Examining Sociotechnical Relationships between Hospital Staff and Plastic Waste

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Margaret Weber

Spring 2023

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

Advisor

Rider W. Foley, Department of Engineering and Society

Introduction

Hospitals produce nearly six million tons of waste each year with each hospital bed creating approximately 33 pounds of waste per day (Argo, 2021). 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). 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, which is defined as any plastic used in the medical field, 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). Health hazards associated with health care waste pollution send otherwise healthy individuals to the hospital and create a vicious cycle of waste creation, subsequent environmental pollution, and infection of the community. Despite concerns over health hazards and environmental impacts, medical waste remains unregulated by the EPA (2016). The mishandling and landfilling of plastic waste leads to an increase in sickness in surrounding areas. A hospital's overarching

goal is to keep patients and the community healthy. Therefore, it is the individual hospital's responsibility to lessen the environmental impact of medical waste.

Despite the durability and high reuse properties of plastic, there is little effort made in most hospitals to recycle medical grade plastic. The research presented in this paper explores the interactions between hospital staff and hospital waste to analyze the social relationships involved in the creation of a medical recycling system. Using the framework of symmetry and actor network theory as defined by Bruno Latour, the relationships between medical waste and hospital staff will be analyzed to explore the social elements involved in the creation of a medical recycling system to best garner support in its use and implementation (Latour, 1992).

Case Context

The University of Virginia (UVA) Hospital creates about four thousand tons of waste annually (UVAHealth, 2023). The University of Virginia, which houses the UVA Hospital and Health System, has a sustainability plan for 2020-2030 which includes being carbon neutral by 2030. (UVA Sustainability, 2019) This plan does not include the hospital and health system in any way essentially giving them the opportunity create unlimited waste with no consequences. Waste that is considered hazardous is incinerated, and all other waste is landfilled. Prior to the COVID-19 pandemic, there were efforts in the UVA Hospital to sort clean and unused medical plastics into a separate bin for recycling. Strict hospital guidelines during the pandemic made it difficult to get staffing to collect the items from these bins. With recycling bins constantly overflowing, hospital staff began to ignore the recycling bins leaving the recyclable material to be sent to the landfill. Even though most, if not all, pandemic related restrictions have been lifted, there have been no centralized movements from the UVA Hospital to resume the recycling project.

Operating rooms have a carbon footprint three to six times greater than any other area in healthcare (Goldfield et al., 2023). Operating rooms also create significantly more waste than other departments in a hospital. Instruments used in operation are covered in sterile plastic packaging and surgeons use disposable scrubs that ultimately become waste. Additionally, surgery packs that contain all the instruments a surgeon could possibly need for a surgery and created in advance and oftentimes contain significantly more material than the average surgeon will use in an operation. The generalization of surgery packs leads to many instruments and materials being removed from their sterile packaging, unused in operation, and ultimately sent to the landfill since the items are no longer sterile. The operating rooms at the UVA Hospital are no exception to this trend, and in a study of three surgeons performing 41 surgeries at the UVA Hospital, it was found that, on average, over nine items were completely unused and wasted (Goldfield et al.,2023). There are multiple surgeons at the UVA Hospital interested in creating a medical recycling program, but lack of a centralized movement and support in creating the recycling system has impeded their progress thus far. Therefore, operating room waste from the UVA Hospital is ultimately sent to the landfill.

Stryker Sustainability, a private company that refurbishes medical devices that would otherwise be single use, has a contract with the UVA Hospital to collect and refurbish specific devices. On each floor of the hospital, there are Stryker provided collection bins for these devices. The bins are conveniently located for hospital staff use and are labeled to control contamination as much as possible. Stryker has FDA approval to refurbish a device as many as six times, but ultimately, the refurbished devices also end up in the landfill despite the possibility for reuse outside of the hospital. Additionally, Stryker's environmental impact is limited since the for-profit company must see significant financial gain in refurbishing these devices.

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). MERCI collects supplies that are brought to the recovery room by hospital staff. There are no collection bins on the hospital floors, so it is the sole responsibility of hospital staff to individually collect their excess inventory and deliver it to MERCI staff. Due to the busy schedule of most hospital employees and lack of convenient collection bins on hospital floors, only a small fraction of recoverable material is ever delivered to MERCI. 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.

The UVA Hospital continues to create a significant amount of waste every day but there continues to be a lack of initiative in creating a centralized system to combat medical plastic waste disposal in the landfill. As the use of single use medical plastics continues to increase, without a medical recycling system, so will the environmental impact of the hospital.

Relationships between Hospital Staff and Waste

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.

In order to implement a system of medical recycling, the relationships between hospital staff and waste must be researched. Additionally, the relationship between hospital waste and hospital staff must be treated symmetrically as the properties of medical waste influence hospital staff use and vice versa. 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, 2023a). 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. The actor network theory framework argues if hospital staff and administration are not included in the design process, the system of medical recycling will ultimately fail. Encountering medical plastic is inevitable for hospital staff, and as Latour argues, all hospital staff opinions should be valued in the process of creating a medical recycling system to maximize participation and overall success of the program. Success in a medical recycling program is measured by amount of hospital staff participation and total waste collected.

Research Question and Methods

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 research question, I analyzed case studies of nine United States of America (US) based hospitals that have successfully implemented plastic recycling systems to review the components that made these systems successful. Additionally, I conducted interviews with seven UVA Health employees, contractors, and volunteers. The results of the interviews and case studies were analyzed using the actor network theory framework to reveal the complex relationships between healthcare employees and medical plastic waste and inform designers on best practices to ensure participation in the recycling program.

The Healthcare Plastics Recycling Council (HPRC), a private technical consortium of industry peers who advocate for the improvement of recycling of healthcare plastics, provides

resources to hospitals across the US and Europe to support the formation and early stages of medical plastic recycling programs. (HPRC, 2023b) The HPRC website hosts a database of case studies of successful hospital recycling programs that detail barriers to creating programs and offer suggestions for overcoming these problems. Due to differences in healthcare procedures and structure between the US and other nations, only the US hospital case studies were analyzed. Eight of the nine cases presented information on an individual health system while the ninth presented a study of a recycling partnership with several health systems. The eight health systems included in individual case studies were Stanford Hospital & Clinics, Gundersen Health, Mayo Clinic, HealthPartners, Dartmouth-Hitchcock, Ohio State, Kaiser Permanente, and Cleveland Clinic in addition to a case study on health systems throughout the Chicago region.

To evaluate UVAHealth knowledge of hospital waste recycling and interest in participating in a recycling system, seven interviews were conducted with individuals connected to the UVAHealth system in various ways. I interviewed one neurosurgeon, one anesthesiologist, one supply manager, one certified nursing assistant (CNA), one fourth-year nursing student, one contractor from Stryker Sustainability, and one MERCI volunteer. The interviews with the Stryker Sustainability employee and MERCI volunteer focused on questions related to operational logistics of medical equipment recovery. Questions included in these interviews were: what some of the challenges are to collecting medical supplies, what percentage of recovered material is improperly disposed of in the Stryker/MERCI bins, and what steps were/are taken to ensure active hospital participation. The other five interviews focused on knowledge and identification of waste, current sustainability methods, and opinions on future directions of medical plastic recycling. Questions included in these interviews were: would you be willing to participate in a recycling training session, would you be willing to individually sort

different types of waste into separate bins, how much waste do you see produced per patient, and what characteristics would you like to see in a recycling program. The results of these interviews revealed the complex social network involved in medical plastic collection and provided clarity on characteristics of a recycling program that are necessary for success.

Results

Communication and collaboration between hospital administration, hospital staff, and outside vendors is essential in the creation of a successful medical plastic recycling program. Interviewees all explicitly stated characteristics they would need to see in a medical recycling program to maximize staff engagement. Additionally, several of the case studies provided key takeaways and recommendations for hospitals starting medical plastic recycling programs. These key takeaways and recommendations all connect to the theme of, as Latour suggests is best practice in his actor network theory framework, consulting hospital staff, or actors, for their opinions on the recycling program before creating and implementing it. To establish a successful plastic recycling program the hospital must first listen to the needs of the stakeholders who will use the technology. The results of the case studies and interviews indicate that, to 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, the system must meet these three criteria: centralized organization with unit-based training and education, convenience in use, and proper staffing and physical space.

Training and Education

Stryker Sustainability is a company that refurbishes medical devices. Stryker collects the medical devices through bins located in various locations throughout hospital units. Alex Foley,

a contractor from Stryker Sustainability, expressed that constant education and re-education is essential to ensuring staff understand expectations of recycling programs (Foley, personal communication, January 12, 2024). These bins include labels that detail which items can be put in the bins. Foley asserts that while labeling measures help, consistent reminders and re-education meetings are necessary to limit contamination.

Before every shift, staff teams share a huddle to go over important information. (Scanlon, personal communication, February 26, 2024). Scanlon, a CNA, asserts that these meetings are a perfect time to remind staff of ways they could be more sustainable throughout their shift. HealthPartners, a Minnesota-based healthcare system, attributes their success to having sustainability committee members join these huddles to give reminders of recycling practices (HPRC, n.d.-b). Scanlon believes implementing a similar strategy in the UVA Health System would increase engagement. Consistent with what other interviewees stated, Scanlon added that labeling recycling bins with items that can and cannot be recycled would help lower the risk of contamination and make the process easier for staff. Scanlon and all other interviewees stressed the importance of proper training to make a medical recycling program successful.

Several of the case studies on the HRPC database identify training and education as a key factor in creating a successful medical plastic recycling program. The Mayo Clinic case study advises hospitals starting programs to start education on a small scale and have individual unit or lab leadership emphasize education and training (HPRC, n.d.-c). A case study on the Ohio State University Wexner Medical Center lists improper education as the main reason for lack of hospital support for recycling programs. (HPRC, 2023c) This case study similarly advocates for an initial small-scale sustainability and education push. The study further advises that creating standard operating procedures for recycling will maximize engagement.

The interviews and case studies suggest that for a hospital plastic recycling program to be successful, the actors who will use the technology must learn how to use the technology. These results suggest that the actors playing the key roles in a plastic recycling program must be consulted and have unit-based training to learn to use the technology before the technology can be implemented.

Accessibility and Convenience

Nurses and other clinicians are busy, and therefore, recycling bins must be put in easily accessible locations so that hospital staff can remain focused on the patient rather than the waste (Traenkle, personal communication, February 26, 2024). Traenkle, a fourth-year nursing student, asserted that for a hospital medical recycling program to gain any support, the collection bins must be placed in easily accessible bins in convenient locations. A case study of the Stanford Hospital and Clinics further emphasized this point and attributed part of its success to the strategic location of bins in the hospital (HPRC, 2013). The recycling bins at the Stanford healthcare system were in areas where most waste was generated to encourage maximum engagement. Additionally, bins were attached to "nurse-on-wheels" carts, so the bins are always accessible to nurses who often generate the most plastic. Hospitals in the Chicago regional area asserted that the operations of the system must minimally affect day-to-day operations to maximize engagement (HPRC, 2016). Gundersen Health in western Wisconsin performed a walkthrough of the hospital following nursing and facilities management staff to determine the optimal locations for collection bins (HPRC, n.d.-a). The engagement with staff from the beginning and convenience of bin location has made staff participation in the plastic recycling program extremely high.

Operating rooms are notoriously one of the largest generators of plastic waste in a hospital. Operating rooms are essentially given a "free pass" to create mass amounts of waste without consequences to maintain patient safety and sterility (Meyer, personal communication, January 16, 2024). In interviews with a neurosurgeon and anesthesiologist, both parties mentioned they would participate in a medical plastic recycling program if collection bins were placed conveniently in the operating room (Moosa, personal communication, November 17, 2023; Meyer, personal communication, January 16, 2024). Operating room staff often open much of their surgical pack prior to the start of an operation, so including a collection bin inside the operating room would make recycling convenient and easy to the operating room staff and increase engagement.

The results of these interviews and case studies indicate that to maximize participation in a medical recycling program, waste collection bins must be placed in convenient locations for staff to use. To determine the best locations for collection bins, the creators of the system should shadow hospital staff and place bins where waste is frequently created. Placing bins in locations where hospital staff are typically creating and interacting with waste will increase the participation and amount of waste recycling. Through consulting the actors and stakeholders in healthcare network, a convenient and easy to operate recycling system can be created.

Staffing and Physical Space

The MERCI program in the UVA Hospital has many problems that limit the success of the program. MERCI lacks the manpower and space necessary to expand the program to truly make an impact (Linda Varin, personal communication, September 14, 2023). Participation in the MERCI program is limited because hospital staff must personally collect and deliver clean and unused plastics to the MERCI room. Additionally, the MERCI program consists of only one

room, so there is not any space to expand the program. Interviewees mentioned their resistance to participate in the MERCI program due to the small scale and lack of staff involved in the program.

Lack of space in the hospital to create a medical plastic recycling program can decrease the level of success the program experiences. Case studies at Kaiser Permanente and the Cleveland Clinic ultimately failed due to lack of space to properly handle the recycled material (HPRC, 2022b). With bins overflowing and nowhere to put the plastic, hospital staff ultimately stopped engaging with the program. To combat this, a medical recycling program must have adequate space to maximize engagement.

Almost all the healthcare systems involved in the case studies had some sort of sustainability staff to monitor and update the medical recycling program. In addition to updates and monitoring, these staff also ensure proper collection of recycled materials. The Dartmouth-Hitchcock Medical Center created a "green team champion" per department that oversees educating, answering questions, and monitoring the recycling system on a department scale. The clinical champion ensures there is active participation in the program.

Overall, to create a successful hospital plastic recycling program, the creators must account for spacing and staffing needs. Actors in the hospital network were found to participate less in recycling programs where there was inadequate space and staffing. Therefore, to foster success in the medical plastic recycling program, the designers must listen to stakeholders and account for recycling program staff and space.

Discussion

Interdepartmental collaboration in healthcare settings has seen an increase over the past decade. Research indicates that increased collaboration leads to better healthcare practices and improved patient outcomes (Bosch & Mansell, 2015). Proper communication and cooperation play a large role in determining the success of these interdepartmental collaborations. When stakeholders can properly communicate their needs, the decision maker understands the variables that must be considered in the development of patient operations. Latour's actor network theory emphasizes the importance of communication with stakeholders to ensure all actors are accurately represented in the design of a technology. When stakeholders' needs are met, they are more actively engaged in interdepartmental collaborations. Stakeholder communication is essential to creating any system in the hospital as indicated in the results of the interviews and case studies as well as interdepartmental collaborations.

The case studies used to collect data for this research paper were all collected from the same source and written by the same organization. The cases, although written and obtained from the same source, varied widely in length, detail, and composition. These extreme differences indicate either a limitation in availability of data or limitation in collection methods across sources. Additionally, since the case studies were all written by the same source which provides funding and guidance for the initial stages of creating medical recycling systems. Therefore, the results of each case study were relatively similar. Additionally, there is potentially bias in the results of interviews conducted with hospital staff, contractors, and volunteers. There were many challenges in finding hospital staff to agree to an interview due to the demanding schedule of healthcare workers. All interviewees agreed to participate in an interview despite their schedule which may indicate a personal interest in this project or sustainability in the hospital. Some participants explicitly mentioned their interest in sustainability and recycling.

Thus, the results of the interviews may be a misrepresentation of opinions on medical plastic recycling in the UVA Health System as a whole. Finally, waste and facilities management would play a large role in creating a medical recycling program, but they were not included in this research due to limitations of scheduling an interview.

In the future, I would look for case studies on successful recycling programs outside of the HPRC database. While these cases are comprehensive and span different regions in the United States, they are all written by the same organization which may have some bias in their composition. I would also review cases where recycling programs fell short on goals or did not work altogether to analyze potential pitfalls in creating a plastic recycling program in a hospital. Additionally, I would seek to increase the scale of hospital staff opinions involved through additional interviews or a survey distributed to multiple departments.

Engineers play an important role in the development and formation of new technology. The results of this research indicate that it is essential to understand the interests and needs of stakeholders who will interact with technology for it to be successful. In my future career as an engineer, there will be many technologies that I develop that will be used by others. Using the results of this research paper to guide my decisions, I will ensure that the needs of those using the technology are considered in the design process. The research presented in this paper also stands as a reminder that communication is essential for successful collaboration which is inherent in an engineering career.

Conclusion

Through interviews of hospital staff, contractors, and volunteers and review of case studies, it is evident that collaboration is essential for creating a medical plastic recycling

program that effectively diverts waste from the landfill. The main takeaway of the research presented above is that all stakeholders involved in the process for creating a medical plastic recycling program must be involved in the program's development. Single-use plastic will not be removed from healthcare settings soon. In understanding the relationships between hospital staff and waste, healthcare systems can assess the needs of healthcare employees to participate in recycling program. With the these needs in mind, the system can develop with characteristics to maximize engagement and volume recycled. Therefore, it is important that healthcare systems consider their environmental impacts and work towards becoming more sustainable. Ultimately, recycling medical plastics is only the first step in becoming more sustainable. Healthcare systems must also work towards recycling materials beyond plastic to minimize the negative environmental impact of hospitals.

References

Argo, Dawson. "How Much Medical Waste Is Produced?" *Medical Waste Pros*, 10 Sept. 2021, www.medicalwastepros.com/blog/how-much-medical-waste-is-produced/.

Azouz, S., Boyll, P., Swanson, M., Castel, N., Maffi, T., & Rebecca, A. M. (2019). Managing barriers to recycling in the operating room. *The American Journal of Surgery*, *217*(4), 634–638. https://doi.org/10.1016/j.amjsurg.2018.06.020

Bosch, B., & Mansell, H. (2015). Interprofessional Collaboration in Health Care. *Canadian Pharmacists Journal* , *148*(4), 176–179. https://doi.org/10.1177/1715163515588106

Dahl, R. (2010). Green Washing. *Environmental Health Perspectives*, *118*(6). https://doi.org/10.1289/ehp.118-a246

Gibbens, S. (2019, October 4). *Can medical care exist without plastic?* Science. https://www.nationalgeographic.com/science/article/can-medical-care-exist-without-plastic#:~:text=Practice%20Greenhealth%2C%20a%20non%2Dprofit

Goldfield, Natalie M., et al. "Sterile Surgical Supply Waste Identification Using Asynchronous Analysis: Pediatric Surgery QI Pilot." *Surgery Open Science*, vol. 15, Sept. 2023, pp. 32–37, https://doi.org/10.1016/j.sopen.2023.07.025. Accessed 5 Feb. 2024.

HPRC. (n.d.-a). *Case Study: Gundersen Health*. Healthcare Plastics Recycling Council. Retrieved March 2, 2024, from https://www.hprc.org/case-study-gundersen-health/

HPRC. (n.d.-b). *Case Study: Health Partners*. Healthcare Plastics Recycling Council. Retrieved March 2, 2024, from https://www.hprc.org/case-study-health-partners/

HPRC. (n.d.-c). *Case Study: Mayo Clinic*. Healthcare Plastics Recycling Council. Retrieved March 2, 2024, from https://www.hprc.org/case-study-mayo-clinic/

HPRC. (2013). *CLINICAL RECYCLING AT STANFORD HOSPITAL AND CLINICS: A HEALTHCARE PLASTICS RECYCLING COUNCIL PILOT STUDY (2013)*.

HPRC. (2016). *Chicago Regional Demonstration Project Report Presented by HPRC and PLASTICS*. https://www.hprc.org/wp-content/uploads/2022/07/HPRC-PLASTICS-Chicago-Project-Final-Report.pdf

HPRC. (2022a). *Creative Cooperation: An In-Depth Look at the Innovative Dartmouth-Hitchcock Recycling Program*. https://www.hprc.org/wp-content/uploads/2022/05/Case-Study-Dartmouth-Hitchcock.pdf

HPRC. (2022b). *Thinking Outside the Box: Exploring Non-Profit Partnerships to Expand Hospital Plastics Recycling A Closer Look at the Kaiser Permanente and Cleveland Clinic Programs*. https://www.hprc.org/wp-content/uploads/2022/05/Cast-Study-Kaiser-Permanente-and-Cleveland-Clinic.pdf

HRCP. (2023a). *Barriers to Recycling Healthcare Plastics | HPRC*. Healthcare Plastics Recycling Council. http://www.hprc.org/barriers-to-recycling-healthcare-plastics/#:~:text=Multi%2DMaterials&text=For%20example%2C%20a%20product%20may

HPRC. (2023b). *For Hospitals*. Healthcare Plastics Recycling Council. https://www.hprc.org/for-hospitals/

HPRC. (2023c, April 13). *Case Study: The Ohio State Wexner Medical Center Barrier Mapping*. Healthcare Plastics Recycling Council. https://www.hprc.org/hospital-barrier-mapping-case-study/

Jain, N., & LaBeaud, D. (2022). How Should US Health Care Lead Global Change in Plastic Waste Disposal? *AMA Journal of Ethics*, *24*(10), E986-993. https://doi.org/10.1001/amajethics.2022.986

Joseph, B., James, J., Kalarikkal, N., & Thomas, S. (2021). Recycling of Medical Plastics. *Advanced Industrial and Engineering Polymer Research*, *4*(3). https://doi.org/10.1016/j.aiepr.2021.06.003

Latour, B. (1992). *"'Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts.'"* http://www.bruno-latour.fr/sites/default/files/50-MISSING-MASSES-GB.pdf

Motzer, J. (2023, August 22). *Single-Use Plastics and Their Alternatives in Modern Healthcare*. The Emerald Review. https://emeraldreview.com/2023/08/single-use-plastics-and-their-alternatives-in-modern-healthcare/

OECD. (2022, February 22). *Plastic pollution is growing relentlessly as waste management and recycling fall short, says OECD*. OECD. https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm

Peng, Y., Wu, P., Schartup, A. T., & Zhang, Y. (2021). Plastic waste release caused by COVID-19 and its fate in the global ocean. *Proceedings of the National Academy of Sciences*, *118*(47). https://doi.org/10.1073/pnas.2111530118

US EPA, O. (2016, February 17). *Medical Waste*. US EPA. https://www.epa.gov/rcra/medical-waste#who%20regulates%20medical%20waste

UVAHealth. (2023a). *Facts & Stats | UVA Health*. Uvahealth.com. https://uvahealth.com/about/facts-stats

UVAHealth. (2023b). *Recycling Medical Supplies: Reducing Waste | UVA Health*. Uvahealth.com. http://uvahealth.com/services/community-relations/recycling-medical-supplies

UVA Sustainability. (2019, December). *Climate Action*. Sustainability.vriginia.edu. https://sustainability.virginia.edu/climate-action

Witt, A. (2022, November 21). *Medical Waste & The Environment*. Medical Waste Pros. https://www.medicalwastepros.com/blog/medical-waste-and-the-environmental-impact/#:~:text=Biomedical%20waste%20and%20chemicals%20(including