Hospital Waste Stream Identification, Diversion, and Remanufacturing

The Impact of Leadership and Staff Training on Blue Wrap Waste Management

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

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November 8, 2024

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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 United States spends an estimated $760 billion to $935 billion each year to manage hospital waste, representing approximately 25 percent of total healthcare expenditures (Shrank et al., 2019). This substantial cost stems from the over five billion pounds of waste generated annually by the U.S. healthcare system, with the operating room being the second largest source (Wisniewski et al., 2020). Among this operating room waste, sterilization wrap—commonly known as blue wrap—makes up roughly 19% of total waste in surgical departments (EPA, 2002). Blue wrap, a polypropylene material, is manufactured using a Spunbond-Meltblown-Spunbond (SMS) process that provides an effective sterile barrier, allowing only sterilizing agents to penetrate and making it ideal for sterilization pouches (Friedericy et al., 2021). However, SMS polypropylene fabric can only be utilized once, and it produces a significant amount of greenhouse gas, which is around 823,000 kg of CO2 over 10 years (Babcock, 2016). Moreover, when disposed of in landfills, SMS polypropylene can take hundreds of years to decompose (NAH, 2024). Due to this significant environmental impact blue wrap has, there is a growing concern over utilizing blue wrap and an increasing effort to recycle it.

The University of Virginia (UVA) hospital, producing about four thousand tons of waste annually, has been collaborating with the Medical Equipment Recovery of Clean Inventory (MERCI) team, a volunteer-run program that collects and diverts clean medical supplies (UVA Health, 2024). Despite this effort, recycling blue wrap remains extremely challenging due to several factors. First of all, the waste stream for the blue wrap at UVA is not well-defined, such as the segregation process of dirty and clean blue wrap and the percentage of the blue wrap being recycled or thrown away. Moreover, the SMS polypropylene fabric's resistance to conventional shredders, which frequently clogs when processing the material, makes recycling blue wrap both

inefficient and energy-intensive (NERC, 2024). This leads most of the blue wrap to eventually end up in landfills. The MERCI team can also only able to manage a fraction of the total blue wrap. Additionally, though there are recycling companies, many of them lack transparency in their data, leaving hospitals hesitant due to a lack of clear carbon footprint reporting or reliable data (Eburajolo, 2023).

Therefore, this technical project will first identify the blue wrap waste stream from the UVA hospital, while looking for potential areas to reduce the blue wrap waste. The second phase will explore the development of a more efficient remanufacturing process, including the design of shredding and recycling solutions. The STS portion of this research will examine the broader socio-technical implications of blue wrap waste reduction in healthcare settings through the lens of Social Construction of Technology (SCOT) theory, particularly the influence of staff training and leadership in successfully implementing and sustaining these practices.

Technical Topic

The first step of the project is to identify a blue wrap waste stream and quantify blue wrap use in terms of frequency and volume at UVA Hospital. Several of Dr. Meyer's anesthesia surgical rooms are planned to be shadowed to examine how blue wrap is currently being segregated into "clean" and "dirty" bins since effectively distinguishing between clean and contaminated blue wrap can reduce significant amounts of energy and water consumption during sterilization (Hong et al., 2018). Hospital administration and the MERCI team will be interviewed to identify the trends of annual blue wrap purchases and the clean blue wrap recovery percentage. Based on the information acquired, Life Cycle Assessment (LCA), an analysis tool used to quantify the environmental impacts of products, systems, or services

throughout their entire life cycle, will be performed on UVA's use of blue wrap (Zhao et al., 2008). Once this step is completed, the actual sterilization process, particularly the potential use of mass autoclaving, will be studied. Given the restrictions on handling biohazard material, chemicals that mimic blood and bodily fluids will be used to simulate contamination and to test the autoclave's effectiveness in this contamination. Moreover, different types of mass sterilization, such as microwave disinfection, will be examined to maximize efficiency (Soares et al., 2013).

The main focus of the technical project will be on identifying and implementing a more effective and efficient shredder that can withstand tougher SMS polypropylene materials. The processed blue wrap polypropylene aims to achieve at least a 95% compositional and structural similarity to original polypropylene and to be in a size less than 1mm in length to be used in remanufacturing (van Straten et al., 2021). Then, innovative ways to repurpose the recycled blue wrap will be explored. A potential partnership with UVA Architecture and Art School will be developed to teach UVA students how to utilize repurposed blue wrap in coursework to offset current material use. The final phase of the project is to publish the process with the associated impact. UVA hospital blue wrap recovery protocol and statistics, accompanied by the methodology of implementation, will be transparently published so that other hospitals or healthcare facilities can replicate the process.

The overall goal of the technical project is to reduce the environmental impact of blue wrap waste at UVA Hospital through a comprehensive, multi-phase approach that identifies the waste stream, optimizes recycling processes, and explores innovative ways to repurpose the material. When effectively executed, this project will significantly reduce the volume of blue wrap waste sent to landfills, lower the hospital's carbon footprint, and promote a more

sustainable approach to waste management. Not only will this benefit the UVA community, but it will also inspire and provide a scalable framework for healthcare facilities across the nation to adopt sustainable waste practices.

STS Topic

Trevor J. Pinch and Wiebe Bijker's article *The Social Construction of Facts and Artifacts* discusses the SCOT theory, a new multidirectional approach to technology study (1984). Unlike technological determinism, which is the idea that technology is independent of social influences, the SCOT defines technologies to be shaped not only by technical factors but also by social, cultural, and political influences. They challenged the viewpoint that technology is linearly developed by technical superiority and asserted that different social groups interpret technology differently, giving interpretive flexibility. SCOT also highlights technology in a wider social context, including cultural beliefs and political dynamics, which determine how technology is developed and integrated into society.

Building on this framework, different social groups, such as healthcare professionals, waste management staff, and hospital administrators, each play a unique role in how waste reduction initiatives are interpreted and implemented. For example, healthcare professionals may prioritize patient safety and immediate sanitation needs, while waste management personnel can focus on regulatory disposal guidelines. Furthermore, hospital administrators play a critical role in the financial and operational oversight of these initiatives. They will assess the programs and ensure they align with their budgetary and sustainability goals. Recognizing these differing priorities of diverse social groups can also impact the effective implementation of the initiatives through staff training that is tailored to each group's specific role (Miamiliotis & Talias, 2023).

Staff training for surgeons and nurses might emphasize waste segregation techniques in the surgical room, while that of waste management staff might focus on handling protocols and regulatory standards. Through the SCOT lens, the project to reduce and remanufacture blue wrap waste emerges as a socially constructed effort, driven by the perspectives, training, and leadership across all levels of the hospital's staff.

In a wider social context, the project is deeply influenced by broader social trends, such as environmental and regulatory mandates. External government leadership, through environmental policies and health regulations, can drive healthcare organizations to adopt sustainable waste practices (Nie et al., 2014). Internal UVA Hospital leadership plays a role in translating these external pressures into internal practices. They can foster a sense of collective responsibility among staff, shifting organizational culture in a more sustainable way (Sapkota et al., 2014). This shift not only encourages a sustainable approach to waste management but also contributes to long-term commitment to initiatives. Additionally, political dynamics and support for sustainable waste management practices, such as incentives and funding, can critically impact the realistic outcome of the project by making implementation more or less feasible (Quinn et al., 2024).

Overall, SCOT theory highlights how technology is deeply intertwined with perspectives, social groups, and society. It underscores that waste management is not merely technical solutions but is shaped and sustained through the complex social values and dynamics, which collectively determine the success and resilience of the project. As different stakeholders may view and prioritize waste management solutions differently, there is interpretative flexibility, but closure could occur when these stakeholders reach a consensus, solidifying specific sustainable practices as the established norm within UVA Hospital.

Research Question and Methods

My research is to answer the following question: How do staff training and leadership impact implementing a sustainable blue wrap waste management at UVA Hospital? To investigate this question, I will conduct both a comparative analysis and a quantitative analysis of implementations of sustainable hospital initiatives.

Several hospitals worldwide have successfully implemented various sustainable initiatives. For instance, Royal Brisbane and Women's Hospital (RBWH) in Queensland, Australia, has shown a successful model in waste management, demonstrating the impact of strong support from both local and hospital leadership (Irianti, 2016). I plan to review at least five case studies of successful implementations and five unsuccessful ones, conducting a comparative analysis to identify key differences in leadership approaches at both the local and hospital levels. This analysis will highlight the role of leadership in shaping effective and sustainable waste management practices and explore how these insights can be applied within UVA Hospital.

To investigate the impact of staff training, I will perform a quantitative analysis of training programs and waste trends to explore their correlation. Using the UVA Healthcare database, I will examine the timeline of the past staff training on waste management and any shifts in emphasis. I will then analyze changes in the amount of waste generated over the same period, conducting regression analysis to identify potential relationships. As literature suggests, staff training, such as raising awareness, can significantly impact the amount of waste produced at the hospital (Lee & Lee, 2022). If this trend holds, a positive correlation is expected between

the emphasis placed on staff training and improved waste management outcomes . Finally, I plan to create a graph to clearly display the correlation between staff training and waste trends.

Conclusion

The growing volume of blue wrap waste has created the need for improved remanufacturing and diversion methods. Upon successful completion of the technical project, concrete data on the blue wrap impact at UVA Hospital will be available, along with a prototype design for a mass sterilization and shredding device, and a published framework for broader implementation. On the STS side, a thorough analysis will explore how staff training and leadership influence waste management initiatives, providing valuable insights into the sociotechnical implications and implementation of the technical solutions. Together, if implemented successfully, it will reduce blue wrap waste and make remanufacturing processes more efficient, while ensuring long-term sustainability implementation. This will not only benefit UVA Hospital but also serve as an inspiring model for other health institutions to follow.

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