Repurposing Surgical Instrument Waste Stream of UVA Health Medical Center

Analysis of the Transition to Single-Use Surgical Tools and Unsustainable Waste Management Practices of American Hospitals

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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 unsustainable generation and management of hospital waste, particularly of hazardous and non-recyclable materials, poses multifaceted environmental and sustainability concerns. Hospitals generate a vast volume of waste daily, making the healthcare industry the second largest contributor to landfill waste in the United States. Healthcare waste generation totals 6.6 thousand metric tons of waste per day (Alger, 2020). Globally, hospitals make up 4.4% of global greenhouse emissions (Budd, 2019). One of the biggest drivers of the trend of increasing hospital waste is the transition from reusable surgical instruments and materials to single-use alternatives. Indeed, the market for single-use surgical tools is expected to grow at a rate of 8.2% from 2023 to 2030 due to the increased prevalence of chronic diseases as well as the increased preference for single-use materials (Disposable Surgical Devices Market Size, Share Report 2030, 2023). Steve Santoro, an Executive Vice President of the medical device manufacturer Micro, is passionate about this issue. He explains that single-use materials are increasingly preferred because recent improvements in engineering have made them much cheaper, there is no risk of the instruments dulling, there is no inconvenient sterilization process required, and there is no risk of cross-contamination due to improper cleaning procedure (Santoro, 2021). Continuing in this direction will result in significant environmental concerns due to the extreme volume of generated waste. Inadequate waste management methods of hazardous waste, such as landfilling without proper segregation or incineration, can lead to soil, groundwater, and air contamination (Janik-Karpinska et. al.).

These unsustainable practices, such as mixing different types of waste, inadequate waste storage and transportation systems, and improper disposal methods like uncontrolled dumping and open-air incineration, have significant negative impacts on public health and the

environment (Abubakar et. al, 2022). Sustainability is more important now than ever. In the age of climate change and environmental destruction, humanity is at a turning point that requires significant technological innovation in the name of sustainability. The air and water pollution, environmental degradation, and methane emissions of this unsustainable waste management all contribute to making certain areas of the world uninhabitable. Low air quality leads to respiratory diseases. Water contamination forces populations to evacuate their homes, and methane emissions contribute to global warming, which increases the risk of natural disasters that destroy vulnerable communities.

My technical project addresses the excessive use of single-use stainless steel surgical instruments. The UVA Health System has recently switched from reusable German steel instruments to lower quality, single use, Pakistani surgical instruments. The project explores ways to sterilize, melt down, and use the steel to create injection molds for other useful products. Repurposing these used materials will contribute to an improvement in sustainability practices for the UVA Health System and other health systems around the country. My STS project explores the political, economic, and social factors that influence the transition from reusable to single-use materials as well as the current unsustainable waste management practices exercised by governments and health systems. It will also explore multifaceted solutions from the perspectives of all stakeholders.

Technical Project Proposal

Operation procedures are one of the largest contributing factors to healthcare waste, with operating rooms producing up to 70% of total hospital waste output across the country (Braschi, 2022). The healthcare industry has also been one of the fastest growing industries in recent years, which has contributed to a substantial increase in healthcare landfill contribution (Kenny, 2021).

This surge in healthcare waste is further exacerbated by hospitals, such as the UVA Health System, 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, this process was abandoned, as the hospital switched to using cheaper, lower quality instruments that rust when attempted to wash, resulting in them being discarded after only a single use. There is no current process in place for recycling disposable surgical instruments, as it is deemed more cost-efficient to simply replace them after each use. The acceptance of the decision to switch to disposable medical supplies also exacerbates greenhouse gas emissions. Healthcare systems already account for nearly 8% of the nation's carbon emissions, but if more single-use items are used, that figure will only increase and cause further damage to the environment (Pichler, 2019). Therefore, development of 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 the collection of used instruments to the construction of injection molds. The first step is to complete a comprehensive lifecycle analysis and quantification of the UVA Health System disposable surgical tool waste stream. Then, a robust decontamination protocol must be implemented to clean the surgical tools, as they are deemed a hazardous waste product by the Environmental Protection Agency (EPA) upon existing 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 (420 vs 440). 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 (420 vs 440). Finally, the injection mold design must be produced from stainless steel and assembled. This process will be validated by the creation of 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 Project

Hospital waste is undoubtedly one of the largest contributors to the epidemic of landfill waste plaguing the world. As the trend of waste production continues to increase, it is critical to understand the complex social factors that influence its production and management. The decisions, and their effects, made by relevant stakeholders must be identified to bring a solution to light. The sweeping transition away from reusable materials towards single use instruments has proliferated waste production, and the risk of mismanagement of hazardous waste continues to loom over the heads of almost every hospital system in the world (Keil, 2022).

To break down this complex societal system, I will employ the Social Construction of Technology (SCOT) framework, which seeks to identify every stakeholder involved in the creation of a technology and how their perspective and social positioning influences said technology. The theory of SCOT rejects the traditional model that represents the development of a product as linear. Instead, it argues that a product's development is more accurately defined as a complex web, wherein each stakeholder brings their own perspectives to the table, and with them, their own problems that must be solved. All of these stakeholders and their respective interests influence the development of a product (Pinch and Bijker, 1984). In the case of the evolution of surgical instruments from reusable to single-use, the relevant stakeholders must be examined. The main stakeholders are hospitals, patients, manufacturers, policymakers, and those most impacted by the waste disposal.

Unsurprisingly, a critical stakeholder in the development of surgical instruments is the hospital. Hospitals prioritize maintaining the highest standard of care possible. When comparing single-use surgical instruments to reusable ones, there are several factors that influence standard of care. First is instrument quality. Hospitals were noticing that as they reused surgical instruments for an extended period, the instruments became subject to wear and tear, resulting in faulty instruments. Scalpels and scissors would dull and rust, and other materials would eventually break down and become less effective. Not only does this cause extreme inconvenience, but it represents a significant danger to the patient (Santoro, 2021). Second is the risk of contamination. When surgical instruments are reused, they must be sterilized. Although sterilization methods are ideally effective and rigorous, there will always be errors that result in unsuccessful sterilization and contamination (Santoro, 2021). Hospitals have realized that single-

use tools solve both of these problems. Such issues have driven hospitals to transition to single-use instruments in recent years (Coffeen, 2023).

Unfortunately, the healthcare system in the United States pushes the cost of care largely onto the patient (Montero, 2022). While the hospital and the patient both share a common interest in the highest standard of care, the unique perspective of the patient is maintaining low cost of care. In fact, 75% of American patients search for providers based on low out-of-pocket costs (Heath, 2017). Due to recent engineering breakthroughs, single-use instruments have become significantly cheaper than reusable ones (Santoro, 2021). The instruments can be made with lower quality of materials because product longevity is no longer a factor. The significant reduction of cost from this switch is likely the largest driving factor behind the transition.

The management of the waste that is produced is largely determined by the policymakers involved at all levels. It is the responsibility of the policymakers to set rules and regulations governing the management of waste, and it is often overlooked. Policymakers are driven by a complex tapestry of issues, a lot of which influence each other. Unfortunately, due to a lack of priority for the environment by policymakers, potential improvements to waste management methods have not been implemented. As a result, solid waste management systems within American hospitals are very poor, and waste is miscategorized and dumped outside of American borders (Jain and LaBeaud, 2022).

Improving the stability of waste management practices is critical for the environmental well-being of the planet. In fact, if hospitals switch from single-use back to reusable surgical materials, the climate change contribution will be reduced by between 38% and 50% (Keil, 2022). Solutions on all sides of the problem must be examined. Hospitals must evaluate their

own waste streams and take steps to reduce the waste they generate. Additionally, policy solutions are critical to improving the way that the waste is properly managed (Jain and LaBeaud, 2022).

Research Question and Methods

What are the social factors, stakeholder perspectives, and environmental policies that impact the production and management of hospital waste in the context of the shift from reusable to single-use surgical instruments? I will begin to answer this question by conducting an extensive literature review. In this review, I will examine the economic and political factors that contribute to the life-cycle of surgical instruments. Additionally, it will examine the market for surgical instruments and what notable changes have happened in recent years. There is an extensive body of literature surrounding hospitals, the healthcare industry, and waste management methods, so I will be able to develop a complex understanding of the stakeholders and their motivations. Once the literature review is complete, I will observe this phenomenon locally through the lens of the UVA Health System. I will interview doctors, administrators, and management within the health system to gain a better understanding of how decisions are made to source surgical instruments and what factors informed their transition from reusable steel instruments to single use ones. Through these interviews, I will gain a comprehensive understanding of the waste management methods of the UVA Health System.

Conclusion

Through my technical project, I will produce a model for an injection mold made from melted down stainless-steel surgical instruments. The injection mold can be used in a myriad of ways by manufacturers across different industries to replace previous, less sustainable models.

Through my STS project, I will gain a better understanding of the waste streams of hospitals, how they are influenced by their stakeholders, and potential policy solutions at a local and national level to make the waste streams more sustainable. The findings of the STS project will be instrumental in informing the policy decisions of health systems and government officials. It can shed light on potential sustainability solutions for all communities. Together, these two projects provide a multifaceted approach to the problem of unsustainable hospital waste management practices. They present both design and policy-oriented solutions that combine to show significant potential for progress within the realm of sustainability.

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