WRIST FRACTURE REDUCTION SIMULATOR

SOCIAL FACTORS THAT INHIBIT MEDICAL TRAINING DEVICES FROM SUCCESSFUL ADOPTION INTO THE MEDICAL INDUSTRY

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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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Introduction

The distal radial fracture (DRF) is a common wrist injury medical professionals encounter in the emergency room. The first treatment necessary to properly heal a DRF is to perform a reduction, where the doctor manually sets the broken bone into its correct anatomical alignment. Currently, the medical industry lacks a sufficient physical simulator to allow students and residents, medical school graduates undergoing post-graduate training, to practice DRF reduction. Currently, there are limited training simulators that try to emulate manual DRF. Many of these options are hand-made without thorough design consideration. The current simulators available are not standardized or widely accepted in the industry due to factors such as high cost and lack of anatomical accuracy necessary to ensure proper training. In fact, the current standard to practice reduction is to perform on a patient under a professional's supervision. The result is many incoming residents do not feel adequately prepared to properly reset fractured wrists (Olson et al., 2020). The medical industry and those with DRF would benefit from improved educational simulation technology designed with the intent of accurately replicating what a medical professional would physically feel when performing a reduction.

The medical industry will need an affordable and easily producible DRF simulator to fill the gap in education and move the status quo away from training on live patients. To accomplish the goal of improving the education and training for reduction, my team members and I will propose an equitable and accurate design to create a physical simulator for DRF reduction. For a simulator to be effective and widely used in the medical industry for training, it is necessary to consider both technical and social factors such as accessibility, maintenance, cost, and demographics (Freitas, 2023). I will draw on the STS framework of technological politics to investigate how social factors, specifically social biases, can influence the implementation and success of technological medical devices. Learning from the adverse social effects of another medical device and how it affected its impact will ensure we consider both technical and political factors that affect the success of a medical device during the design of our device.

If solely the accuracy of the model is considered and not the social factors, the device would face challenges to becoming widely accepted and equitable, thus not satisfying the goal of providing the medical industry with a viable simulator for DRF reduction. Therefore, its success requires attending to both technical and social aspects. In what follows, I set out two related research proposals: a technical project proposal for developing a DRF reduction simulator and an STS project proposal for examining how technological politics and bias in medical devices can influence the device's success in the medical industry.

Technical Proposal

Currently, medical residents typically practice DRF reduction by performing on live patients (Jackson et al., 2022). This is not the most effective environment to perfect this skill as there are many uncontrollable factors like the behavior of the patient and the stress to perform. Improper reduction can lead to re-displacement, where the bones become unaligned after the reduction, or incorrect healing during splinting (Jackson et al., 2022). This leads to new medical professionals in training feeling inadequately prepared to perform reductions and manage real patients for this type of injury (Olson et al., 2020). The goal of the technical project is to create new technology that will provide a controlled environment for trainees to properly learn the reduction technique.

The most important design parameter of the simulator is that it provides an anatomically and physically realistic training experience that mimics the forces and motions necessary to perform a reduction. Simulation-based training provides a means of risk-free learning in the medical world and will provide the opportunity to become comfortable with the technique before performing on live patients (Bradley, 2006). This will greatly improve the success of reductions and mitigate complications after healing. The design will have mechanical features that can be adjusted or interchanged to alter the physical feeling, such as the force necessary to overcome displacement. This will ensure realistic feeling and enable simulation of various fracture severity and patient demographics. These modular features will be easily reproducible through 3D printing to provide accessibility and low cost, so it is a viable option for medical institutions. DRFs are more common among certain demographics such as older patients (Ikpeze, 2016). The design of our simulator will allow for scaling the size to help account for different demographics and their respective wrist size.

To ensure the simulator is meeting the teams' goals, it will be assessed on the variability of forces to overcome the initial displacement, accessibility, time to change configuration, percentage of demographics modeled, and anatomical accuracy. The force to overcome the initial displacement will be created by an elastic band with adjustable tension. Data will be collected on the minimum and maximum forces that can be selected to determine the range. To measure accessibility, data on the time it takes to change mechanical components and acquire new parts will be measured. The percentage of the population's hands modeled by the different sizes will be calculated. The simulator will also be compared to correct anatomical structure and feedback from professionals on the accuracy of motion will be collected. These different sets of data will validate the accuracy and viability of the simulator. With an emphasis on equity, affordability, adaptability, and accuracy this distal radial fracture simulator will provide the medical industry with a standard training model to enhance education and proficiency in radial fracture reduction.

STS Project Proposal

We are in a technological age, and in the past decades, there has been a massive increase in the usage of simulation-based training (SBT) for medical professionals (Ryall et al., 2016). SBT has been a concept since the 1960s, but with the advancement of technology, we now have more tools to realistically model medical procedures. This advancement in medical education allows healthcare professionals to improve their skills in a controlled environment without risking patients' safety (Elendu et.al, 2024). However, throughout the history of technological medical devices, it is apparent that the effectiveness of a device is not solely technological. Devices can have social biases that can lead to designs that undermine efficacy among different groups of patients.

An example of bias in the implementation of medical devices can be seen in the spirometer. A spirometer is "the most common lung function test and represents the cornerstone diagnostic and management tool for individuals with chronic respiratory disease" (Braun, 2015). The device is widely used in medical institutions to measure the maximum volume of air an individual can inhale and exhale relative to time. The results from this test help medical professionals diagnose lung conditions such as asthma or chronic obstructive pulmonary disease (COPD). While spirometers are a useful tool for medical professionals, the standards associated with the calibration of spirometers contain social bias that provides less accurate results for certain demographics. For decades, spirometers have been calibrated using a standardized model in the medical industry that adjusts the results based on race. The history of this standardization is rooted back to times of slavery, when prominent figures like Thomas Jefferson asserted that White people and Black people had different pulmonary structures (Braun, 2015). This speculation transferred to the medical world and continued to affect practices.

The calibrations adjust the normal lung function values differently for people of color. “In the United States (US), spirometers use either correction factors of 10% to 15% for individuals labelled ‘black’ and 4% to 6% for people labelled ‘Asian’”, which can alter results and lead medical professionals to underdiagnose or overlook respiratory conditions for these patients (Braun, 2015). Another study found that testing a 65-year-old man’s ability to exhale volume in one second had a “result of 70% (i.e., moderate lung disease) using a White race correction as opposed to a result of 82% (i.e., normal lung function) using a Black race correction” (Reddick, 2023). The biased technique is still in literature, as most articles on the subject, 83.6%, “reported that "other racial and ethnic groups" have a lower lung capacity compared to "white"; 94% of articles failed to examine socioeconomic status (Braun et al., 2013). The explicit bias during the implementation of the spirometer created inequitable calibration methods, which compromised medical care for people of color by providing inaccurate results, inadequate treatment, and missed diagnoses. This case offers insight into how political power can alter the effectiveness of technology and marginalize certain groups. Therefore, I argue the spirometer performs both technical and political work, where the ladder privileges some and diminishes the medical care for people of color.

To frame my analysis of the bias associated with the spirometer, I will draw on Langdon Winner’s Technological Politics, which explores how technology is inherently political. Winner argues that technological designs can be shaped, either intentionally through explicit bias or unintentionally, by power structures in society. He disagrees with technological determinism and argues that technology impacts and is impacted by the political context it exists in. Therefore, the design and implementation of technologies can have political consequences, often serving to concentrate power and adversely affecting certain groups of people (Winner, 1986). To support my argument, I will analyze evidence from online medical journals that provide information on the disparity created in lung disease diagnoses for people of color.

Conclusion

The current standard for practicing DRF reduction in the medical industry is training on live patients or utilizing low-quality training models. There is no current simulator that is easily accessible, accurate, and thoroughly designed to accomplish the goal of emulating the physical feel of reduction. The current gap for reduction SBT could be improved through a technical project to develop an advanced simulator that accurately models the feeling of performing a DRF reduction. This project will deliver a hands-on simulation tool to foster an educational environment that enhances medical professionals' proficiency and skills in treating DRF.

The technical aspects of the simulator are not the only factors contributing to the success of a medical device. The STS research project will provide an analysis of social factors that influence medical device integration into medical institutions. The history of the spirometer and the standards that were placed in conjunction with this technology supports the idea that the device is also impacted by political factors and success is not only dependent on technical factors. Excluding demographics from design and calibration considerations led to biases in diagnostics for Black and Asian patients. This contributed to misdiagnoses and delayed treatment for these demographics, even though the spirometer was a sound technical medical device. By learning from the technological politics of this case, we aim to design our simulator with demographic inclusivity at the forefront of design. Our simulator intends to not only fill a gap in current technology for DRF reduction simulation but to also consider different demographics of patients to ensure that the technology is equitable and impactful as an educational tool.

Word Count: 1820

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