

The Impact of Single-Use Hospital Plastic Medical Devices on the U.S. Healthcare Landscape

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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 Medical Waste Crisis in the United States

The escalation of medical waste, particularly with the increased use of single-use plastic medical devices, is a significant challenge for the United States Healthcare system. In 2018 alone, the country produced a staggering 292.4 million tons of municipal solid waste (Jain & LaBeaud, 2022). Considering the substantial volume of waste created, the healthcare system contributed over 14,000 tons daily (Wen, 2023). This waste production is further exacerbated by the lack of a comprehensive system to repurpose medical waste, resulting in hospitalized patients producing 34 pounds of waste daily (Wen, 2023). Acknowledging the imperative for prompt action, the research will center on UVA Health as a case study, supplemented by nationwide data, to delve into the sociotechnical obstacles confronting hospitals in their efforts to implement plastic waste reduction systems. This study employs Pinch and Bijker's Social Construction of Technology (SCOT) framework to address this question. This framework looks at the issue through a theoretical lens that unravels the interpretive flexibility among different stakeholders in the healthcare system.

This vital research extends beyond a minor waste management concern; it encompasses the major contributing factors in the healthcare landscape leading to detrimental environmental practices. According to a 2019 survey, the healthcare system in the United States accounts for 8% of the nation's total carbon emissions (Pichler et al., 2019). This number continues to rise with the increased use of single-use plastics during and after the COVID-19 pandemic. By employing the SCOT framework to review the proposed research question, this paper examines the socio-technical dynamics influencing the persistence of single-use plastic medical devices, critically examining the decisions by the US government, healthcare professionals, and the product designers themselves.

Methodology: Investigating Sociotechnical Barriers

The research question guiding this STS investigation is as follows: What are the sociotechnical barriers to hospitals implementing systems to reduce hospital plastic waste? The research adopts a mixed-methods approach to investigate the social construction of technology in the medical waste crisis. Primary data sources include an in-depth literature review and interviews with key stakeholders within the UVA Health System and the medical sustainability industry. The extensive literature review spans historical trends, policy documents, and case studies, providing a comprehensive background to contextualize the current state of the medical waste crisis. The keywords guiding this research are as follows: Medical waste, Single-use plastics, healthcare sustainability, social construction of technology (SCOT), interpretive flexibility. Interviews from healthcare professionals, policymakers, and industry experts uncover insights into the interpretive flexibility surrounding the adoption of single-use plastic medical devices in US hospitals. The SCOT framework guides the analysis, offering a wide lens to unravel the socio-technical dynamics influencing the continued dominance of single-use devices in the medical industry.

Background: Evolution of Single-Use Plastic Medical Devices

Understanding the gravity of the medical waste issue in the United States necessitates delving into the historical context and evolving trends that led to the domination of single-use plastics in the healthcare industry. Even though humans have been using medical devices for thousands of years, “metal was the principal material for the first long stretch of history as it served a wide range of purposes, including surgical instrument[s], dental implants, and steel

plates” (Johnsen, 2015). However, although surgical procedures have been in use for many years, before the late 19th century, “their application for the treatment of human disease was limited because of a mortality rate from postoperative infection alone of about 50%. (Alexander, 1985). The root of the problem was in the overall cleanliness of the surgical procedures themselves. Hospitals needed easily and readily usable tools, which could also limit contamination between the tools and the patients.

In the 1970s, plastic production techniques became refined enough to allow plastic to become the dominant material used in hospitals. A recent study explains that “their use increased through the 1980s and 1990s [was] with single-use plastic items like syringes, blood bags, and tubing” (Hodges, 2017). The adoption of single-use medical devices allowed the world’s healthcare industry to overhaul the issue of medical hygiene. However, even though plastics are now a significant symbol of cleanliness and hygiene in the medical industry, their continued domination of the industry has led to other significant health and environmental concerns throughout the United States and the rest of the world.

Moving away from predominantly metal multi-use instruments to disposable plastic alternatives is not merely an operation shift. Instead, it is a complex web of policy decisions, product designs, regulatory dynamics, and public quality perceptions. This shift leads to two contemporary issues surrounding the increase in hazardous waste and in the United States’ greenhouse gas emissions. According to a recent study, “in the United States, the healthcare system is becoming more, not less, polluting: emissions increased 6 percent from 2010 to 2018” (Explainer, 2022). The immediate disposal and use of contemporary medical devices contradict the more sustainable practices hospitals employ. Understanding the consequences of this shift involves exploring the interconnected factors influencing the decision-making processes in

healthcare settings.

Furthermore, the lack of a widespread circular economy approach for plastic medical waste in the United States aggravates the environmental impact of medical waste disposal. A circular economy is a system based on repurposing and reusing materials and products to reduce the waste streams flowing into environmentally detrimental landfills. While the outside world is progressing towards more circular economy policies, the United States lags in adopting these widespread policies. The scarcity of these policies, coupled with the design choices by companies favoring single-use medical devices over reusable alternatives, amplifies the medical waste crisis. This gap has widened during the COVID-19 pandemic, where operational waste management procedures and the absence of circular economic systems exacerbate the improper disposal and use of plastic medical waste (Lee & Lee, 2022; Selvaraj et al., 2022; European Parliament, 2017).

The role of companies and product designers in the medical device sector also play a crucial role in contributing to the crisis. According to research, product designers often opt for less sustainable materials in medical devices due to reduced costs and fewer regulations on single-use items. These choices further reinforce the prevalence of single-use plastic medical devices and contribute to the millions of tons of plastic waste generated annually by hospitals. The sheer quantification of this plastic waste underscores the undeniable role that product designers and hospitals play in exacerbating the plastic waste crisis, revealing the far-reaching environmental implications of increased reliance on landfills and their adverse environmental effects on the surrounding soil, water, and wildlife (Okafor, 2020; Leissner & Ryan-Fogarty, 2019).

Social Construction of Technology and Hospital Waste

Examining the medical waste crisis through the lens of Science, Technology, and Society (STS) provides a nuanced understanding of the complex interplay between technology, societal structures, and environmental consequences. The SCOT framework serves as a fundamental STS perspective for this research, offering a comprehensive analytical tool to investigate how different stakeholders interpret and shape the adoption and use of single-use plastic medical devices (Pinch & Bijker, 1984). With SCOT, it is crucial to understand the “interpretive flexibility” of the different stakeholders. That is, how the various stakeholders interpret and use the different technologies.

Key contributors to the SCOT framework, such as Pinch and Bijker, extensively examined how technologies are not simply neutral objects but products of social negotiations, controversies, and interpretations. In the context of the social studies of science, “[SCOT] suggests that technology design is an open process that can produce different outcomes depending on the social circumstances of development” (Klein, 2002). In the context of medical waste, SCOT explores the social construction of decisions surrounding the use of single-use plastic medical devices, shedding light on the diverse interpretations by various stakeholders within the United States healthcare system. For instance, a paper by Philip Brey in 2008 delves into the ethical dimensions of technology and how different value systems influence the social construction of technology. In the context of single-use plastic medical devices, understanding the full scope of ethical considerations is crucial for comprehending the decisions and policies driving the increased use of these devices in the contemporary healthcare setting.

While scholars utilizing SCOT generally agree on the socially constructed nature of technology, there may be disagreements regarding the specific dynamics and actors involved in

the construction process. One researcher suggests that “SCOT sees no ‘right’ or ‘wrong’ technologies, as all technologies have the potential to be shaped differently based on which actors and groups are [building them]” (Prell, 2009). Some scholars may emphasize the role of regulatory bodies and policy decisions, while others may highlight the influence of economic and monetary considerations. This diversity in scholarly perspectives enriches the application of SCOT to the contemporary medical waste crisis, enabling a more comprehensive analysis of the complex factors contributing to the adoption and persistence of disposable medical devices in current United States healthcare practices. The importance of applying the SCOT framework to the medical waste crisis lies in its ability to unveil the intricacies of decision-making processes, the power dynamics among stakeholders, and the broader societal implications of technology adoption within the healthcare system.

Results & Discussion: Sociotechnical Dynamics and Stakeholder Perspectives

While navigating the intricate landscape of the healthcare industry's evolving relationship with single-use plastic medical devices, the literature review and interviews unveil a troubling trend in critical stakeholders' role in abetting the continuing medical waste crisis. The healthcare sector is navigating a pivotal issue characterized by the domination of single-use medical plastics in the industry, ushering in widespread changes with ramifications extending beyond medical practices, environmental sustainability, and the political discourse of the United States. This significant shift towards a less sustainable option is one of convenience, hygiene, and economic considerations, propelling the medical industry to become one of the most prominent contributors to our nation's growing carbon footprint (Zikhathile et al., 2022). Recent data indicates that "around 80 percent of the health care industry's carbon footprint is a result of the

production, transportation, use, and disposal of single-use medical supply chain" (Merritt, 2023). Additionally, the continued dominance of single-use devices is born out of profits, efficiency, and unwillingness to change. Many single-use devices have minimal evidence to support their superiority over their reusable counterparts (Greene et al., 2022). However, this surge in single-use plastic medical waste has been compounded by the heightened reliance on these plastics during the pandemic and the post-COVID-19 era, reflecting a heightened concern for the problem. Furthermore, this shift towards a less sustainable future is intertwined with current political discourse, influencing new policies and decision-making processes. The growing reliance on single-use plastics indicates a broader socio-technical dynamic, where the interplay of many different stakeholders can wield a substantial impact on environmental sustainability and shape the political narratives within the healthcare sector.

Historical Trends & Interpretive Flexibility Among Stakeholders

The continued persistence of single-use plastic medical devices within the healthcare industry inherently ties to the concept of interpretive flexibility among various stakeholders. In the context of SCOT, interpretive flexibility means that different technological artifacts have different meanings and interpretations depending on each stakeholder (Clayton, 2002). Stakeholders within the healthcare industry have varying opinions on the role of single-use plastic medical devices. However, the current problem persists due to the massive issue of sterility in medical devices before the middle of the 20th century. At that time, sterilization techniques and technologies were not as advanced, and therefore, there were major strides toward cheaper and more efficient options. Additionally, the adoption of single-use medical

devices "helped prevent the spread of dangerous diseases by eliminating reuse and the need to sterilize a device" (Kurtz, 2023).

Even though the adoption of single-use medical devices allowed for safer medical practices at the time, as sterilization and sanitation techniques increased in efficacy, the use of reusable tools did not increase at the same pace. On the contrary, the opposite has happened, and single-use plastic medical devices have increasingly dominated the pool of medical devices in use and supply. Through the literature review process and conducting interviews with Dr. Matthew Meyer, MD | Critical Care & Anesthesiology, and Alex Foley | Stryker Sustainability Solutions, there is a striking difference in interpretive flexibility between product manufacturers, physicians, and waste management specialists. According to many diverse sources, there are many different benefits for product manufacturers, such as focusing more on the continued production of single-use medical devices rather than reusable devices. Although it may not seem like the case, the production of single-use medical devices is usually more cost-effective in the long term due to the lack of need for resources to ensure the device's safety for multiple patients and uses. Additionally, single-use medical devices offer the ability to save time for the product manufacturers and designers because rather than needing time to design, manufacture, and then sterilize the tools for reuse, they only need to design tools to be used once before being disposed. Finally, in relation to needing systems for sanitation and sterilization for the reuse of devices, there are many regulatory rules that manufacturers must follow to produce reusable medical devices (O'Malley, 2021; Collier, 2011). The convenience, cost-cutting measures, and the lack of regulatory issues of single-use plastic medical devices influence medical device manufacturers' interpretive flexibility and continued production.

Contrary to the attitude and display from product designers and manufacturers, resources, and interviews with physicians and waste management specialists exemplify different interpretive flexibility for the support and need for more sustainable medical devices and practices in UVA health and beyond. In previous years, many hospitals in the United Kingdom agreed to efforts to reduce their plastic footprints. Even though the COVID-19 pandemic made these goals increasingly difficult due to the essential need for single-use plastic personal protective equipment (PPE), a survey in the post-COVID world indicated that "although COVID-19 had increased the procurement and the use of single-use plastic, it did not appear to have changed the focus of hospitals on implementing measures to reduce single-use plastic in the long term" (Hu et al., 2021).

Dr. Mathew Meyer and Alex Foley have similar attitudes on more sustainable practices, with interview questions outlined in Appendix I. When asked about the life cycle of single-use devices compared to reusable devices, Mr. Foley, a sustainability, and medical waste management representative, explained that "a single-use device is manufactured, packaged, and shipped to the medical center for use. Once used, it is immediately discarded and sent through the hospital's waste management system and will eventually end up in a landfill. On the other hand, a reusable device has all the same steps besides being sterilized and reused until it reaches the maximum allowed uses as defined by the manufacturer. The device is then sent through the waste management system and will go to a landfill" (Foley, Personal Communication, 1/26/2024). Mr. Foley went on to explain that the reuse of medical devices reduces plastic waste produced by hospitals and decreases the overall carbon footprint of each hospital. Dr. Meyer of UVA Health had a similar view on the benefits of reusable medical devices by saying, "Many of the single-use devices in the hospital are of lower quality than reusable devices and because of

that cannot be used and are thrown away before use altogether. Because of this quality issue, we continue to add more waste into circulation. However, this problem will not persist to the same degree if hospitals focus on adopting more reliance on reusable medical devices rather than continued use of single-use devices (Meyer, Personal Communication, 2/20/2024).

The exploration of interpretive flexibility between varying stakeholders highlights the intricate dynamics between both sides of the life cycle of single-use medical devices. The interpretive diversity of the stakeholders underscores the socio-technical complexities of the issue, with the SCOT framework providing a critical lens. Originating from historical sterilization issues and the increased need to curb the spread of diseases, single-use plastic medical devices began to dominate the healthcare sphere. However, as techniques for proper sterilization allowed for the safety and efficacy of reusable tools, there became a rift in interpretive flexibility between product manufacturers, physicians, and waste management specialists. Whereas manufacturers continue to prioritize the ease and cost-effectiveness of producing single-use plastics, physicians and waste management specialists stress the needs and environmental benefits of reduced waste with reusable devices. The varying degrees of interpretative flexibility between all stakeholders underscores the need for a nuanced approach to policy and manufacturing interventions that promote more sustainable practices throughout the lifecycle of plastic medical devices.

Environmental Impact of Single-use Plastics in Healthcare

Through the continued dominance of single-use plastic medical devices in the healthcare sphere, the surrounding environment continues to take a toll. The massive influx of plastic into

the environment escalates challenges with water purity, ecological damage, and greenhouse gas emissions. Extensive research highlights that hospital waste sent to landfills is known to contaminate groundwater and pollute waterways, which can endanger aquatic life and pollute the agricultural irrigation systems for the United States food supply. Similarly, “open-air storage of medical waste can release a mass of harmful gases such as methane and sulfide, which seriously pollutes the atmosphere” (Hossain et al., 2010; Wei et al., 2021; Witt, 2022). Despite the convenience of single-use plastic medical devices, Dr. Meyer and Alex Foley underscored the importance of using reusable medical devices in hospitals. Mr. Foley explained the stark contrast in the lifecycle of a single-use medical device and a reusable medical device, stating that “single-use devices generate disproportionate amounts of waste compared to reusable devices. Companies like Stryker Sustainability Solutions aim to reduce the strain on landfills by providing and promoting reusable alternatives to single-use medical devices in UVA Health and hospitals around the country” (Foley, Personal Communication, 1/26/2024).

On another note, Dr. Meyer explained the geographical prevalence of these products in hospitals. When asked where single-use devices are used, he explained, “Most single-use devices are used anywhere outside the operating rooms (ORs). Currently, most of the reusable tools in the UVA Health system are used in ORs, while single-use tools are used in all other settings” (Meyer, Personal Communication, 2/20/2024). Since the ORs make up only a small percentage of the total number of medical devices used in hospitals each day, the continued widespread usage of single-use plastic devices intensifies the environmental impact of hospitals. It underscores the urgent need for a more balanced use of reusable medical devices than single-use plastics. However, despite growing awareness, Dr. Meyer explained that the transition towards more sustainable healthcare practices faces challenges due to different views from varying

stakeholders. He continued to say that in order to move towards a more sustainable future in healthcare, all parties must be on the same page when it comes to phasing out single-use plastic medical devices, which will take a massive effort due to changing the relied-on and known medical practices that have been in place for over half a century.

Political Implications and Policy Dynamics Surrounding Single-Use Plastics

The surge in single-use plastic medical devices in the healthcare industry created a stakeholder divide over different variations of interpretive flexibility and environmental concerns through the more significant part of the last century. However, it also triggered intricate political ramifications and policy dynamics in the United States. As detailed in the preceding sections, the imperative to enhance safety through sterility drove the initial adoption of single-use plastic medical devices. (Rizan et al., 2020). Because of this need at the time, US policymakers promoted a shift towards single-use devices. However, this trajectory has evolved through interviews with Dr. Meyer and Alex Foley, revealing contemporary political challenges rooted in sustainability. Political narratives from both sides are entangled with economic considerations, as the convenience and cost-effectiveness of single-use plastics continue to align with the market interests and views of the product manufacturers. These opposing sides create a complex web of influence on policy decisions around the healthcare waste sphere.

Medical waste policy dynamics involve federal, state, and institutional regulations. In 2022, the Department of the Interior vowed to phase out all single-use plastic products on Department-managed lands by 2032 (DOI, 2022). Although this bill is only related to about 20% of the land in the United States, similar policies show slow progress toward a future without

single-use plastics in and outside hospitals. Stakeholders, including policymakers, medical device manufacturers, healthcare institutions, physicians, and waste management specialists, must collaborate in developing policies that balance patient safety, economic considerations, and environmental impact. Dr. Meyer and Alex Foley underscored the need for small steps and targeted initiatives to promote more sustainable policies inside hospitals. These steps include hospitals employing companies like Stryker Sustainability Solutions and adapting their practices to recycle and reuse medical devices to phase out the sheer volume of single-use plastic devices used in UVA Health and other hospitals nationwide.

Challenges and Opportunities for Change in Sustainable Healthcare Practices

As the healthcare industry grapples with the environmental repercussions of the widespread use of single-use plastic medical devices, comprehensive analysis and interviews with specialists reveal a landscape open to transformative changes. Alex Foley explained that "one of the biggest issues that we battle with currently is an issue of perception. Even though we go through arguably more testing and regulatory boundaries to ensure that our repurposed devices are safe and effective compared to new single-use devices, many doctors assume that since it is a repurposed and reused device, it must be tainted in some way" (Foley, Personal Communication, 1/26/2024). Overcoming this incorrect perception necessitates a shift in the mindset of healthcare professionals to ensure that reusable devices do not have a negative perception attached.

The ability to innovate and alter existing systems highlights the path toward a more sustainable healthcare system that does not rely on single-use medical plastics. Data from

interviews with Dr. Meyer and Alex Foley and research suggests that a concerted effort is needed to foster collaboration among all stakeholders. However, the interviews also highlight the benefits of phasing out single-use medical devices from the deeply rooted societal norm that has existed for over 70 years. This effort would serve to reduce the carbon footprint of the United States healthcare industry by reducing plastic waste and serve as a roadmap to a circular economy (MacNeill et al., 2020). By understanding the needs and incentives behind the interpretive flexibility of each stakeholder, policymakers, manufacturers, physicians, and waste management specialists can collaborate to steer the healthcare sector toward a more socially and environmentally conscious future. Using the SCOT framework as a lens emphasizes the importance of understanding these diverse interpretations and interests to allow stakeholders to work together to compromise on a plan that not only serves the safety and economic needs of the front-end stakeholders but also promotes the environmental needs of the stakeholders on the back end of the life cycle of the medical devices.

Limitations and Future Research

While extensive due to the mixed-methods approach to the research question, it is essential to acknowledge the limitations of this research. Due to the narrow focus on interviews in the UVA Health System, answers about the UVA Hospital may limit the findings' generalizability to the broader healthcare landscape in the United States. Additionally, limiting the interviews to one physician and one waste management specialist who advocates for phasing out single-use plastic devices can offer a biased or opinionated view. Offering more interviews from stakeholders on both sides of the issue and research beyond the scope of UVA Health

would allow for a deeper understanding of hospitals that do not already have sustainable practices and policies.

As the researcher, continuing this line of inquiry would involve a deeper exploration of the life cycle analysis between single-use plastic medical devices and reusable medical devices. Additionally, by collaborating with other researchers in the Science, Technology, and Society (STS), research can be continued to explore the ever-evolving landscape surrounding sustainability and the healthcare sphere. These areas may include more sustainable materials for single-use devices, policies worldwide promoting a circular economy, in-depth cost comparisons between single-use and reusable devices, or methods used by sustainable healthcare solutions companies to promote themselves and their products to hospital systems. These future research endeavors are essential to using a wide lens to foster a comprehensive understanding of the interpretive flexibility of all stakeholders and the wide range of socio-technical dynamics influencing contemporary medical waste management.

Conclusion

Assessing the varying roles of interpretive flexibility using the SCOT framework can unravel the complexities of the healthcare industry's reliance on single-use plastic medical devices. This research unravels the nuanced dynamics surrounding environmental, economic, and political changes. Evidence reveals the stark contrast in interpretive flexibility from varying stakeholders throughout the entire life cycle of medical devices. Whereas product manufacturers focus on cost-centric convenience at the front end of the life cycle, physicians, and waste management specialists advocate for environmentally conscious medical practices to reduce the

volume of plastic waste sent into the environment. The SCOT framework serves as a guide by emphasizing collaboration between all stakeholders to understand all the needs and incentives behind each group's viewpoints. Through these conversations and collaborations with one another, proper policy interventions can steer the healthcare sector into more sustainable practices. As the country grapples with the consequences of a surge in medical waste, this research highlights the imperative for transformative changes. Together, collective action and recalibration of deeply rooted norms can open a new era of healthcare that promotes patient safety, economic considerations, and environmental responsibility.

Appendix

I. Interview/Survey Questions for Dr. Matthew Meyer, MD | Critical Care & Anesthesiology, Alex Foley | Stryker Sustainability Solutions,

- a.** What does the lifecycle look like for single-use devices compared to reusable?
- b.** Where are single-use devices being used?
- c.** What are your thoughts on more sustainable options?
- d.** What is currently being done to try and make UVA Health more sustainable?
- e.** What can be done in and out of the hospital to promote more sustainable practices?
- f.** Do others in your field have similar beliefs on the need for more sustainable options?
- g.** Do doctors have a negative view of products that have been repurposed or re-sterilized to be used again?

How much plastic waste does UVA Health produce each day/week/year etc.?

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