Repurposing Surgical Instrument Waste Stream of UVA Health Medical Center
(Technical Project)

Single-Use Design of Hospital Plastic Medical Devices Contributing to Environmental and Political Issues in the United States Healthcare Sphere
(STS Project)

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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

Amid society's buzzing political debates and turmoil, there is a silent crisis going unnoticed among the masses: the challenge of waste. According to the American Medical Association's Journal of Ethics, "In 2018, the United States produced 292.4 million tons of municipal solid waste" (Jain & LaBeaud, 2022). Unfortunately, this problem is also seen in the United States healthcare system. Studies have shown that "Every day, U.S. healthcare facilities generate 14,000 tons of waste. One patient being hospitalized results in nearly 34 pounds of waste every day." (Wen, 2023). In today's healthcare landscape, there is currently no widely accepted system to repurpose these thousands of tons of medical waste, leading to most items being sent to landfills, further endangering public health and the environment. Due to this significant lack of systems to not only sort through hazardous medical waste but also to repurpose available waste, a systemic overhaul of the United States healthcare waste system is needed to reduce the waste output to our landfills and encourage the reuse of materials.

Although the increase in medical waste is a global problem made worse by the United States' contribution, my group and I will design and implement successful waste management on a local scale by targeting the University of Virginia (UVA) Medical Center. According to a case study published in The American Journal of Surgery, the United States operating rooms (ORs) contribute upwards of 70% of the United States' yearly hospital waste output (Braschi et al., 2022). With this in mind and conducting preliminary interviews with UVA's Medical Equipment Recovery of Clean Inventory (MERCI), a program to repurpose and reuse the hospital's medical waste, we found it paramount to target a specific waste stream that produces much of the waste buildup in the ORs.

After researching specific tools used universally in ORs, we propose that the UVA Health

System implement systemic waste stream changes to redesign and repurpose stainless steel OR surgical tools. In this system, surgical instruments can be put through a foundry to create metal castings for injection molds in additive manufacturing of novel medical devices. To complete this technical project, UVA Health's surgical instruments must be properly collected, sterilized, melted, and formed into injection molds. However, for proper completion, the technical project requires collaboration with UVA Facilities Management, UVA Health Staff, and foundry experts at the UVA School of Architecture, who may have different regulations and standards needed to follow.

In my STS project, I will focus on the underutilization of plastic medical waste in the United States healthcare systems and the harm caused by an influx of single-use plastics into landfills. To study these issues through the lens of Science, Technology, and Society (STS), I am employing Pinch and Bijker's social construction of technology (SCOT) framework. Viewing the problem through this framework will help examine how different stakeholders in the United States medical sphere adopt specific policies and procedures instrumental in causing potential environmental and health harm from medical waste.

Technical Topic

Operation procedures are one of the largest contributing factors to healthcare waste in the United States. Healthcare has also been one of the fastest-growing industries in recent years, contributing to a substantial increase in healthcare landfill contribution (Kenny & Priyadarshini, 2021). This surge in healthcare waste is further exacerbated by hospitals, such as the UVA Health Medical Center, switching from reusable surgical instruments to disposable alternatives.

The UVA Medical Center previously used high-grade German stainless steel surgical

instruments that could be sterilized and reused for years without needing to be replaced. The procedure included collecting surgical tools after a procedure and using an autoclave to decontaminate the instruments before redistributing them to be used again. However, hospitals abandoned this process by switching to using cheaper, lower-quality instruments that rust when attempted to wash, resulting in them going in the garbage after one use. There is no current process for recycling disposable surgical instruments, as replacing them after each use is deemed more cost-efficient. Accepting the switch to disposable medical supplies also exacerbates greenhouse gas emissions. Healthcare systems already account for nearly 8% of the nation's carbon emissions. However, if hospitals use an increased number of single-use items, that figure will only increase and cause further damage to the environment (Pichler et al., 2019). Therefore, developing a protocol for reusing disposable surgical tools for a practical purpose is necessary to decrease hospital waste output.

The goal of the technical project is to design a process for recycling used stainless steel surgical tools and remanufacturing them into injection molds that can be used for three-dimensional model fabrication. The project is broken down into four major components that need to be implemented, from collecting used instruments to constructing injection molds. The first step is to complete a comprehensive lifecycle analysis and quantification of the UVA Health disposable surgical tool waste stream. Then, a robust decontamination protocol must be implemented to clean the surgical tools, as they are deemed hazardous waste products by the Environmental Protection Agency (EPA) upon exiting the surgical suite (EPA, 1992). Therefore, bacteria and pathogen tests must be conducted after decontamination to examine the efficacy of the sterilization process and ensure that all surgical waste is safe for repurposing. The next step will be to refine and melt the surgical tools. With the refinement process, the chemical

composition of the stainless steel will be tested for its chromium content, which determines the strength and durability of the metal (Modak, 2023). In October 2023, the United States Food and Drug Administration (FDA) released Import Alert 76-01, a warning about imported disposable surgical instruments, citing that "the quality of the instruments appear to fall below that which they were represented to possess. Documented analysis revealed great variability in chromium content" (FDA, 2023). Therefore, upon melting, the steel must be analyzed for its chemical composition to ensure a chromium content of 12-18% is achieved for adequate durability and strength (Modak, 2023). Finally, the injection mold design must be produced from stainless steel and assembled. This process will be validated by creating a model using the mold and analyzing the scale of precision as well as the efficiency of the overall process in its ease of use and accessibility for users.

STS Topic

Global studies show that political choices favoring single-use medical plastics are harming our environment, causing a surge in plastic waste dumped into landfills (Nielsen et al., 2020). In the current healthcare scene, policies and design choices supporting the use of single-use plastics in medical device designs not only contributes to a rise in environmental safety concerns, but also contributes to a significant rise in landfill waste in the United States. Unlike regular waste, hazardous plastic medical waste can slip through varying levels of sterilization protocols, posing an increased risk of hazardous materials stemming from medical waste.

As it currently stands, policymakers have failed to implement a widespread circular economy regarding plastic medical waste in the United States. A circular economy is a system based on repurposing and reusing materials and products to reduce waste streams into

environmentally detrimental landfills. However, resolving the United States' plastic medical waste predicament is not out of reach. Efforts published by the European Parliament outline the potential for transformative change in plastic waste management (European Parliament. Directorate General for Parliamentary Research Services. et al., 2017). Similarly, a study in the *International Journal of Environmental Research and Public Health* outlines contemporary issues in surges of plastic waste due to the COVID-19 pandemic in the United States. The case study concludes that a critical factor leading to the improper reuse of plastic medical waste is operational waste management procedures and the lack of circular economic systems to reduce and repurpose waste streams (Lee & Lee, 2022).

Additionally, design choices leading to single-use medical devices rather than reusable devices significantly contribute to the medical waste crisis. Research suggests that product designers in the United States prefer less sustainable materials in medical devices due to reduced costs and fewer regulations on single-use devices (Okafor, 2020). However, a case study relating to single-use formula bottles in maternity hospitals calls on product manufacturers to address the overarching need for reusable alternatives. The study provides a quantitative analysis showing that the large production of single-use formula bottles results in a high potential for hazardous materials and a significant amount of plastic waste. (Leissner & Ryan-Fogarty, 2019).

I contend that policymakers and product designers are not only to blame for the crisis. The millions of tons of plastic waste per year in hospitals (Wen, 2023) underscores the evidence of hospitals' role in aiding the plastic waste crisis. Hospitals play a pivotal role in shaping these increased waste generation trends due to lack of substantial medical waste management and efficient recycling systems. Furthermore, statistics from a case study of hazardous personal protective equipment (PPE) in hospitals "show our growing reliance on plastic, [and] its …

leakage into the environment, causing a new environmental crisis" (Selvaraj et al., 2022) rather than aiming to find and use reusable alternatives. The paper portrays the far-reaching environmental implications of increased reliance on landfills. This reliance leads to soil and water contamination along with adverse effects on wildlife due to the hazardous materials seeping into the environment from the contaminated medical waste. These consequences magnify the urgency of addressing plastic waste generated by hospitals and emphasize the gravity of the associated environmental and political challenges that can be mitigated with circular economy efforts.

The STS framework I will employ in this research project is the social construction of technology (SCOT). The SCOT framework delves into the wide-ranging implications of different technologies. With SCOT, it is crucial to understand "interpretive flexibility," or how different stakeholders interpret different technologies (Pinch & Bijker, 1984). In the United States healthcare system, I propose that there is a wide array of interpretive flexibility being employed by the varying stakeholders regarding single-use plastic medical-devices, from the policymakers down the ladder to the communities having to deal with potentially hazardous environmental conditions from waste.

Research Question and Methods

The question I set out to answer is: Why are plastic medical devices in hospitals not being designed to be reused or repurposed? I will use SCOT to explore the different stakeholder interpretive flexibility surrounding single-use hospital plastics and the hospital's role in the lack of reusable alternatives. I will interview UVA Health physicians, UVA Facilities Management, and hospital staff responsible for making circular economy policy decisions. These interviews

will ask structured questions to explore their reasonings behind why hospitals have not adopted universal circular economy policies to reduce and repurpose waste as well as the reasonings behind why hospitals and product designers are failing to make and use reusable alternatives to current single-use products. Along with the interviews, I will continue my literature review of case studies and data, ideally within the last decade, surrounding the current systems leading to single-use medical devices rather than reusable devices. By narrowing down the period to take data, I can get a more recent and comprehensive view of the problems surrounding single-use plastic medical devices and the lack of circular economy policies.

Conclusion

In my technical project, I will create a system for collecting, sterilizing, and melting stainless steel surgical instruments to create metal castings for injection molds. These molds will be used for additive manufacturing of novel medical devices so that a significant waste stream from UVA Health can be reused rather than sent to landfills. In the STS deliverable, I will investigate the consequences of single-use plastic medical devices, the decisions leading to insufficient use of reusable medical devices, and a scarcity of policies that mandate a circular economy approach in the United States healthcare system. By understanding why current plastic medical devices are being designed to not be reusable, we can create and find solutions to mitigate the current medical waste crisis's detrimental environmental and health effects.

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