

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

**The Economic and Environmental Impact of Single-Use Products in the
Healthcare Industry on Society**
(STS Paper)

A Thesis Prospectus Submitted to the
Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Rebecca Byrd
Spring, 2020

Technical Project Team Members
Rebecca Byrd
Robert Pazhwak

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 _____
Rebecca Byrd

Approved _____ Date _____
Timothy Allen, Department of Biomedical Engineering

Approved _____ Date _____
Dr. Nishaki Mehta, Department of Cardiovascular
Medicine

Introduction

Everyone is affected by healthcare; from the commonplace antibiotics, vitamins, and supplements we take every day to the more extreme cases of reconstructive surgeries and cancer treatment, this industry affects our daily lives more than we realize. The healthcare industry is growing at a rapid pace; global annual health spending reaching \$7.077 trillion in 2015 and is expected to grow to \$8.734 trillion by 2020 (“Just How Big Is The Healthcare Industry?,” 2018). The United States spends 15% of its Gross National Product on healthcare, due to the development of new technologies and the increasing costs associated with these new technologies (Kern & Jaron, 2003).

The healthcare industry has been rapidly evolving since the development of Germ Theory in the late nineteenth century (Editors of Encyclopedia Britannica, n.d.). Germ Theory led to an increase in medical and public health advances, such as immunizations and the development of antibiotics (Egger, 2012). One of the most important outcomes of the development of Germ Theory is the concept of sterility. Preventing contamination by only using instruments for one patient, especially for surgical procedures, has proven to be the most effective method for reducing the number and severity of surgical site infections (SSIs) acquired. However, using each piece of equipment one time creates an excessive amount waste and contributes to our planet’s growing problems with global warming.

Based on the projected increasing trend in healthcare spending and rising concerns about the environment, a potential area for improvement exists at the cross-section of healthcare and sustainability. Hospitals create over 6,000 tons of waste every day. Only 15% of this waste is considered to be infectious, meaning that the remaining 85% is considered solid waste (“Recycling Medical Supplies | UVA Health,” n.d.). A large amount of this solid waste comes from the \$40.3 billion disposable medical supply industry. Given the sizeable amount of waste

that hospitals produce, this capstone project focuses on redesigning the current disposable scrub cap to increase sterility in operating rooms, be more ergonomic, and be reusable.

For my STS topic, I will investigate how the use of single-use products in the healthcare industry impacts society, both economically and environmentally. The intersection of these seemingly unrelated fields is quickly growing. The healthcare industry is continuously discovering remedies to diseases from plants and animals in varying ecosystems. Additionally, the healthcare field utilizes resources that have the potential to harm the environment if they are not properly cleaned or disposed of after use. The economic aspect of this research is relevant due to the continuing rise in the size of the healthcare industry, while the environmental aspect of the research aims to display the need for a paradigm shift in the way that hospitals determine what equipment should be thrown away and what can be sterilized and reused.

Designing a Better Scrub Cap

Currently, scrub caps are mass produced and, therefore, created as “one-size fits all” in order to be more cost effective. However, no two people are exactly the same size, and this leads to a lot of variability in the fit of the cap. The caps can be especially uncomfortable for healthcare professionals with longer hair or facial hair, as they have to take extra measures in order to ensure that all of their hair is contained in the cap. It is essential for the cap to fit well, as loose hairs in a sterile environment can lead to patients developing SSIs.

Additionally, scrub caps that the majority of hospitals distribute to their staff are disposable which creates a large amount of nonhazardous waste. It is estimated that hospitals create 2.2 million tons of nonhazardous waste per year (“Recycling Medical Supplies | UVA Health,” n.d.). A report from the Ontario Hospital Association estimates that operating rooms alone are responsible for 20-33% of total hospital waste (Wendy Glauser, Jeremy Petch &

Sachin Pendharkar, 2016). Further, since the caps are single-use, the hospital acquires recurring costs of approximately \$36.00 per 1000 caps, and they must purchase these caps multiple times a month (“Keystone Blue Lightweight Polypropylene Bouffant Cap: Protective Caps,” n.d.). By creating a reusable cap, hospitals could potentially be able to significantly reduce the amount of unnecessary waste they produce per year, in addition to reducing costs by purchasing a smaller amount of scrub caps each year.

Additionally, because of the uniformity of disposable scrub caps, operating room personnel occasionally report difficulty identifying other personnel in the operating room. The prevalence of this problem can be seen by the rise in popularity of a news story surrounding an anesthesiologist's use of identifiers on his scrub cap (“Doctor’s Simple Idea To Write Names And Titles On Scrub Caps Can Save Lives,” n.d.).

Consequently, the design of a new scrub cap may help improve the quality of life of healthcare professionals, the exposure of patients to hair contamination, and the ability to identify healthcare professionals in the operating room. In order to discover any additional flaws in the current cap design, the team developed a short, ten-question iCore questionnaire and interviewed a total of 20 medical students and medical professionals (**Appendix A**). From this survey, we will determine the best way to implement new suggestions and how to fix the current problems.

The collaborators on this project are Rebecca Byrd and Robert Pazhwak, both of whom are fourth year biomedical engineering students. The technical portion of this prospectus will be carried out under the advisement of Dr. Nishaki Mehta, a doctor for UVA Department of Cardiovascular Medicine, and Katerina Morgaenko, a biomedical engineering graduate student working for Dr. Mehta.

At the end of the Fall semester and the beginning of the Spring semester, the team will have an idea of what new and existing features will be incorporated into the new scrub cap design. Once this has been done, the team will begin creating a design and prototype that incorporates the given feedback to be tested by current users. The users will be asked to give valuable feedback, with which the team will respond to and correct to the best of their abilities in an iterative process until both parties are satisfied with the result. The main deliverable for the Fall semester is a design for the first iteration of a prototype. The project will ideally culminate with a viable prototype design that can be put through the clinical trial process.

The Economic and Environmental Impact of Single-Use Equipment in the Healthcare Field on Society

Since the development of Germ Theory in the late nineteenth century, sterility has become an important aspect of the healthcare industry. Healthcare professionals, including but not limited to nurses, doctors, and techs, are required to wear hair coverings such as scrub caps in sterile environments (Information, Pike, MD, & Usa, 2009). However, many of these hair coverings are disposable, and therefore thrown away after one use. The large number of caps used can drive up costs for hospitals, as well as increase the amount of waste that the hospital produces.

In the operating room, general equipment often comes on pre-packaged trays. Once the tray packaging has been opened, the tray is not considered to be sterile anymore, and all of the materials that were used, and even the ones that were not used, are thrown away (Wendy Glauser, Jeremy Petch & Sachin Pendharkar, 2016).

Upon disposal, waste should be separated into categories depending on the level of degradation and cleaning it must go through before it goes into a landfill. According to the World Health Organization, there are eight different categories of waste created in the healthcare industry (“Health-care waste,” n.d.):

1. Infectious waste
2. Pathological waste
3. Sharps waste
4. Chemical waste
5. Pharmaceutical waste
6. Cytotoxic waste
7. Radioactive waste
8. Non-hazardous or general waste

The largest producer of waste out of these eight categories is nonhazardous waste, which accounts for approximately 85% of all hospital waste (“Health-care waste,” n.d.). Given that there are already eight categories of waste, it is not unrealistic to propose that a ninth category be added for materials that could be sterilized, repackaged, and reused. Reusing these non-sterile, but not contaminated, tools would cut down the amount of unnecessary nonhazardous waste that hospitals produce.

The costs associated with waste disposal could also be a significant factor to hospital decision makers. If the amount of waste that the hospital is producing decreases, it can be assumed that the waste management costs for the hospital would also decrease because there is less to transport. Additionally, in order to properly dispose of some types of waste, the waste must be treated chemically to neutralize the effects of the biohazardous substances on the

environment or incinerated (Rao, Ranyal, Bhatia, & Sharma, 2004). However, if done incorrectly, the incineration process can result in harmful chemicals and dusts being released into the air which effects the environment. The large amount of waste produced, and the occasional mistreatment of disposed waste, is contributing to global warming.

This research is important because everyone is affected by the actions of the healthcare industry. Patients are affected because they have direct interactions with people wearing disposable scrub caps and they are being operated on with sterile equipment. Hospital decision makers are affected because they must consider the balance between cost and efficacy of equipment while maintaining a sterile environment for patients. Healthcare professionals are affected because it affects their day-to-day operations, including how they obtain their scrubs and scrub caps and how they work with patients and in the operating room. The general public affected because of the damage to the environment. Additionally, a portion of their taxpayer dollars go towards funding public hospitals (Himmelstein & Woolhandler, 2016).

Research Question and Methods

My research question will help understand how different types of waste are viewed in the healthcare industry and how a paradigm shift can change the way that hospitals operate with regards to waste disposal. Answering the questions: “How did single-use products become the norm in the healthcare industry?” and “How do these single-use products impact society, both environmentally and economically?” is crucial to determining how hospitals can reduce the amount of nonhazardous waste they produce each day. To understand this question more in depth, I will investigate the costs associated with disposable scrub caps as compared to the costs of reusable scrub caps, including the cost of the physical cap and the cost of maintaining the same level of cleanliness that normal scrub sets are washed at. It is anticipated that the initial cost

of the reusable caps will be greater than the cost of a comparable disposable cap. However, it is also anticipated that the cost to maintain the cleanliness of the reusable caps will be less than the recurring costs of purchasing disposable caps. Additionally, I will look into how much of the nonhazardous waste that hospitals produce is due to excessive packaging and estimate the amount of equipment that is thrown out that is not used because it is no longer perfectly sterile.

The two most important factors to consider during this analysis are sterility and cost of the current processes. Sterility is of utmost importance because it has been shown to be the most effective way to reduce the incidence of SSIs in patients. Cost is also another driving factor in this analysis because if the proposed solution is not affordable, then it will not be considered to be adopted.

Conclusion

Overall, I have discussed the problems with the current scrub cap design, as well as a discussing the sociotechnical frameworks of the intersection between healthcare and sustainability, with regards to the quantity of waste that hospitals produce. The technical research project will involve the development of a new and improved reusable scrub cap that will help hospitals reduce the amount of nonhazardous waste they produce. The new cap will provide better hair coverage, be more adjustable and customizable to each individual, and will help hospitals produce less waste. The STS research portion is expected to provide a basis of knowledge for how hospitals currently operate, and a potential paradigm shift in the way that the hospital produces waste and how they dispose of it. Together, these research projects will propose both a technological and a social approach to reduce the amount of waste that hospitals produce.

References

Doctor's Simple Idea To Write Names And Titles On Scrub Caps Can Save Lives. (n.d.).

Retrieved November 1, 2019, from <https://www.scarymommy.com/theatre-cap-challenge/>

Editors of Encyclopedia Britannica. (n.d.). Germ Theory | Medicine. Retrieved September 24, 2019, from Encyclopedia Britannica website: <https://www.britannica.com/science/germ-theory>

Egger, G. (2012). In Search of a Germ Theory Equivalent for Chronic Disease. *Preventing Chronic Disease, 9*. <https://doi.org/10.5888/pcd9.110301>

Health-care waste. (n.d.). Retrieved September 24, 2019, from <https://www.who.int/news-room/fact-sheets/detail/health-care-waste>

Himmelstein, D. U., & Woolhandler, S. (2016). The Current and Projected Taxpayer Shares of US Health Costs. *American Journal of Public Health, 106*(3), 449–452. <https://doi.org/10.2105/AJPH.2015.302997>

Information, N. C. for B., Pike, U. S. N. L. of M. 8600 R., MD, B., & Usa, 20894. (2009). *The team will consistently use methods known to minimize the risk for surgical site infection*. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK143246/>

Just How Big Is The Healthcare Industry? Here's What You Need to Know. (2018, April 24). Retrieved October 13, 2019, from Dreamit Ventures website: <https://www.dreamit.com/journal/2018/4/24/size-healthcare-industry>

Kern, S. E., & Jaron, D. (2003). Healthcare technology, economics, and policy: An evolving balance. *IEEE Engineering in Medicine and Biology Magazine : The Quarterly Magazine*

of the Engineering in Medicine & Biology Society, 22(1), 16–19.

<https://doi.org/10.1109/MEMB.2003.1191444>

Keystone Blue Lightweight Polypropylene Bouffant Cap: Protective Caps. (n.d.). Retrieved November 1, 2019, from Amazon website: https://www.amazon.com/Keystone-110NWI-10-21-BBG-Lightweight-Polypropylene-Bouffant/dp/B006PIZ146?ref_=fscpl_pl_dp_5

Rao, S., Ranyal, R., Bhatia, S., & Sharma, V. (2004). Biomedical Waste Management: An Infrastructural Survey of Hospitals. *Medical Journal Armed Forces India*, 60(4), 379–382. [https://doi.org/10.1016/S0377-1237\(04\)80016-9](https://doi.org/10.1016/S0377-1237(04)80016-9)

Recycling Medical Supplies | UVA Health. (n.d.). Retrieved November 1, 2019, from <https://uvahealth.com/services/community-relations/recycling-medical-supplies>

Wendy Glauser, Jeremy Petch & Sachin Pendharkar. (2016, August 18). Are disposable hospital supplies trashing the environment? Retrieved September 24, 2019, from <https://healthydebate.ca/2016/08/topic/hospital-medical-waste>

Appendix A: Scrub Cap iCore Questionnaire

Operating Room Identification

1. How do you currently identify team members in a critical setting in a surgical operating room if they are unknown?
2. How do you feel your ability to identify people in a surgical operating room impacts your understanding or ability to perform your role or patient care?
3. Do you see a need or have a desire for better methods of identification in the operating room? if so, what information is more important and how can it displayed.

Scrub Cap Design

1. Have you ever had any issues with the fit of a scrub cap? If so, what were they?
2. How would rate the following in order of importance: comfort, aesthetics, customizability, feel, material?
3. Would you be comfortable wearing a scrub cap that is made out of the same material that scrubs are currently made out of?

Scrub Cap Sterility

1. Has hair contamination ever been a problem in the operating room for you or any other team member?
2. How often do you change your scrub cap during the day and why?
3. What features would you like your dream scrub cap to have?