HOSPITAL WASTE STREAM IDENTIFICATION, DIVERSION, AND REMANUFACTURING

EXAMINING SOCIOTECHNICAL RELATIONSHIPS BETWEEN HOSPITAL WASTE AND HOSPITAL STAFF

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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

Hospitals produce nearly six million tons of waste each year, and over 1.5 million tons of that waste is plastic (Jain & LaBeaud, 2022). Consumption of plastics in healthcare settings continues to increase due to durability and sterile qualities of plastic as well as the cheap cost of manufacturing. The COVID-19 pandemic further increased the demand for medical plastic and created over 8 million tons of pandemic-associated plastic waste (Peng et al., 2021). Streamlined hospital recycling is a difficult task due to lack of funding and support, insufficient sorting methods, and lack of space (Joseph et al., 2021). Additionally, the introduction of single stream recycling in healthcare settings has decreased the overall cost of recycling but has increased sorting costs and risk of contamination (Dahl, 2010). Therefore, efforts to recycle medical plastics continue to fall short as only 4% of US plastic is recycled leaving 1.44 million tons of waste to be landfilled or incinerated (OECD, 2022). Landfilled plastics can take over a thousand years to decompose and produce microplastics that can become toxic to humans, microorganisms and the environment, and incinerated plastics can release toxic chemicals to the environment (Gibbens, 2019; Motzer, 2023). Medical waste can contain chemicals and other hazardous substances that are more likely to contaminate groundwater and pollute waterways than other types of waste (Witt, 2022). Despite concerns over potential health hazards and environmental impacts, medical waste remains unregulated by the EPA (2016). Therefore, it is the individual hospital's responsibility to lessen the environmental impact of medical waste.

The University of Virginia (UVA) Hospital creates about four thousand tons of waste annually (UVAHealth, 2023). To combat the amount of waste entering the landfill from the hospital, a volunteer organization called medical equipment recovery of clean inventory (MERCI) collects clean, unused, or out of date medical supplies from the UVA Hospital and redistributes these supplies (UVAHealth, 2023). Although the MERCI program is a step in the

right direction, most of the medical supplies collected by MERCI ultimately end up in the landfill as well. This technical project will develop a process to efficiently manufacture a usable material from existing silicone tubing to divert the waste stream from the UVA hospital towards reuse, while the second portion explores the interactions between hospital staff and hospital waste. Using the framework of symmetry and actor network theory as defined by Bruno Latour, the social relationships involved in the creation of a medical recycling system will be analyzed (Latour, 1992).

Technical Topic

To extend the life of medical plastic outside the landfill, this project will identify a single hospital stream, divert it from the landfill, and remanufacture the waste into a useful material. Through interviews with MERCI and hospital staff, the silicone tubing waste stream was selected. Following selection, a lifecycle assessment must be conducted to understand the current manufacturing methods, use, and disposal of silicone tubing. After identifying and assessing the lifecycle of silicone tubing, the next step is to assure the sterility of tubing to avoid contamination. Silicone tubing can be sterilized using rubbing alcohol or a vacuum autoclave cycle (Southmedic, 2020). The UVA Hospital sterilizes its waste before sending it to landfill to lessen the probability of hazardous waste entering the landfill, but since sterilization is not guaranteed, the tubing must be sterilized again (S. DiGuilio, personal communication, October 23, 2023). To ensure the effectiveness and efficiency of the sterilization technique, silicone tubing will be artificially contaminated, sterilized through an autoclave or rubbing alcohol, swabbed and cultured, and assessed. In addition to quantifying data measuring the effectiveness of the sterilization technique, the cost of sterilization will be measured.

Following cleaning and sterilization of the silicone tubing, the focus of the project will shift to degradation and design. The silicone tubing will be broken down into sheets of plastic

using repetitive cutting and heating measures. This flat sheet of silicone can be shredded and melted again to create filament for 3D printing. Silicone filament, which is known for creating smoother parts than other materials, will then be used to print the final prototype (Protolabs, 2022). To design this prototype, interviews with hospital staff will be conducted to assess current medical device needs and discuss potential collaboration on new product implementation.

The overall goal of this technical project is to develop an efficient and sustainable method for disposing of silicone tubing, producing an effective and efficient means of confirming silicone tube sterility, and designing and manufacturing a product from clean silicone tubing waste. The identification, diversion, and remanufacturing of even one stream of medical plastic can be impactful on slowing the effects of climate change (Thiel et al., 2021).

The proposed solution to this technical problem relies on collaboration between the capstone group, MERCI, and hospital staff to ensure that waste is being handled properly.

Sociotechnical relationships in a hospital recycling system

In his 1992 article titled *Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts*, Latour discusses the concept of symmetry between both human and nonhuman actors. Latour defines the idea of symmetry using the example of a door to show that humans influence the development of technology while development of technology also influences the behavior of humans. In his example, the invention of the door allowed people to have privacy while also creating a barrier. The invention of the door then created the need for human interaction to open the door thus showing that the door and humans act symmetrically. Latour also defines a network of actors and analysts that influence the development of technology. Actors' and analysts' ideas must be treated symmetrically so that all influenced social groups are included in the process. If the actors, or creators of technology, do not consult the analysts' opinions when creating technology, valuable stakeholder groups will experience

unintended consequences of the technology. Again, using the door as an example, Latour demonstrates that the creation of a hydraulic door closer certainly lessened the sound of a door closing, but the technology unintentionally discriminates against elderly and young people who do not have the strength to push the door open. These two facets of Latour's framework will be used to examine the relationships between those facilitating the creation of a plastic recycling system and those participating in the recycling system itself.

Previously implemented medical recycling programs often have poor results. These unfavorable outcomes are often due to insufficient training of the actors operating within the recycling system. In a study conducted by the Mayo Clinic to determine the barriers to recycling within the operating room, the primary barrier to medical recycling was lack of knowledge on what can and cannot be recycled (Azouz et al., 2019). Using Latour's framework, it is obvious that for a recycling system to be successful, the hospital staff must, at a very minimum, be informed on how to recycle properly. Additionally, hospital staff in the administration department must be consulted to ensure that there is enough space and proper infrastructure for waste collection. The Healthcare Plastics Recycling Council determined that lack of space and improper labeling of receptacles creates a huge barrier for recycling in many hospitals around Europe (HRCP, 2023). In order to address the problems with recycling in hospitals, it is imperative that the analysts consult the actor network, as Latour suggests.

Analysts, or the MERCI volunteers and capstone project creators, as well as actors, or hospital staff, must work together to find a solution to recycle medical plastic to ensure no groups are not represented. As Latour argues, if hospital staff and administration are not included in the design process, the system of medical recycling will ultimately fail.

Research question and methods

It is evident that to create a system of recycling medical plastics, there needs to be a function network with active participation from hospital staff. Lack of education and training as well as resistance to change have created barriers to implementing recycling programs (Wyssusek et al., 2018). With these barriers in mind, my research will address the question: how can we garner hospital staff support to create a system of recycling of medical plastic from the UVA Health System to divert the waste from the landfill? To investigate this question, I will conduct a case study of hospitals that have successfully implemented plastic recycling systems as well as distributing a survey to hospital staff to gauge support for a recycling program.

There are successful plastic hospital recycling programs both in Europe and the United States of America. Additionally, PVCMed Alliance has helped hospitals in Denmark create successful plastic recycling programs and offers resources for hospitals on their website (Sparrow, 2019). To gain an understanding of how successful programs operate, I will review and analyze literature that details the components of successful plastic hospital recycling programs.

To evaluate how current UVA hospital staff knowledge of hospital waste recycling and interest in participating in a recycling system, I will interview hospital staff that serve various roles in the hospital system. In addition to surgeons, doctors, and nurses, I will interview administration and facilities management staff to include opinions of hospital staff from all departments. Examples of questions I would ask in these interviews include would you be willing to participate in a recycling training session, would you be willing to individually sort plastic, how much waste is produced by a single patient at the UVA Hospital, and what would you like to see in a recycling program. The results of these interviews will allow me to fully

understand the social view of recycling within the UVA Hospital and gather resources to garnering hospital support for creating a medical plastic recycling program.

Conclusion

The growing demand and use of plastic in the American healthcare system has created the urgent need for medical recycling systems in American hospitals. To prevent further environmental damage, it is imperative that hospitals start recycling medical plastics. The overall goal of this project is to divert silicone tubing waste from the UVA Hospital from the landfill and into a useful product.

The research outlined in this paper will produce conclusions of how well UVA hospital staff understand medical recycling and their willingness to participate in a program to reduce medical plastic waste entering the landfill. These conclusions will help in creating a program to increase hospital staff support of a medical recycling system.

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