Thesis Project Portfolio

Redesigning the Incentive Spirometer through Gamification

(Technical Report)

How Race-Adjustments in the Spirometer Worsens Health Disparities

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis

Pulmonary medicine is a specialized area of internal medicine that specifically focuses on the diagnoses, management, and treatment of certain disorders and diseases regarding the respiratory system. My technical and STS projects look at certain pulmonary medical devices in different ways but have the overall goal of improving pulmonary medicine care for all patients.

My technical project is about redesigning the incentive spirometer (IS) with a gamified component to increase patient adherence. For my STS topic, I will discuss the racial bias embedded within pulmonary testing, specifically the spirometer. While the incentive spirometer is a breathing tool to exercise the lungs and the spirometer is a diagnostic tool for diagnosing certain chronic pulmonary illnesses like chronic obstructive pulmonary disease (COPD) and chronic asthma, both projects look at improving pulmonary medical devices for the better.

It has been proven that the IS improves lung function by improving diaphragm movement and by increasing muscle in the upper chest. Yet, over one-third of patients do not use their given IS during their postoperative care (Martin et al., 2018). To address this issue, my technical project involves redesigning the IS by creating a gamified modification to the existing device to create a more engaging version of the IS. The redesigned IS will perform the same functions as a traditional IS, but will additionally have enticing, fun elements to drive an increase in patient adherence. By redesigning the IS, we hope to increase adherence rate by 50% and make our design more engaging by 1) creating a functional IS capable of measuring volume of air inhaled and flow rate, 2) including a gamified element that appeals to adults and is easy to manufacture, and 3) gathering patient and provider feedback. Increasing adherence of the IS is a significant part of our goal because we want to prevent postoperative pulmonary complications like atelectasis, hypoxemia, and pneumonia. Pulmonary rehabilitation, especially with use of the IS, is vital in preventing these

complications, but it also lowers mortality rate, shortens hospital stays, and prevents hospital readmissions.

In my STS research paper, I will argue that race-based adjustment in medical devices, which serve as pulmonary diagnostic tools, (like the spirometer) has helped perpetuate bias in the medical system due to the long-standing history that insinuates lung performance differs by race, the over-reliance of this adjustment leading to misdiagnosis for patients of color, and the ignorance of risk factors that can increase risk of chronic pulmonary diseases. The literature review will provide examples of how certain designs of medical devices show racial bias, background information on common pulmonary diseases diagnosed with a spirometer, and the several types of pulmonary diagnostic tools used in the medical system. Additionally, the literature review will include background information about the spirometer and why race-based adjustments were added into this device in the past. Data was gathered through several journal articles and books with historical analysis to answer the research question. Configuring the User was the STS framework used to examine why the race-based adjustments are in spirometers. Through my analysis, I will find how these adjustments started, how it affects patient care, and why it is not the best factor to use in measuring lung function. From these analyses, I will find that race-based adjustments are doing more harm than good and are not necessary in helping diagnose patients with chronic pulmonary diseases. In my conclusion, I discuss what the necessary next steps are for the hospitals, biotechnology companies, and health providers, so that health disparities among races, due to race-based adjustments, are recognized and reduced.

There was a benefit in doing both the technical and STS projects at the same time as they were both relevant to pulmonary medicine and medical devices. As a result, when doing research for both topics, I found a lot of overlap in terms of the definition of lung function. For example, I

found there to be certain parameters and measures relevant for both the IS and the spirometer which further connected my two projects together. Specifically, the volume of air inhaled by the patient was tell-tale sign of lung function whether it meant that their lung function was improving or in decline.

Additionally, working on both projects allowed me to experience the realistic expectations of working in a group and going through the engineering design process, but to also consider the social aspects and consequences of certain engineering designs. My STS project on racial health disparities provided insight on current medical device designs which is relevant to my technical project where I redesign a pulmonary device.

Works Cited

Martin, T. J., Patel, S. A., Tran, M., Eltorai, A. S., Daniels, A. H., & Eltorai, A. E. M. (2018). Patient Factors Associated with Successful Incentive Spirometry. *Rhode Island Medical Journal (2013)*, *101*(9), 14–18.