Sterility, Sustainability, and Justice: Rethinking Healthcare Waste at UVA

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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 U.S. healthcare industry is a major contributor to environmental waste and greenhouse gas emissions, producing over 6 million tons of waste annually across hospitals, clinics, and outpatient centers. This includes a broad spectrum of materials: regulated medical waste, pharmaceuticals, plastics, textiles, food waste, and packaging. The U.S. healthcare system is the world's largest producer of healthcare-related plastic waste, creating an ethical imperative for leadership in global sustainability efforts (Kyrillos & Kass, 2022). Approximately 85% of this waste is non-hazardous, yet much of it is improperly sorted and ends up in high-impact disposal streams such as incineration or landfilling, which release pollutants including dioxins, furans, and heavy metals (WHO, 2018). In addition to solid waste, the U.S. healthcare system is responsible for around 8% of national greenhouse gas emissions, linking clinical operations directly to climate-related health burdens (Eckelman & Sherman, 2016).

One of the most waste-intensive areas of hospital operations is the operating room, which accounts for 20–33% of total hospital waste, despite representing a fraction of the hospital's physical space (Kagoma et al., 2012). High usage of disposable instruments, drapes, gowns, and packaging materials—combined with conservative infection control protocols—has entrenched a culture of disposability across many departments. While single-use materials became standard in the 1980s and 1990s due to infection risk concerns, evolving sterilization technologies and global waste infrastructure now challenge the necessity of this model (SCENIHR, 2009). Recent studies suggest that hospitals may be over-relying on regulated medical waste disposal methods, leading to avoidable costs and environmental harm (Duong, 2023).

Beyond environmental impacts, the economic burden of poor waste management practices is substantial. Hospitals routinely overpay for the treatment of non-hazardous waste

when it is misclassified as regulated or infectious waste. Additionally, procurement models centered on single-use goods demand repeated purchasing of tools and supplies that could otherwise be reused, refurbished, or recycled. The National Institutes of Health (2023) reports that recycling steel alone can reduce production energy by 60%, water usage by 40%, and mining waste by 97%, underscoring the missed opportunity in current disposal habits. Despite the availability of more sustainable alternatives, many institutions lack the internal infrastructure, vendor coordination, and staff training required to adopt them effectively.

This research investigates healthcare waste generation and management at UVA Health as a case study for understanding broader institutional challenges and opportunities. Rather than proposing an immediate intervention, this project assesses the feasibility of integrating sustainable waste practices—such as improved segregation, recycling, and reuse—within clinical and operational workflows. Drawing on a combination of stakeholder interviews, internal institutional data, and environmental literature, this study seeks to identify actionable points of leverage where UVA Health could reduce waste without compromising safety or care quality. As healthcare systems increasingly recognize the link between environmental health and patient outcomes, sustainable waste management must become an institutional priority. UVA Health, like many academic medical centers, is uniquely positioned to lead in this area by aligning its clinical practices with its public commitments to climate action and community well-being. This research offers a foundation for informed decision-making at the intersection of sustainability, efficiency, and ethical responsibility in hospital operations.

Background and Significance

The widespread adoption of single-use metal instruments in healthcare aimed to mitigate infection risks. However, the environmental and financial burden of their disposal has become increasingly apparent. The incineration or landfill disposal of these instruments contributes to pollution and greenhouse gas emissions, leading to the unnecessary depletion of high-quality metals. Given advancements in sterilization technology and recycling infrastructure, there is a pressing need to reconsider the reliance on disposable medical tools. Hospitals can implement more sustainable practices that not only align with environmental goals but also reduce costs and improve operational efficiency. A significant portion of this waste is incinerated or sent to landfills. Incineration, often chosen for its ability to neutralize infectious agents, releases harmful pollutants such as dioxins, furans, and heavy metals, especially when filtration systems are inadequate or outdated. These pollutants contribute to both local and global environmental degradation, affecting air quality and posing long-term health risks. Landfilling healthcare waste, particularly when not properly segregated, risks contaminating soil and groundwater and often increases the volume of regulated medical waste requiring specialized handling and disposal (National Research Council, 2000; WHO, 2018).

The COVID-19 pandemic further intensified these concerns, triggering a sharp rise in the production and disposal of items like masks, gloves, face shields, and gowns. In many facilities, pre-existing waste infrastructure proved insufficient to handle this surge, and emergency disposal protocols often relied on incineration regardless of environmental consequence (WHO, 2022; Andeobu et al., 2022). As a result, the pandemic highlighted the fragility of current healthcare waste systems and drew international attention to the need for more resilient and sustainable waste handling practices.

Waste from healthcare facilities is not only environmentally harmful but also inequitably distributed in its impacts. Incinerators, landfills, and treatment centers are disproportionately located in low-income and marginalized communities, exposing residents to higher levels of pollution and health risks. Over 75% of waste incinerators in the U.S. are located in communities of color or economically disadvantaged areas, where emissions of dioxins, mercury, and particulate matter contribute to elevated rates of asthma and cancer (Energy Justice Network, n.d.). These patterns often reflect historical disinvestment and political disenfranchisement, leaving affected communities with few resources to contest environmental burdens (Environmental and Energy Study Institute, 2019). As a result, healthcare waste has become an environmental justice issue, prompting calls for hospitals to consider not just the operational logistics of disposal but also its broader social and ecological consequences.

Within hospitals themselves, the complexity of waste categorization and disposal contributes to inefficiencies and mismanagement. Studies have shown that a large proportion of non-infectious waste is incorrectly disposed of as regulated medical waste (RMW), which is more costly and environmentally damaging to process. Furthermore, institutional behaviors—driven by risk aversion, convenience, and procurement practices—often default to overuse of disposable materials, even when alternatives may be available (Duong, 2023; Practice Greenhealth, n.d.). At UVA Health and similar institutions, these challenges are mirrored in daily operations. From operating rooms to emergency departments, medical waste streams are shaped by clinical workflows, sterilization procedures, and storage protocols that frequently prioritize sterility and speed over long-term sustainability or waste reduction. As a result, healthcare waste represents not only an operational issue but also a broader environmental and ethical concern—one that intersects with climate change, community health, and institutional responsibility.

Methodology

This study employs a mixed-methods approach to assess the institutional, environmental, and operational dimensions of healthcare waste generation at UVA Health. Rather than testing a specific intervention, the goal of the research is to document and contextualize current waste practices, using multiple forms of data to explore how and why waste is produced, managed, and perceived within the hospital environment. The central research question guiding this analysis is: *How do current healthcare waste practices at UVA Health contribute to environmental and operational challenges, and what institutional insights can inform more sustainable future strategies?*

The first component of the methodology involved a comprehensive literature review to examine prevailing trends and challenges in healthcare waste management. This included an analysis of academic research, institutional reports, and policy documents addressing the environmental, operational, and ethical dimensions of medical waste. The review covered topics such as the environmental impacts of single-use materials, barriers to recycling and reuse, and the economic inefficiencies associated with improper waste classification. Particular attention was given to frameworks for sustainable waste practices, comparative assessments of reusable versus disposable materials, and real-world case studies of institutional reform. This literature helped contextualize UVA Health's waste practices within broader national and international patterns, revealing systemic issues such as overreliance on disposables, misclassification of waste, and the uneven implementation of sustainability initiatives. It also provided examples of alternative models that have successfully reduced environmental impact and operational costs, informing the questions and priorities explored in subsequent stages of this study.

The other dimension of the study involved conducting semi-structured interviews with key stakeholders at UVA Health. Interviewees included clinical staff, such as emergency department nurses and anesthesiologists, as well as support personnel from facilities management and hospital sustainability initiatives. These conversations focused on firsthand experiences with waste generation and disposal, staff perceptions of recycling and reuse, and the logistical, cultural, and institutional factors that shape waste-related decision-making. Questions were designed to elicit both practical insights and ethical considerations, including concerns about infection control, convenience, and workflow efficiency. All interviews were analyzed thematically to identify recurring patterns, points of friction, and perceived opportunities for change.

To guide the analysis, this research draws on the Science, Technology, and Society (STS) framework, with a specific emphasis on environmental justice. This lens enables a critical examination of how healthcare waste is not just a technical or operational issue, but one with social and ethical dimensions. By triangulating findings from literature, institutional documents, and stakeholder interviews, this methodology provides a comprehensive, multi-layered understanding of healthcare waste practices at UVA Health. Rather than proposing immediate implementation solutions, the study aims to identify where systemic barriers exist, where institutional readiness may emerge, and where further research or investment could yield the greatest impact. These findings are intended to inform future waste reduction initiatives, procurement reforms, and sustainability-focused policy changes within UVA Health and comparable institutions.

Literature Review

Recent research has underscored the significant environmental burden posed by healthcare waste, particularly from single-use materials. While hospitals generate millions of tons of waste annually, the systems for managing, repurposing, or recycling that waste remain underdeveloped. A foundational study by Plisko (2015) outlines a tiered approach to waste prevention in hospitals, emphasizing source reduction, reuse, recycling, and energy recovery. However, the report also identifies that many hospitals still prioritize waste disposal over prevention, in part due to operational constraints and limited staff engagement. Despite the existence of national standards and EPA guidelines, recycling and reuse programs are often implemented inconsistently across healthcare institutions. The McComb et al. (2024) capstone study at UVA provides a comprehensive life cycle assessment (LCA) comparing single-use and reusable stainless steel surgical instruments. The authors evaluated environmental impacts across cost, energy, global warming potential (GWP), and water consumption. They found that reusable instruments offer substantial environmental and economic benefits, with break-even points in cost and GWP achieved after as few as 3 to 9 uses. Over a three-year period, the study projected savings of over $160,000 and 12,000 kg CO_2-equivalent emissions from switching to reusable instruments in select categories. However, one notable trade-off was a dramatic increase in water usage due to autoclaving, raising questions about the sustainability of sterilization infrastructure and the need for future investment in more efficient systems.

In addition to environmental assessments, real-world pilot programs have offered insight into how healthcare institutions can shift procurement and disposal habits. Practice Greenhealth (n.d.) reports that UCLA Medical Center's reusable isolation gown initiative saved $1.1 million and diverted nearly 300 tons of textile waste from landfills between 2012 and 2015. Although

focused on garments rather than instruments, this case demonstrates that institutional procurement change is both feasible and impactful when paired with clear policy support and clinical engagement. However, few examples of similar programs exist for metal surgical tools, highlighting a gap in the operationalization of recycling pathways for high-quality steel. The economic and environmental case for recycling stainless steel is well established. According to data from the National Institutes of Health (NIH), recycling steel saves 60% in production energy, 40% in water usage, and reduces mining waste by over 90% (NIH, 2023). Nevertheless, there is currently no dedicated recycling stream for single-use metal surgical instruments in most U.S. hospitals. Companies such as Sharps Medical Waste Services focus on compliant disposal of sharps and pharmaceuticals, but they do not offer collection or resale programs for steel instruments—a missed opportunity identified in both the McComb study and broader literature (Sharps Medical Waste Services, n.d.). International case studies have also begun to explore the viability of circular approaches to medical steel. For instance, van Straten et al. (2021) describe a Dutch program that collected and refurbished surgical steel from hospitals, converting it into raw material for new instruments. The program not only demonstrated net cost savings of over €39,000 across participating hospitals but also showed that both single-use and reusable discarded tools had recovery potential. These findings suggest that the failure to recycle stems less from technological limitations and more from the absence of institutional protocols and market partnerships.

Beyond operational efficiency and environmental performance, recent literature emphasizes the environmental justice implications of healthcare waste. Waste incineration and landfill facilities are disproportionately located in low-income neighborhoods and communities of color, leading to heightened exposure to pollutants and adverse health outcomes. The

American Public Health Association (2023) reports that incinerators and medical waste treatment sites emit carcinogens, heavy metals, and other toxins that accumulate in nearby environments, contributing to respiratory issues, cancer, and long-term developmental disorders in affected populations. These communities are not only more likely to live near such facilities but also have fewer resources to oppose them or mitigate their impacts. The Energy Justice Network (n.d.) similarly documents how municipal zoning policies have historically concentrated polluting infrastructure in marginalized areas, resulting in a form of environmental racism that is rarely addressed by healthcare institutions themselves. A recent investigation by KFF Health News (2023) found that trash incinerators in states like Florida disproportionately affect Hispanic and Black neighborhoods, creating a public health crisis that extends beyond the walls of the hospital. Meanwhile, the Environmental and Energy Study Institute (2019) emphasizes that waste burdens must be assessed through a justice-oriented lens, particularly when health systems claim commitments to health equity and community wellness. These findings argue for a broader framing of hospital sustainability, one that includes not only emissions reductions or cost savings but also accountability for where waste goes, who it affects, and how these outcomes intersect with race, income, and power. As UVA Health and similar institutions develop sustainable waste strategies, it is imperative to consider these justice-based perspectives to ensure that improvements within hospital walls do not externalize harm onto already-vulnerable communities.

Together, this body of literature reveals that while the technical feasibility and environmental advantages of reusable and recyclable instruments are well documented, the main barriers are organizational and logistical. There remains a critical need for research that synthesizes environmental data with internal institutional dynamics—such as procurement

policies, staff practices, and vendor relationships—to identify how sustainability initiatives can be implemented effectively in specific hospital contexts. This study responds to that need by examining UVA Health's current waste practices, reviewing opportunities for recycling and reuse, and highlighting institutional readiness and barriers through stakeholder interviews and document analysis.

Discussion and Results

Stakeholder interviews and institutional document analysis at UVA Health reveal that the challenges of sustainable healthcare waste management are not isolated to any one material category, but are instead deeply embedded in clinical routines, infrastructure limitations, and organizational culture. While single-use metal instruments emerged as a particularly compelling case study due to their high material value and recoverability, broader categories of waste—such as textiles, plastics, and regulated medical waste (RMW)—also contribute substantially to the hospital's environmental impact. These findings affirm the patterns identified in the literature, which emphasize that healthcare systems often default to disposability for reasons of speed, sterility, and habit, even when more sustainable options are both available and cost-effective.

Clinical staff interviews pointed to a culture of "automatic" disposal. One emergency department nurse described how every metal instrument, regardless of condition or contamination status, is discarded into the sharps container immediately after use. A similar sentiment was expressed by an anesthesiologist, who noted that many tools are used only briefly and discarded because that has become the norm. These practices are not necessarily rooted in clinical necessity, but rather in workflow momentum, sterilization hazards, and the absence of clearly supported alternatives. The overuse of sharps containers for non-hazardous items was identified by several staff members as a missed opportunity. Once an item enters the sharps

stream, it is treated as hazardous and incinerated—foreclosing any chance of recycling or reuse. This reflects broader concerns in the literature regarding the misclassification of waste and the institutional tendency to over-rely on regulated disposal methods due to convenience and perceived liability.

Interviews with sustainability and facilities staff further revealed that while vendor partnerships exist for general waste, RMW, and pharmaceuticals, no such partnerships are currently in place for the collection and recycling of clean surgical metals. This absence is not due to technological infeasibility, but rather due to gaps in contracts, procurement incentives, and administrative direction. A staff member remarked that while some vendors could be approached to handle recyclable metals, no department has formally requested this change, and no protocols currently exist to enable it. These findings mirror those from case studies abroad, such as the Netherlands' circular healthcare model for metal instrument recovery and highlight the role of institutional will in translating environmental feasibility into operational practice.

Despite these structural limitations, staff expressed significant openness to change, particularly if it is designed to be simple and integrated seamlessly into clinical workflows. The UCLA Medical Center's successful implementation of reusable isolation gowns offers a domestic example of how targeted procurement and disposal reforms can be scaled effectively. At UVA Health, such a pilot could serve as a low-risk entry point for broader waste reduction efforts. However, the success of any intervention would require cross-departmental coordination, infection control approvals, and consistent communication to staff. As one nurse explained, "We won't change work habits overnight". Importantly, the interviews also illuminated how waste challenges extend far beyond metal tools. Staff described the sheer volume of plastic packaging and unopened materials disposed of during routine procedures, with one clinician noting that "we

throw out so much plastic with every kit". This speaks to a broader issue of overpackaging and one-size-fits-all kits that leave hospitals discarding large amounts of unused materials. Literature similarly emphasizes that healthcare institutions often lack the infrastructure to differentiate between contaminated and clean waste, leading to costly and environmentally damaging overuse of RMW disposal pathways. Reforms in this area could include restructured surgical kits, improved waste labeling, and staff education focused on more nuanced classification.

Although much of the focus in this study has been on operational and environmental outcomes, several interviewees also raised questions about where UVA Health's waste ultimately ends up and who is affected by it. While staff were not always aware of the final destination of incinerated or landfilled material, some expressed concern upon learning about the broader environmental consequences. This echoes what scholars and advocacy organizations have long argued: that healthcare waste is not just a matter of internal efficiency, but one of environmental justice. Incinerators and landfills receiving medical waste are often located in socioeconomically disadvantaged communities, exposing residents to disproportionate levels of air and soil pollution. These facilities become silent extensions of clinical decision-making—places where the externalities of single-use culture and disposal protocols are felt most acutely. While UVA Health has made public commitments to sustainability and community health, its current waste practices risk contributing to systemic harm unless disposal pathways are explicitly evaluated for their justice implications. Incorporating environmental justice metrics into procurement and disposal policy—such as vendor location, treatment method transparency, and community burden assessments—could help align institutional values with real-world outcomes. Doing so would not only enhance UVA's environmental stewardship but also reinforce its ethical obligations to equity in public health.

Taken together, the interview and institutional findings reveal three intersecting barriers: a culture of disposability shaped by routine and risk-aversion; a lack of infrastructure and vendor pathways to support material recovery; and insufficient data to drive accountability or investment. Yet these are not immutable obstacles. The success of programs at institutions like UCLA, the potential efficiencies outlined in the McComb et al. life cycle assessment, and the enthusiasm of staff for low friction changes all point toward a path forward. UVA Health, with its strong sustainability mission and academic resources, is well-positioned to take incremental but meaningful steps—starting with pilot programs, improved tracking, and stakeholder engagement—that align daily hospital practices with long-term environmental and ethical goals.

Conclusion

This research has examined the institutional practices, environmental implications, and stakeholder perspectives surrounding healthcare waste at UVA Health, with a particular focus on the overlooked category of single-use metal surgical instruments. Through a combination of literature review, internal data analysis, and interviews with clinical and sustainability staff, the study highlights a critical tension: while environmental and financial incentives for recycling and reuse are well established, the systems needed to operationalize those practices are largely absent.

Staff at UVA Health recognize the scale and cost of daily waste and expressed interest in participating in sustainability initiatives. Yet the lack of designated recycling streams, vendor partnerships, and centralized sterilization coordination has created a default culture of disposability. Instruments that are used for mere seconds are routinely discarded, not because of clinical necessity, but because of logistical inertia and policy gaps. These behaviors persist

despite compelling evidence that reusable instruments outperform single-use ones in both cost and environmental impact after minimal use.

The literature demonstrates that successful transitions toward sustainable procurement and waste systems are possible when institutions combine clear administrative commitment with simple, actionable interventions. Whether through UCLA's reusable gown initiative or the Netherlands' steel refurbishment program, these examples show that procurement decisions, clinical behaviors, and environmental justice outcomes are all interconnected. At UVA Health, the opportunity exists to take similar steps—beginning with a pilot recycling bin for clean metal tools, better waste tracking, and a more strategic approach to autoclaving.

More broadly, this study situates healthcare waste within the framework of environmental justice. The materials discarded in UVA's Emergency Department today may end up in incinerators or landfills tomorrow—facilities that are disproportionately located in low-income and marginalized communities. These communities, already burdened by environmental hazards and health inequities, bear the downstream consequences of clinical waste decisions made far from their neighborhoods. As such, reducing healthcare waste is not solely an operational or environmental imperative; it is an ethical obligation. UVA Health must recognize that its sustainability initiatives affect not only internal efficiency but also public health beyond hospital walls. By integrating justice-based metrics into waste management—such as assessing the geographic and demographic distribution of disposal impacts—UVA can elevate its sustainability strategy into a model of socially responsible healthcare. In doing so, it has the potential not only to reduce its environmental footprint, but to lead the field in aligning clinical excellence with community well-being and environmental equity.

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