operated healthcare facilities make their services accessible to disabled patients, disabled Americans are still at a disadvantage when it comes to receiving adequate medical care (*An Overview of the Americans With Disabilities Act | ADA National Network*, n.d.). According to a 2013 study conducted by Carrie Henning-Smith, an associate professor of health policy and management at the University of Minnesota, disabled patients are more likely to experience delayed and unmet healthcare needs (40% and 23%, respectively) than non-disabled patients (24% and 10%, respectively) (Henning-Smith et al., 2013, Results section). These disparities may lead to disproportionate health outcomes for disabled patients, as shown in Figure 3 (Maragh-Bass et al., 2018, para. 1).

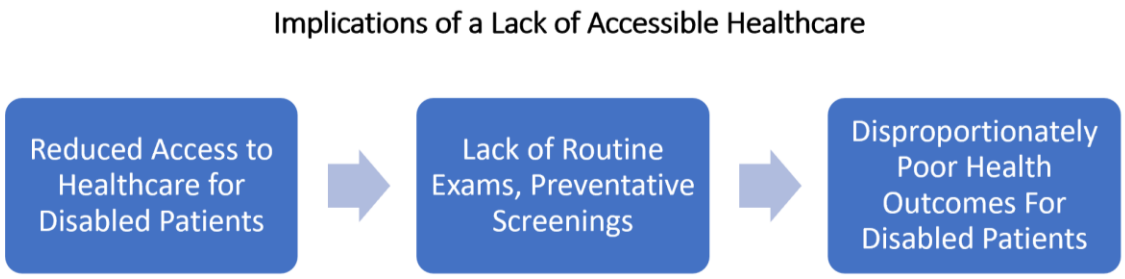

Figure 3: Implications of a lack of accessible healthcare. Disabled patients typically have less access to medical devices and healthcare practices, which can lead to missing routine check-ups and preventative screenings. This, in turn, may lead to disproportionately poor health outcomes for disabled patients. (Harvey, 2021)

Specifically in prenatal care, women with physical disabilities (WWPD) are at a significant disadvantage to nondisabled patients. WWPD regularly face barriers to adequate care at various levels throughout their pregnancy, ranging from an absence of accessible equipment to ill-prepared physicians (Mitra et al., 2017, Results section). A series of interviews with WWPD who had received prenatal care, conducted by renowned disability and healthcare researcher Lisa Iezzeoni, found that physically disabled women did not have standard access to medical examinations or routine weight checks during their pregnancies due to inaccessible exam tables and scales (Iezzoni et al., 2015b, Results section). Additionally, interviews conducted with both obstetricians and WWPD have cited a lack of general scientific knowledge about the reproductive capabilities and needs of pregnant physically disabled women as a barrier to care (Mitra et al., 2017; Smeltzer et al., 2016). Thus, the sociotechnical thesis stands to answer the question: how have these disparities in prenatal care developed, and how can the unique prenatal care needs of physically disabled women be better met?

CURRENT BIASES

In his essay "Confined to Your Legs", disability scholar Gregor Wolbring brings to the reader's attention a dichotomy that exists in modern society: that while disabled and non-disabled people often feel similar levels of satisfaction with their lives, non-disabled people often perceive people with disabilities as experiencing a poorer quality of life (Wolbring, 2003, pp. 144). Wolbring also describes the medical model of disability, which views disability as an inherent medical problem in an individual that results in "a deviation from societal norms and a putative low quality of life for the person and his or her relatives" (Wolbring, 2003, pp. 142). The medical model of disability refuses to accept and accommodate disability. This view, in combination with the wonders of modern medicine, has led to the desire to eradicate all traces of disability from the human race, despite this not being the wish of most people with disabilities.

This degrading view of disability ripples into the perception of pregnancy in physically disabled women, and subsequently prenatal care. If physically disabled women are already living a subpar life, why should their right to be a mother be protected? Furthermore, there is a bias, captured by Iezzoni (2015) in interviews with WWPD, that physically disabled women are unfit to be mothers. These sentiments were reportedly vocalized to various interviewees in public, who received questions about their competency or angry comments regarding their choice to become a mother (Iezzoni et al., 2015a, Questioning Competence section). Thus, a society where physically disabled women are neither valued nor viewed as capable of raising a child has in turn crafted a prenatal care system that is not only unable, but also unwilling, to accommodate the needs of these patients.

In order to further investigate the current state of prenatal care for physically disabled women, an analysis of the medical field and surrounding technologies and institutions will be

conducted using Michel Callon and John Law's Actor Network Theory (Law & Callon, 1988). This analysis, rendered in Figure 4, examines some of the influences that contribute to poor prenatal care for WWPD; as shown in the figure, the network is complex, and most of the actors in the network interact with several others. This interconnectedness indicates a high level of societal influence in prenatal care, which cannot be separated from disability bias. Thus, the sociotechnical thesis will examine where current prenatal care practices fail WWPD through the lens of these biases and identify ways in which prenatal care can be reformed to better accommodate physically disabled patients. This analysis will be described in a scholarly article that may serve as a starting point from which disability rights activists or policy makers can model new strategies for reform, in hopes of creating a prenatal care system where disabled mothers are respected and valued as much as non-disabled mothers.

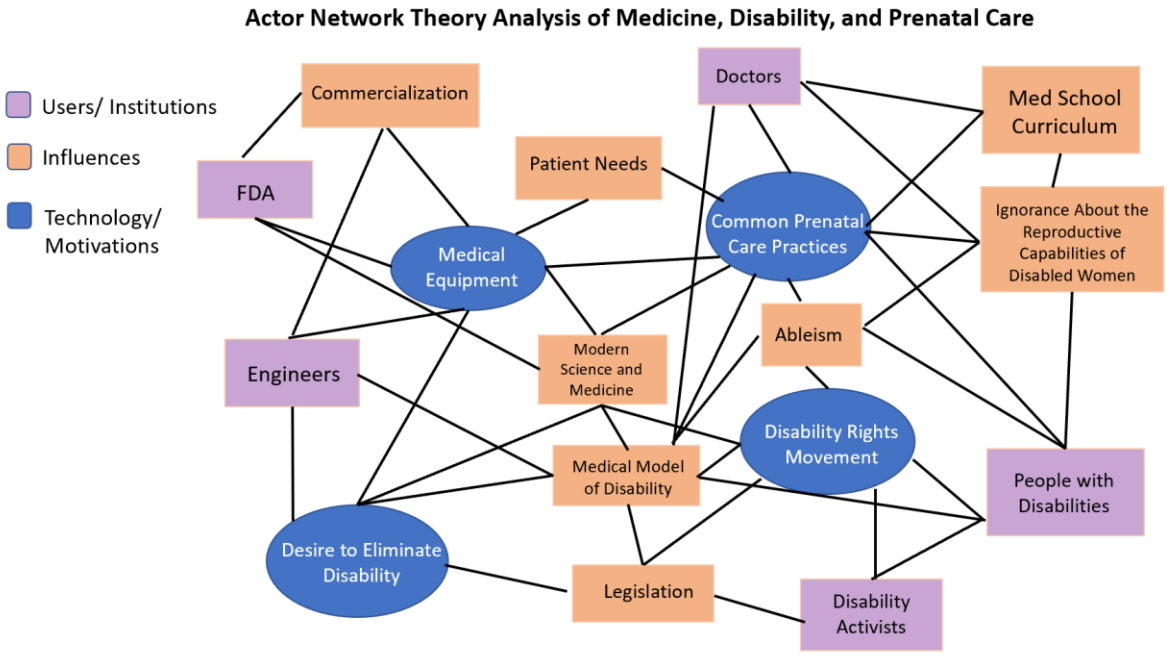

Figure 4: Actor Network Theory analysis of medicine, disability, and prenatal care. This figure visualizes the major users, institutions, influences, technologies, and motivations surrounding medicine and disability. (Adapted by Harvey (2021) from Law and Callon, 1988)

A LIFE WORTH LIVING

Able-bodied individuals have no authority to determine whether or not the life of a disabled person is worth living; yet, the biases of "normal" people continue to govern access to healthcare for disabled patients and subsequently their quality of life. Inaccessible examination tables and scales, and a general lack of knowledge surrounding the needs of those with disabilities are just a few examples of barriers to healthcare experienced by disabled patients. Moreover, this exclusion of disabled patients from medicine is a reflection of the perceived value of these individuals in a predominantly nondisabled society. Unless action is taken to reform healthcare, through both the invention of more accessible medical devices and a medical education system that caters towards patients with disabilities, disabled patients will continue to suffer from these inequities, and in doing so fulfill the prophecy that to be disabled is to be vastly disadvantaged.

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