

Accounting and Healthcare Waste Management: Strategies to Improve Financial Efficiency and Reduce Environmental Impact

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ABSTRACT

Healthcare waste management represents both a financial and environmental challenge for healthcare institutions. This article discusses accounting and financial management strategies that can be implemented to optimize operational costs related to healthcare waste disposal, while minimizing environmental impact. A theoretical framework based on financial and environmental sustainability is proposed, integrating environmental accounting policies and waste management methodologies. The results demonstrate that adequate financial planning and the implementation of treatment technologies can significantly reduce costs and improve efficiency in healthcare waste management. The findings highlight the need for more robust management policies and greater investment in sustainable treatment technologies.

1. Introduction

Healthcare waste management has emerged as a growing challenge for health systems worldwide, due to the increase in the generation of waste derived from hospital activity, especially in contexts of pandemics and global health crises such as COVID-19 (López et al., 2022). This type of waste, which includes both hazardous biological materials and chemical and pharmaceutical products, requires rigorous management that guarantees public safety and environmental protection (Pérez & Díaz, 2021). Mismanagement of this waste can have disastrous consequences, not only because of the potential for the spread of infectious diseases, but also because of the long-term damage to the ecosystem.

From a financial perspective, healthcare waste management represents a significant burden for healthcare institutions. The costs associated with the storage, transportation, treatment, and final disposal of hazardous waste are high and require efficient planning (Smith & Brown, 2023). However, many health institutions do not have adequate environmental accounting systems in place that allow them to integrate these costs into their financial analysis, limiting their ability to optimize resources and reduce expenses (Simpson & Taylor, 2023).

The need to improve efficiency in waste management has led many organizations to adopt approaches based on environmental accounting, which integrates environmental costs into financial decision-making, allowing for better allocation of resources and greater long-term economic sustainability (Romero et al., 2021). The implementation of environmental accounting in waste management not only helps to identify and reduce the hidden costs associated with inefficient waste management, but also encourages greater environmental responsibility in institutions (González & Martínez, 2022).

In this context, emerging technologies and new waste management strategies play a crucial role. Investment in more sustainable waste treatment technologies, such as sterilization and incineration with energy recovery, has proven to be an effective solution to reduce both the volume of hazardous

waste and operating costs (Fernández et al., 2022). However, for many health institutions, especially in resource-limited regions, these technologies can represent a considerable upfront investment, underscoring the need for detailed financial analysis based on environmental accounting (Schaltegger et al., 2020).

The objective of this study is to analyze how the integration of environmental accounting in healthcare waste management can improve the financial efficiency of health institutions and, at the same time, reduce the environmental impact of these activities. In addition, strategies and technologies that can be implemented to optimize the waste management process and ensure greater long-term sustainability are investigated. This research focuses on reviewing the best practices documented in recent years and exploring the experiences of health institutions that have successfully implemented waste management policies based on financial and environmental sustainability (López et al., 2022; Romero et al., 2021).

This introduction seeks to provide a comprehensive view of the problem, highlighting the importance of proper financial and environmental management in the management of sanitary waste. The relationship between financial costs and environmental impact is critical, and this study proposes an interdisciplinary approach that integrates accounting and environmental management to meet this global challenge (Simpson & Taylor, 2023).

Theoretical Framework

Environmental Accounting and its Application in Healthcare Waste Management

Environmental accounting is an approach that allows organizations to integrate environmental costs and benefits into financial decision-making. This approach helps health institutions identify, measure, and manage the costs associated with their environmental impacts, including those derived from the generation and disposal of sanitary waste (Schaltegger et al., 2020). According to López et al. (2022), the implementation of environmental accounting in hospitals is key to optimizing resources and reducing costs related to hazardous waste management. This type of accounting includes not only direct costs, such as transportation and treatment, but also indirect costs, such as fines for non-compliance or reputational costs.

Environmental accounting can be divided into two main components: physical accounting and monetary accounting (Romero et al., 2021). The first focuses on the measurement of physical waste flows, while the second focuses on the calculation of the costs associated with the management of this waste. The combination of both components allows institutions to identify opportunities to improve their financial efficiency while reducing their environmental impact (Simpson & Taylor, 2023).

Healthcare Waste Management: Classification and Regulations

Healthcare waste is generally classified into four main categories: infectious waste, pathological waste, pharmaceutical waste, and chemical waste (López et al., 2022). Each of these types requires different methods of handling, treatment, and disposal. In healthcare waste management, it is essential to follow strict regulations to ensure both the safety of healthcare workers and the protection of the environment. According to the World Health Organization (WHO), up to 85% of the waste generated in healthcare facilities is non-hazardous, while the remaining 15% is classified as hazardous, and requires specialized management (World Health Organization, 2021).

Table 1. Classification of Sanitary Waste and Treatment Methods

Type of Waste	Description	Treatment Method
Infectious Residues	Materials contaminated with blood or other bodily fluids	Autoclave, incineration, chemical disinfection

Pathological Waste	Human tissues, organs or animals	Incineration
Pharmaceutical Waste	Expired or unused medications	High-temperature incineration
Chemical Residues	Toxic or corrosive substances	Chemical treatment, neutralization

Source: Adapted from World Health Organization (2021)

In addition to international regulations, countries implement national regulations that determine how this waste should be handled. In the European Union, for example, Directive 2008/98/EC on waste establishes specific requirements for the management of medical waste, including measures to prevent risks to human health and the environment (López et al., 2022). Similarly, in the United States, the Environmental Protection Agency (EPA) regulates the management of hazardous waste in the healthcare sector through the Resource Conservation and Recovery Act (RCRA) (Pérez & Díaz, 2021).

Emerging Technologies for Healthcare Waste Treatment

Advances in healthcare waste treatment technologies have facilitated the adoption of more sustainable and efficient practices. The most commonly used technologies include incineration, autoclaving, and chemical sterilization. According to Fernández et al. (2022), incineration remains one of the most widespread technologies, especially for infectious and pharmaceutical waste. However, due to environmental concerns related to gas and particulate emissions, cleaner alternatives, such as gasification and pyrolysis, are being developed.

Another emerging approach is the use of chemical and biological sterilization technologies, which are better suited for pathological and pharmaceutical waste that cannot be incinerated. These technologies offer a safer and more sustainable option for hazardous waste disposal, minimizing environmental impacts (González & Martínez, 2022).

Sustainability and Financial Efficiency in Healthcare Waste Management

Sustainability in healthcare waste management refers to the implementation of practices that minimize negative impacts on the environment, while optimizing financial resources. According to Gómez et al. (2020), health institutions that have adopted sustainable management practices have managed to significantly reduce both operating costs and the volume of waste generated. A key part of this success has been the integration of environmental accounting into the financial systems of these institutions, allowing them to keep detailed track of the costs associated with waste management (Simpson & Taylor, 2023).

Financial efficiency, on the other hand, is directly related to an institution's ability to manage its resources effectively, minimizing costs without compromising service quality or regulatory compliance. Institutions that invest in sustainable technologies and optimize their waste management processes have been able to reduce costs in the long term and improve their reputation in terms of environmental responsibility (Smith & Brown, 2023).

Table 2. Cost Comparison Between Traditional Methods and Emerging Waste Treatment Technologies

Treatment Method	Average Cost Per Ton	Environmental impact
Traditional Incineration	\$500-\$700	CO2 emissions, toxic waste
Autoclave	\$300-\$450	Low environmental impact
Chemical Sterilization	\$350-\$500	Moderate environmental impact
Gasification and Pyrolysis	\$400-\$600	Low environmental impact

Source: Adapted from Fernandez et al. (2022) and Simpson & Taylor (2023)

2. Methodology

The methodology used in this study was designed with the aim of identifying and analyzing the best practices in the management of medical waste and its relationship with financial efficiency through environmental accounting. To do this, a mixed approach was used that combined a systematic review of recent scientific literature, data collection through interviews with health sector professionals, and a comparative analysis of case studies.

1. Systematic Review of Literature

The first stage of the study consisted of a systematic review of the literature, which focused on research published between 2019 and 2023. Open access and subscription academic databases were used, such as Scopus, Web of Science, PubMed, and Google Scholar. Studies were selected that addressed the following key areas: environmental accounting in the health sector, healthcare waste management, sustainability and waste treatment technologies.

The inclusion criteria for the articles were as follows:

- Publications in peer-reviewed journals.
- Studies that analyze the financial impact of waste management in health institutions.
- Research that assesses the environmental impact of healthcare waste treatment methods.
- Studies that propose or evaluate emerging technologies in waste management.

We excluded studies that were not specific to the health sector or that were outdated. In total, 120 relevant articles were identified, of which 50 met all inclusion criteria and were selected for final analysis (Fernández et al., 2022; Romero et al., 2021; Simpson & Taylor, 2023).

Table 1. Inclusion and Exclusion Criteria in the Systematic Review

Inclusion Criteria	Exclusion Criteria
Peer-reviewed publications between 2019-2023	Studies prior to 2019
Research on environmental accounting in health	Non-health items
Studies on the financial and environmental impact of waste	Reports without peer review or isolated case studies
Evaluation of emerging technologies in waste management	Non-academic sources or without empirical data

Source: Authors.

2. Semi-Structured Interviews with Health Professionals

The second phase of the research consisted of semi-structured interviews with 15 health professionals, including financial managers, environmental managers and specialists in medical waste treatment from hospitals located in Europe and Latin America. The purpose of the interviews was to obtain qualitative information on current waste management practices and the integration of environmental accounting in their institutions.

The interviews were conducted remotely through videoconferencing platforms such as Zoom and Google Meet, with an average duration of 45 minutes each. Participants were asked to describe the main financial challenges related to waste management, the impact of environmental regulations, and the technologies used to minimize environmental impact.

Key questions included:

- How is healthcare waste managed in your institution?
- What treatment technologies do you use to minimize costs and environmental impact?
- Are environmental accounting principles applied to quantify the costs associated with waste management?
- What challenges does your institution face in implementing more sustainable practices?

3. Comparative Case Analysis

In addition, a comparative analysis of case studies in health institutions that have successfully implemented sustainable technologies and practices in waste management was carried out. Five hospitals recognized for their good practices in environmental sustainability and financial waste management in Europe and Latin America were selected. The comparative analysis focused on the following aspects:

- **Technologies used:** The technologies used in each hospital for the treatment and disposal of hazardous waste were identified.
- **Financial impact:** The costs associated with waste management before and after the implementation of these technologies were analyzed.
- **Environmental impact:** The environmental benefits derived from the reduction of emissions and hazardous waste were evaluated.

This analysis made it possible to compare the different strategies and draw lessons applicable to other health institutions.

Table 2. Case Studies: Comparing Technologies and Financial Results

Hospital	Technology Used	Cost Before (\$/Ton)	Cost After (\$/Ton)	Reduction (%)
Hospital A (Spain)	Autoclave	600	450	25%
Hospital B (Germany)	Incineration with energy recovery	700	500	28%
Hospital C (Brazil)	Chemical sterilization	550	400	27%
Hospital D (Argentina)	Gasification	650	470	28%
Hospital E (UK)	Incineration and selective recycling	620	480	23%

Source: Authors' elaboration based on data from Fernández et al. (2022), González and Martínez (2022), Simpson and Taylor (2023).

4. Data Analysis

The analysis of the data collected in the systematic review, interviews and case studies was carried out using a qualitative-quantitative approach. For the qualitative data obtained from the interviews, thematic content analysis was used, where recurring patterns were identified in the participants' responses, such as the main financial challenges and the benefits of the implementation of environmental accounting.

On the other hand, the quantitative data of the case studies were processed through a descriptive analysis, calculating the percentage reductions in waste management costs and the improvement in environmental sustainability indicators.

The use of a mixed approach made it possible to triangulate data from different sources and obtain a comprehensive view of the problem, supporting the validity and reliability of the results obtained (Simpson & Taylor, 2023; Romero et al., 2021).

3. Results and Discussion

A The analysis of data obtained through systematic literature review, interviews with health professionals and case studies revealed important results in relation to improving financial efficiency and reducing environmental impact through more sustainable management of healthcare waste. The main findings of the study are detailed below.

1. Adoption of Sustainable Technologies for Healthcare Waste Management

One of the most outstanding findings is the positive relationship between the adoption of emerging technologies for waste treatment and the reduction of operating costs. Hospitals that have invested in technologies such as autoclave, incineration with energy recovery, and gasification reported a significant decrease in costs per ton of waste treated, as well as an improvement in their environmental sustainability indicators (Fernández et al., 2022; Simpson & Taylor, 2023).

In the comparative analysis of cases, it was observed that hospitals that used incineration technologies with energy recovery and gasification achieved cost reductions ranging from 23% to 28%, while those that used chemical sterilization and autoclaves achieved reductions of up to 25% (González & Martínez, 2022). The following table summarizes the results obtained in terms of the reduction of operating costs in the institutions analyzed.

Table 1. Reducing Costs by Adopting Healthcare Waste Treatment Technologies

Hospital	Technology Used	Initial Cost (\$/Ton)	Final Cost (\$/Ton)	Reduction (%)
Hospital A (Spain)	Autoclave	600	450	25%
Hospital B (Germany)	Incineration with energy recovery	700	500	28%
Hospital C (Brazil)	Chemical sterilization	550	400	27%
Hospital D (Argentina)	Gasification	650	470	28%
Hospital E (UK)	Incineration and selective recycling	620	480	23%

Source: Authors' elaboration based on data from Fernández et al. (2022), González and Martínez (2022), Simpson and Taylor (2023).

2. Optimization of Waste Segregation Processes

Another important finding is related to the proper segregation of waste in health institutions. Hospitals that implemented strict protocols for the classification of infectious, pathological, and non-hazardous waste were able to reduce the total volume of hazardous waste generated, which in turn decreased treatment costs (López et al., 2022). According to the interviews, the correct segregation of waste allowed hospitals to reduce the volume of waste classified as hazardous by 10% to 15%, which significantly decreased the costs associated with specialized treatment.

An example of this is Hospital C in Brazil, which implemented an education and training program for health personnel on the correct segregation of waste. As a result, the hospital achieved a 15% reduction in the volume of hazardous waste, which allowed them to save approximately \$30,000 a year in treatment costs (Pérez & Díaz, 2021).

Table 2. Reducing the Volume of Hazardous Waste Through Correct Segregation

Hospital	Initial Volume of Hazardous Waste (Ton)	Final Volume (Ton)	Reduction (%)	Estimated Annual Savings (\$)
Hospital C (Brazil)	200	170	15%	30,000
Hospital B (Germany)	180	160	11%	22,000
Hospital A (Spain)	150	135	10%	18,000
Hospital D (Argentina)	170	150	12%	25,000
Hospital E (UK)	190	170	11%	27,000

Source: Authors' elaboration based on data from López et al. (2022) and Pérez & Díaz (2021).

3. Integration of Environmental Accounting in Waste Management

A critical aspect that emerged in the interviews with the financial managers of the hospitals was the importance of integrating environmental accounting into the financial systems of the institutions. Those hospitals that adopted this approach reported greater transparency in the actual costs associated with waste management and improved financial decision-making (Simpson & Taylor, 2023). Environmental accounting allowed institutions to quantify both direct costs, such as waste treatment and transportation, and indirect costs, such as fines for non-compliance with environmental regulations or reputational costs (Romero et al., 2021).

The data obtained showed that hospitals that implemented an environmental accounting system managed to improve their financial efficiency indicators in waste management by 15% on average, which translated into considerable annual savings.

Table 3. Impact of Environmental Accounting on Financial Efficiency

Hospital	Financial Efficiency Before	Financial Efficiency After	Improvement (%)	Estimated Annual Savings (\$)
Hospital A (Spain)	75%	88%	13%	20,000
Hospital B (Germany)	70%	85%	15%	25,000
Hospital C (Brazil)	68%	83%	15%	22,000
Hospital D (Argentina)	72%	86%	14%	23,000
Hospital E (UK)	74%	87%	13%	24,000

Source: Authors' elaboration based on data from Simpson & Taylor (2023) and Romero et al. (2021).

4. Environmental Impact and Regulatory Compliance

Finally, hospitals that adopted sustainable waste management practices reported a significant improvement in their environmental impact indicators, as well as greater compliance with international and local regulations on hazardous waste management (López et al., 2022; World Health Organization, 2021). The data showed that institutions that implemented cleaner and more sustainable technologies managed to reduce their greenhouse gas emissions by up to 30%, which contributed not only to environmental well-being, but also to an improvement in their institutional reputation.

4. Conclusion and future scope

Healthcare waste management presents significant challenges both financially and environmentally. From the results obtained in this study, it can be concluded that the implementation of environmental accounting strategies, together with the adoption of sustainable technologies and the optimization of waste segregation processes, offers tangible benefits for health institutions. These practices not only improve financial efficiency, but also contribute significantly to the reduction of environmental impact.

1. Financial Efficiency Through Environmental Accounting

The integration of environmental accounting in health institutions has proven to be an effective strategy to improve transparency and financial decision-making related to waste management (Romero et al., 2021). By identifying and quantifying the direct and indirect costs associated with waste, institutions can optimize their resources and reduce costs in the long term. Hospitals that adopted this approach achieved a 13% to 15% improvement in their financial efficiency indicators, saving them between \$20,000 and \$25,000 annually on average (Simpson & Taylor, 2023). This improvement is particularly important in a sector where pressure on budgets is constant and the need to comply with environmental regulations is increasing (González & Martínez, 2022).

2. Impact of Emerging Technologies on Cost Reduction

The use of advanced technologies for waste treatment, such as incineration with energy recovery, autoclaving, and gasification, has been instrumental in reducing operating costs and minimizing environmental impact. Hospitals that invested in these technologies managed to reduce their hazardous waste management costs by a range of 23% to 28%, thus improving their operational efficiency (Fernández et al., 2022). The adoption of these technologies not only results in financial savings, but also allows institutions to comply with stricter environmental regulations and reduce their carbon footprint (López et al., 2022). These results underscore the importance of continuing to promote technological innovation in healthcare waste management.

3. Importance of Waste Segregation for Volume and Cost Reduction

Proper segregation of medical waste is key to reducing the volume of hazardous waste that requires specialized treatment. As shown in the case analysis, hospitals that implemented rigorous segregation protocols managed to reduce the volume of hazardous waste by 10% to 15%, generating significant savings in treatment costs (Pérez & Díaz, 2021). This approach not only reduces the financial burden for institutions, but also contributes to more efficient and sustainable waste management. Training staff in the correct classification of waste is a critical component in this process and should be part of sustainability strategies in health institutions (López et al., 2022).

4. Reduced Environmental Impact and Improved Regulatory Compliance

Hospitals that implemented sustainable practices and clean technologies achieved a significant reduction in their environmental impact, allowing them not only to comply with local and international environmental regulations, but also to improve their institutional reputation (World Health Organization, 2021). In particular, institutions that adopted treatment technologies such as incineration with energy recovery and gasification reduced their greenhouse gas emissions by up to

30% (Simpson & Taylor, 2023). These results highlight the importance of health institutions taking a proactive approach to waste management, investing in sustainable solutions that allow them to improve their long-term environmental and financial performance.

5. Recommendations for the Future

Based on the results obtained, it is recommended that health institutions continue to integrate environmental accounting into their financial systems, in order to obtain a clearer view of the costs associated with waste management and facilitate informed decision-making (Romero et al., 2021). In addition, it is suggested to increase investment in emerging waste treatment technologies, which not only offer financial benefits, but also environmental ones. Ongoing training of staff in proper waste segregation should also be a priority to ensure more efficient and safer management of healthcare waste.

In conclusion, the combination of environmental accounting, advanced technology and improved segregation processes represents a comprehensive approach that can transform the way healthcare institutions manage their waste. This transformation is crucial not only for the financial sustainability of hospitals, but also for the protection of the environment and the well-being of the communities in which they operate (González & Martínez, 2022).

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