

Designing a Reusable Scrub Cap to Meet Clinical Needs in a Sterile Environment
(Technical Paper)

**A Proposed Paradigm Shift in the Relationship Between Climate Change and Healthcare in
the United States**
(STS Paper)

A Thesis Prospectus Submitted to the
Faculty of the School of Engineering and Applied Sciences
University of Virginia • Charlottesville, Virginia
In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Robert “Bobby” Pazhwak
Fall 2019

Technical Project Team Members:
Rebecca Byrd

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.

Signature _____ Date _____
Robert Pazhwak

Approved _____ Date _____
Nishaki Mehta, Department of Biomedical Engineering

Approved _____ Date _____
Thomas Seabrook, Department of Science and Technology

Introduction

Climate change is the greatest threat to global health in the 21st century. From temperature extremes, degraded air quality, increases in vector-borne illnesses and malnutrition, climate change is poised to have an enormous impact on human health around the globe (“AR5 Climate Change 2013: The Physical Science Basis—IPCC,” 2013; “COP24 Special report,” 2018). Despite this, climate change is still largely portrayed in American media as an ecological issue, and healthcare providers’ perception of the intersection of health and climate change has not been well studied (Sheffield, Durante, Rahona, & Zarcadoolas, 2014). Furthermore, according to the World Health Organization, healthcare activities account for 8% of the United State’s national greenhouse gas emissions, compared to the 5.5% average across members of the Organisation for Economic Co-operation and Development (OECD) (Pichler, Jaccard, Weisz, & Weisz, 2019; “WHO | Climate impacts,” n.d.). These figures indicate a disconnect between American healthcare and efforts to reduce greenhouse gas emissions.

In order to bridge this gap, new technologies are needed to help the healthcare industry reduce their carbon footprint. Additionally, healthcare providers in the United States must support and encourage sustainable lifestyles and adopt common sense practices to make their own work more sustainable. Thus, I aim to design and build a reusable scrub cap to be used in surgical operating rooms and other sterile spaces. The new scrub cap will address many of the design flaws of the current disposable scrub caps used in many hospitals, and help hospitals reduce their waste. In addition, I will propose a paradigm shift in the relationship between healthcare and climate change within the United States. Considering the enormous health implications of climate change, I aim to assert that healthcare professionals have an ethical obligation to support sustainable lifestyles, and make their own practices more environmentally

friendly. The union of healthcare and sustainable practices has the potential to greatly improve public health around the globe and fundamentally shift healthcare practices towards greater environmental sustainability.

Technical Topic

The disconnect between healthcare and climate change is evident in the amount of waste produced by the healthcare industry. Healthcare is the second leading contributor to waste in the United States, producing more than 40 billion pounds of waste annually (Kwakye, Brat, & Makary, 2011). This waste is not only a problem environmentally, polluting bodies of water and contributing to greenhouse house emissions, but also economically, costing an average of \$790 per ton (Windfeld & Brooks, 2015). Operating rooms are particularly wasteful, producing around 70% of all hospital waste along with labor-delivery suites (Albert & Rothkopf, 2015). Accordingly, operating rooms should be a major focus for hospitals looking to reduce their waste and become more environmentally friendly.

Both the American College of Surgeons (ACS) and the Association of Perioperative Registered Nurses (AORN) guidelines suggest that all personnel in the operating room wear head coverings in order to reduce the risk of surgical site infections (SSIs) (Elmously et al., 2019; “Statement on Operating Room Attire,” 2016). In addition, ACS and AORN guidelines mandate that all personnel wear freshly laundered scrubs. Currently, a large number of hospitals provide single-use disposable surgical caps for personnel to use in the operating room (Price, Frey, Junge, & Technologists, 2004). This contrasts with scrubs, which hospitals generally reuse and launder (“Association of Surgical Technologists Guidelines for Best Practices for Laundering Scrub Attire,” 2017; Vera, Umadhay, & Fisher, 2016). These caps are thrown away

directly after a procedure, contributing to the waste produced in the operating room. In addition, preliminary interviews with doctors in the UVA Health System indicated that many doctors, especially with longer hair, report having trouble containing all their hair in traditional scrub caps. This decreases physician comfort and potentially exposes patients to microbial contamination that can cause SSIs (Dineen & Drusin, 1973; Mastro et al., 1990). Furthermore, many doctors have trouble identifying people within an operating room setting due to the uniformity of disposable caps (Gatollari, 2019; Stone, 2019). No current commercially available scrub caps address the issues of reusability, hair contamination prevention, and identification while also maintaining sterility and user comfort (“Blue Sky Scrubs | Explore Our Patented Pony Scrub Hat Collection | Luxury Scrub Caps,” n.d.; “Disposable Medical Supplies,” 2019; “Let’s Talk About Disposable Scrub Caps,” 2018; “Surgical Caps, Single-Use & Reusable | Praxisdienst,” n.d.; Designs, n.d.; Markel et al., 2017). As a result, the goal of this project is to investigate the problems associated with disposable scrub caps and design a reusable alternative that addresses the identified design flaws.

In order to investigate issues with the current disposable scrub cap design and identify further areas of innovation, we will interview at least 20 healthcare professionals within the University of Virginia (UVA) Health System about their scrub cap use. Professionals outside of the medical field, such as in food services, will also be interviewed, to assess how hair contamination is managed in their field. We then hope to use the data collected from interviews to make preliminary designs featuring novel characteristics. Once the major design flaws and opportunities are identified, we aim to fabricate a working prototype that can be tested in volunteer clinical trials. We will then iterate upon the prototyped scrub cap design using feedback and adenosine triphosphate (ATP) cleaning identification data from the clinical trials.

The project team will consist of two undergraduate biomedical engineering team members, Bobby Pazhwak and Rebecca Byrd, who will work alongside Dr. Nishaki Mehta, MD, and Katerina Morganeko at the University of Virginia (UVA) Health System. This project will also be supported by Dr. Timothy Allen, an associate professor in the UVA Biomedical Engineering Department. Laboratory space and equipment within UVA will be used to fabricate and test the prototyped scrub cap.

Successful implementation of this technology will aid in doctor identification in critical situations, prevent hair contamination sourced SSIs in sterile settings, and reduce the amount of waste produced by hospitals using disposable caps. Furthermore, it will provide greater comfort and flexibility to healthcare provider's with longer hair. For example, preliminary design features include characteristics such as a launderable polyester material, an expandable pouch to account for longer hair, and a mechanism in the front to hold an identification card. Thus, this project has many potential benefits, from increased patient safety to more environmental sustainability, and will add important data to the sparse medical literature surrounding scrub cap use in hospitals.

STS Topic

In his 1962 book, *The Structure of Scientific Revolutions*, Thomas Kuhn popularized the idea of a “paradigm” (Finn, 1995). According to Kuhn, paradigms serve as a framework through which scientific disciplines can base research and draw relationships between data and theory. The dominant paradigm in a field may undergo a “shift” when new evidence is presented that goes against the prevailing paradigm or a new paradigm is better able to explain existing phenomena (Vinet, 2018, p.). These paradigm shifts are impactful, as they influence the lens

through which scientists and society view new discoveries and classify information (Lane & Lane, 1981).

Medicine has undergone many paradigm shifts throughout history (Heikkinen, 2000). For example, for much of the 20th century, medicine had a “hospital-based pathogenic biomedical paradigm” that viewed health as the absence of disease and considered healthcare professionals as “biological engineers” who understood the intricacies of the human body and were capable of using scientific treatment to treat individuals in a hospital setting. This paradigm was effective in diagnosing and treating many life-threatening diseases, and greatly advanced patient care (DeAngulo & Losada, 2015). However, this paradigm also caused many healthcare professionals to ignore the lifestyle, social, and emotional dimensions that contribute to pathological symptoms and disease manifestation (DeAngulo & Losada, 2015; Wade & Halligan, 2004). As a result, healthcare professionals failed to treat many diseases, particularly mental illness, that did not have obvious biologic indicators (Holtzman, 2012). This void in psycho-social health treatment resulted in a paradigm shift at the end of the 20th century, where the focus of medicine shifted from the origin of disease to the origin of health, prompting doctors to investigate and recognize the importance of society, community, and emotions on a patient’s overall health (DeAngulo & Losada, 2015; Heikkinen, 2000). This paradigm shift allowed healthcare professionals to better treat and diagnose patients with a number of diseases, improving the overall quality of public health.

Recently, many studies have revealed climate change to be an enormous threat to human health with potentially disastrous effects across the globe (“AR5 Climate Change 2013: The Physical Science Basis—IPCC,” 2013, p. 5; “COP24 Special report,” 2018). The United States is not exempt from the risks of climate change, as according to the National Climate Assessment,

many populations in the United States will also be at risk in a changing climate (“Human Health | National Climate Assessment,” n.d.). This evidence demonstrates a clear need for healthcare professionals in the United States to consider climate change when evaluating their practices.

However, for healthcare to adapt their practices to address the public health dangers of climate change, healthcare providers must first include climate change within their public health paradigm. Very little research has been conducted in the United States to explore healthcare professionals’ view of climate change (Sheffield et al., 2014). Additionally, although numerous studies have explored the benefits of healthcare embracing sustainability, there is little evidence to suggest that the healthcare industry have adapted their practices, and healthcare greenhouse gases emission rates have continued to increase (Bottero et al., 2015; Eckelman & Sherman, 2016; “Environmental Sustainability in Hospitals,” 2014; Frumkin, Hess, Lubet, Malilay, & McGeehin, 2008; Kwakye et al., 2011). The lack of climate consideration in the medical industry is perhaps most obvious when examining medical school curricula, as the majority of physicians receive no education surrounding climate change (Wellbery et al., 2018). This absence of climate change in the current medical paradigm is dangerous, as a lack of climate awareness amongst healthcare professionals puts Americans at an elevated risk of suffering from climate-related illness and will prevent the healthcare industry from adequately responding to emerging climate threats (Frumkin et al., 2008).

Consequently, for my STS Topic, I hope to propose evidence that a paradigm shift is necessary in the healthcare industry to make combating climate change a paramount public health issue. Furthermore, I aim to explore the importance of adopting this paradigm in terms of societal costs and healthcare providers’ ethical obligation to help their patients. I will do this by first analyzing how the medical paradigm has evolved in the past to combat emerging public

health threats. I will then explore the current and historic relationship between climate and medicine within the medical paradigm, and present evidence for climate change's effect on health. This will allow me to make an argument for a paradigm shift. Thomas Kuhn's analysis of how paradigms change in *The Structure of Scientific Revolutions* will serve as the basis through which I argue for a paradigm shift. A focus on the societal and ethical benefits of adopting this paradigm will be emphasized. Lastly, I will introduce commonplace changes that healthcare providers may adopt to combat climate change.

As mentioned, a paradigm shift in the medical field towards addressing climate change as a public health has the potential to save many lives in the United States. Additionally, the proposed paradigm shift could significantly change how healthcare professionals operate in their roles on a daily basis. This could help reduce the enormous amount of waste and greenhouse gas emissions produced by the healthcare industry as a whole, slowing the rate of climate change. The proposed paradigm shift could also significantly impact how climate change is communicated to the public, and the practices and lifestyles recommended by healthcare professionals to patients. This has many potential cascading effects, and could significantly impact the public perception of climate change and help create the momentum needed to make substantive climate policy. Lastly, regardless of the paradigm shift, this study will also fill an important void in medical literature, as there is currently a lack of information surrounding healthcare practitioners' view of climate change (Sheffield et al., 2014).

Research Question and Methods

The overarching research question guiding my STS topic is: how can the healthcare industry best be convinced to adapt their view of public health to better incorporate climate

change and adopt more sustainable practices? However, this question is broad and multifaceted. Accordingly, to address my STS research question, I have subdivided the research question stated above into multiple manageable questions that align with the proposed structure of the STS research paper.

The first research question which I hope to answer is: how has the medical paradigm shifted historically in the United States? In order to answer this question, historical case studies on medical paradigms will be analyzed and reviewed. This will help provide a basis for how medical paradigms have shifted in the past, allowing similar arguments to be made for my proposed shift. In addition, reviewing historic case studies of paradigm shifts will allow me to outline the stakeholders needed to enact such a paradigm shift.

The second research question is: what is the current relationship between climate change and healthcare? This question must be answered in order to make the argument that climate change needs to be incorporated into the medical paradigm. A variety of methods will be used to evaluate this research question including, documentary research, interviews, and surveys. Documentary research, in the form of literature reviews, will be used to explore existing research on healthcare professionals' view on climate change. Furthermore, documentary research from sources such as the International Panel on Climate Change (IPCC) and the National Climate Assessment (NCA) will be used to gather the evidence necessary to show that climate change will pose an imminent public health threat. Due to the lack of published literature surrounding healthcare providers' views on climate change, I plan to also conduct interviews and surveys within the UVA Health System to gather data surrounding healthcare providers' view of climate change. The survey will be used to collect quantitative data such as the percentage of healthcare professionals who believe in climate change, the percentage of professionals who see climate

change as a pertinent issue in their field, and the percentage of professionals who actively promote sustainable practices in their work. The interview, on the other hand, will be used to gather qualitative data about healthcare professionals' views on climate change in order to get a more in depth understanding of the relationship between the two. I aim to gather at least 50 survey results and conduct at least 10 interviews. This data will be important when making an argument for a paradigm shift, as I cannot properly propose a shift without first evaluating medical professionals' perspective of climate change in the current medical paradigm. Thus, a combination of documentary research, interviews, and surveys are necessary to properly address this question.

The final research question which I hope to answer in order to address my overarching question is: what commonplace practices can healthcare providers adopt in order to be more sustainable without degrading patient care? This research question is critical, as without examples of methods that the healthcare industry cannot employ to meet this paradigm shift, the shift above research will not be actionable. Thus, I will perform documentary research in the form of literature reviews to compile common practices that have been studied to be effective. This research will also help me relate the technical portion of my project to my STS research.

I aim to have analyzed the historical case studies for the first research question by December 2019. I then hope to complete all documentary research, interviews, and surveys needed to answer the second research question in January and February 2020. I will then use March 2020 to perform the documentary research needed to answer the final question. In April 2020, I will synthesize the research, and present my written report by May 2020.

Conclusion

The design of a new scrub cap has the potential to improve patient care, physician comfort, and waste reduction in a sterile clinical setting. This technology will serve to improve hospital efficiency and care while simultaneously reducing the environmental impact of healthcare facilities. The anticipated outcome of the technical research is to identify design flaws and opportunities with current disposable scrub caps, fabricate a working prototype for a design that addresses the identified concerns, and conduct preliminary clinical trials with the reusable scrub cap design.

Furthermore, a paradigm shift in the way healthcare addresses climate change could mark a fundamental shift in public health and the fight against climate change. The union of healthcare and climate change could help the United States save a countless number of citizens from the adverse effects of climate change and significantly reduce the nation's greenhouse gas emissions. Moreover, regardless of the acceptance of the paradigm shift, this research paper also aims to help fill a critical void in current literature describing healthcare professionals' view of climate change. In addition, it hopes to present commonplace methods and practices through which healthcare professionals may encourage sustainability, both in the lives of their patients and in their own work. Thus, together with the technical topic which will help hospitals reduce their single-use waste, the proposed research has the potential to have a significant influence on the ecological impact of the healthcare industry and the environmental sustainability of the entire healthcare industry.

References

- Albert, M. G., & Rothkopf, D. M. (2015). Operating room waste reduction in plastic and hand surgery. *Plastic Surgery*, 23(4), 235–238.
- AR5 Climate Change 2013: The Physical Science Basis—IPCC. (2013). Retrieved January 11, 2019, from <https://www.ipcc.ch/report/ar5/wg1/>
- Association of Surgical Technologists Guidelines for Best Practices for Laundering Scrub Attire. (2017, April 14). Retrieved October 1, 2019, from https://www.ast.org/uploadedFiles/Main_Site/Content/About_Us/Standard%20Laundering%20Scrub%20Attire.pdf
- Blue Sky Scrubs | Explore Our Patented Pony Scrub Hat Collection | Luxury Scrub Caps. (n.d.). Retrieved October 24, 2019, from <https://www.blueskyscrubs.com/surgical-caps/pony-scrub-hat/>
- Bottero, M. C., Buffoli, M., Capolongo, S., Cavagliato, E., di Noia, M., Gola, M., ... Volpatti, L. (2015). A Multidisciplinary Sustainability Evaluation System for Operative and In-Design Hospitals. In S. Capolongo, M. C. Bottero, M. Buffoli, & E. Lettieri (Eds.), *Improving Sustainability During Hospital Design and Operation: A Multidisciplinary Evaluation Tool* (pp. 31–114). https://doi.org/10.1007/978-3-319-14036-0_4
- COP24 Special report: Health & Climate Change. (2018, April 1). Retrieved November 1, 2019, from <https://www.who.int/publications-detail/cop24-special-report-health-climate-change>
- DeAngulo, J., & Losada, L. (2015, May). Health Paradigm Shifts in the 20th Century. Retrieved October 16, 2019, from https://www.researchgate.net/publication/279278351_Health_Paradigm_Shifts_in_the_20th_Century

- Designs, H. S. (n.d.). Harmony Scrub Hats: Scrub Caps for Women. Retrieved October 24, 2019, from Harmony Surgical Designs website: <https://www.harmonysurgicaldesigns.com/>
- Dineen, P., & Drusin, L. (1973). EPIDEMICS OF POSTOPERATIVE WOUND INFECTIONS ASSOCIATED WITH HAIR CARRIERS. *The Lancet*, *302*(7839), 1157–1159. [https://doi.org/10.1016/S0140-6736\(73\)92933-4](https://doi.org/10.1016/S0140-6736(73)92933-4)
- Disposable Medical Supplies: United States. (2019, January). Retrieved October 23, 2019, from The Freedomia Group website: <https://www.freedomiagroup.com/freedomia-focus/disposable-medical-supplies-united-states-FF40019.htm>
- Eckelman, M. J., & Sherman, J. (2016). Environmental Impacts of the U.S. Health Care System and Effects on Public Health. *PLOS ONE*, *11*(6), e0157014. <https://doi.org/10.1371/journal.pone.0157014>
- Elmously, A., Gray, K. D., Michelassi, F., Afaneh, C., Kluger, M. D., Salemi, A., ... Pomp, A. (2019). Operating Room Attire Policy and Healthcare Cost: Favoring Evidence over Action for Prevention of Surgical Site Infections. *Journal of the American College of Surgeons*, *228*(1), 98–106. <https://doi.org/10.1016/j.jamcollsurg.2018.06.010>
- Environmental Sustainability in Hospitals: The Value of Efficiency | AHA. (2014, May). Retrieved October 30, 2019, from American Hospital Association website: <https://www.aha.org/ahahret-guides/2014-05-28-environmental-sustainability-hospitals-value-efficiency>
- Finn, A. (1995). Paradigms & Paradigm Shifts. Retrieved October 16, 2019, from http://mason.gmu.edu/~afinn/html/teaching/courses/UMD_comm470/readings/ar1-paradigms.htm
- Frumkin, H., Hess, J., Luber, G., Malilay, J., & McGeehin, M. (2008). Climate Change: The

- Public Health Response. *American Journal of Public Health*, 98(3), 435–445.
<https://doi.org/10.2105/AJPH.2007.119362>
- Gatollari, M. (2019). Doctors Are Saving Lives by Writing Their Names on Their Scrub Caps. Retrieved October 23, 2019, from Distractify website:
<https://www.distractify.com/trending/2019/01/28/u6L9ZRJNq/doctor-sharpie-scrub-caps>
- Heikkinen, E. (2000). A paradigm shift: From disease to health orientation. *The Aging Male: The Official Journal of the International Society for the Study of the Aging Male*, 3(4), 171–176. <https://doi.org/10.1080/13685530008500345>
- Holtzman, E. (2012, March). A home way from home. Retrieved October 16, 2019, from <https://www.apa.org> website: <https://www.apa.org/monitor/2012/03/asylums>
- Human Health | National Climate Assessment. (n.d.). Retrieved January 12, 2019, from <https://nca2014.globalchange.gov/report/sectors/human-health#image-tab1>
- Kwakye, G., Brat, G. A., & Makary, M. A. (2011). Green Surgical Practices for Health Care. *Archives of Surgery*, 146(2), 131–136. <https://doi.org/10.1001/archsurg.2010.343>
- Lane, N. R., & Lane, S. A. (1981). Paradigms and perception. *Studies in History and Philosophy of Science Part A*, 12(1), 47–60. [https://doi.org/10.1016/0039-3681\(81\)90004-2](https://doi.org/10.1016/0039-3681(81)90004-2)
- Let's Talk About Disposable Scrub Caps. (2018). Retrieved October 23, 2019, from Blue Sky Scrubs website: <https://www.blueskyscrubs.com/blog/lets-talk-about-disposable-scrub-caps/>
- Markel, T. A., Gormley, T., Greeley, D., Ostojic, J., Wise, A., Rajala, J., ... Wagner, J. (2017). Hats Off: A Study of Different Operating Room Headgear Assessed by Environmental Quality Indicators. *Journal of the American College of Surgeons*, 225(5), 573–581.
<https://doi.org/10.1016/j.jamcollsurg.2017.08.014>

- Mastro, T. D., Farley, T. A., Elliott, J. A., Facklam, R. R., Perks, J. R., Hadler, J. L., ... Spika, J. S. (1990). An Outbreak of Surgical-Wound Infections Due to Group A Streptococcus Carried on the Scalp. *New England Journal of Medicine*, 323(14), 968–972.
<https://doi.org/10.1056/NEJM199010043231406>
- Pichler, P.-P., Jaccard, I. S., Weisz, U., & Weisz, H. (2019). International comparison of health care carbon footprints. *Environmental Research Letters*, 14(6), 064004.
<https://doi.org/10.1088/1748-9326/ab19e1>
- Price, P., Frey, K. B., Junge, T. L., & Technologists, A. of S. (2004). *Surgical Technology for the Surgical Technologist: A Positive Care Approach*. Taylor & Francis.
- Sheffield, P. E., Durante, K. T., Rahona, E., & Zarcadoolas, C. (2014). Emerging Roles of Health Care Providers to Mitigate Climate Change Impacts: A Perspective from East Harlem, New York. *Health and Human Rights*, 16(1), 113–121.
- Statement on Operating Room Attire. (2016, August 4). Retrieved September 30, 2019, from American College of Surgeons website: <https://www.facs.org/about-ac/s/statements/87-surgical-attire>
- Stone, C. (2019, March 8). Doctor's Simple Idea To Write Names And Titles On Scrub Caps Can Save Lives. Retrieved October 23, 2019, from <https://www.scarymommy.com/theatre-cap-challenge/>
- Surgical Caps, Single-Use & Reusable | Praxisdienst. (n.d.). Retrieved September 30, 2019, from <https://www.praxisdienst.com/en/Hygiene/Protective+Wear/Surgical+Caps/>
- Vera, C. M. A., Umadhay, T., & Fisher, M. D. (2016). Laundering Methods for Reusable Surgical Scrubs: A Literature Review. *AANA Journal*, 84(4), 246–252.
- Vinet, F. (2018). Paradigm Shift—An overview | ScienceDirect Topics. Retrieved October 16,

2019, from <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/paradigm-shift>

Wade, D. T., & Halligan, P. W. (2004). Do biomedical models of illness make for good healthcare systems? *BMJ: British Medical Journal*, 329(7479), 1398–1401.

Wellbery, C., Sheffield, P., Timmireddy, K., Sarfaty, M., Teherani, A., & Fallar, R. (2018). It's Time for Medical Schools to Introduce Climate Change Into Their Curricula. *Academic Medicine: Journal of the Association of American Medical Colleges*, 93(12), 1774–1777.
<https://doi.org/10.1097/ACM.0000000000002368>

WHO | Climate impacts. (n.d.). Retrieved October 14, 2019, from WHO website:
<http://www.who.int/sustainable-development/health-sector/health-risks/climate-impacts/en/>

Windfeld, E. S., & Brooks, M. S.-L. (2015). Medical waste management – A review. *Journal of Environmental Management*, 163, 98–108.
<https://doi.org/10.1016/j.jenvman.2015.08.013>