

Review

Anesthesia and Operating Room Waste Management

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Keywords: "operating room", "surgical room", "anesthesia", "healthcare waste", "hospital waste", "anesthesia waste", "reducing waste", "waste reduction", "surgical packs", "standard 5 packs", "recycling", and "cost saving"

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Introduction

Operating rooms (ORs) are associated with high waste generation that contribute significantly to the overall hospital waste production, costs, and environmental impact. Hence, this study sought to explore the impact of the revision of single-use surgical packs in waste reduction and hospital cost savings.

Methods

A systematic review with meta-analysis was conducted to assess waste reduction strategies in operating rooms. A search was conducted on databases to evaluate the impacts of interventions on anesthesia waste reduction and cost savings. The search was limited to studies conducted between 2014 and 2024.

Results

The findings of the systematic review indicate that the revision of single-use surgical packs was associated with significant reductions in OR and anesthesia waste production and hospital costs.

Conclusion

The findings show that waste reduction initiatives could be effective in enhancing the sustainability of surgical procedures. The study underscores the role of simple but sustainable practices in addressing persistent environmental and financial challenges in the healthcare sector.

1.0. INTRODUCTION

Waste generation, disposal, and management are key challenges in the global healthcare industry. Waste generated by healthcare facilities contribute to pollution, emissions, and harm to population health. In the United States, an estimated 8.5% of the total greenhouse gas emissions come from the healthcare industry.¹ Annually, the United States produces 6 billion tons of waste that cost the healthcare system \$3 billion in disposal costs.² Operating rooms (ORs) are among the largest contributors to healthcare waste, accounting for up to 70% of all wastes generated by hospitals.³ Anesthesia waste form a critical component of medical waste in ORs due to the huge amounts of unused or partially drugs, ampoules, syringes, and inhalation agents.⁴ These wastes are associated with huge financial burdens due to the need for costly disposal, incineration, autoclaving, and sterilization. In operating rooms, single-use disposable surgical items are frequently used with significant contribution to the environmental burden of the healthcare system.⁵ Healthcare professionals, particularly in surgical departments, prefer single-use items for their assurance in quality, sterility, and convenience. Consequently, single-use devices form a significant component of medical wastes

in OR.⁶ However, various opportunities exist for minimizing waste in ORs including the implementation of recycling initiatives.² The minimization of waste in operating rooms has the potential to reduce environmental impact and financial burden of the healthcare system. This study sought to explore the efficacy of waste reduction interventions in hospital operating rooms.

2.0. METHODS

2.1. PROTOCOL AND REGISTRATION

The study followed the standard protocol of scientific systematic review and meta-analysis. As a systematic review, the study was deemed a non-human-subject research, per Georgetown University guidelines, and thus ethic review was not required. Protocol registration was not done for this study.

2.2. ELIGIBILITY AND CRITERIA

The primary focus of this study was the examination of the cost-saving and waste reduction potential of the revision of common surgical supply packs in operating rooms. Studies

were included in the review and analysis if they met pre-determined eligibility criteria. First, articles were eligible if they focused on the topic of waste reduction in operating room. Second, articles were included if their interventions involved the revision of surgical packs. The search was restricted to articles written in the English language. Additionally, the eligibility criteria inclusion criteria included articles that adopted robust research designs such as randomized controlled trials (RCTs), cohort studies, clinical audits, clinical trials, and cross-sectional studies. Articles were included in this study if they were published in the past ten years from 2014 to 2024. The exclusion criteria included studies that did not explicitly evaluate the effectiveness of interventions, articles that were not focused on operating rooms, inaccessible articles, and articles written in languages other than English.

INFORMATION SOURCES

This study relied on information collected from published sources. It primarily focused on previous studies on waste management interventions in OR and their impacts on healthcare costs. Studies used as sources of information in this systematic review were original peer-reviewed journal articles.

2.3. SEARCH STRATEGY

Searches were conducted on databases including PubMed, CINAHL, EBSCO, EMBASE, Scopus, Web of Science, and the Cochrane Library in July 2024. The search relied of key terms such as “operating room”, “surgical room”, “anesthesia”, “healthcare waste”, “hospital waste”, “anesthesia waste”, “reducing waste”, “waste reduction”, “surgical packs”, “standard

packs”, “recycling”, and “cost saving”. The Boolean operators “AND” and “OR” were used to combine concepts and search words.

2.4. DATA COLLECTION PROCESS

Data was collected from the articles that met the inclusion criteria. An Excel spreadsheet was used to extract data relating to study characteristics such as authors, country of study, year, study design, study setting, sample size, and type of interventions used. In addition, data on unused items in standard single-use packs was collected.

2.5. RISK OF BIAS IN INDIVIDUAL STUDIES

In systematic reviews, the quality of evidence inherent in analyzed studies determines the value of the results. Thus, biased and poorly conducted studies could skew the results of systematic reviews. Hence, evaluating the rigor and quality of individual studies is critical in generating reliable findings. In the present study, individual studies were evaluated for methodological quality, rigor, and biases. Studies with any potential biases were excluded.

2.6. SYNTHESIS OF RESULTS

A narrative synthesis was adopted to summarize the findings of individual studies by integrating and comparing the findings across studies. The similarities and relationships between these studies were highlighted and described. In addition, a quantitative synthesis was used to analyze the evidence in these studies using statistical methods. Quantitative metrics such as means and medians were calculated and presented in tables and charts. Pooled prevalence was determined for waste reduction initiatives and their impacts on cost savings and environmental impact.

3.0. RESULTS

3.1. STUDY SELECTION

The initial search process yielded 831 records of articles that addressed the reduction of waste in surgery operating rooms and the impacts of these initiatives on cost. Of these records, 342 were removed due to duplications. A total of 489 records were screened for eligibility of which 456 were removed because they did not specifically address the topic of interest. In the end, 33 articles were read and assessed for eligibility. Subsequently, 25 articles were excluded due to lack of interventions and methodological issues. Thus, eight articles met the inclusion criteria established in this study and were subjected to qualitative and quantitative analyses [Figure 1].

3.2. STUDY CHARACTERISTICS

A total of eight articles met the inclusion criteria established in this study. The studies examined the feasibility of interventions for reducing waste, hospital savings, and improving the environmental impact in general surgery cases. Six of the studies were conducted in the United States and one in each in Australia and France. The studies involved various levels of pre-post research designs. Table 1 summarizes the articles analyzed in this study.

3.3. RISK OF BIAS WITHIN STUDIES

The studies included in this review had low to moderate risks of bias. The studies adopted robust research designs with reliable data collection and analysis methods. As such, the overall risk of bias in the systematic review was low. Table 2 summarizes the risks of bias across the studies included in this review.

3.4. RESULTS OF INDIVIDUAL STUDIES

The revision of commonly used surgical supply packs led to significant reduction in waste generation and hospital costs across most studies. Three articles reported a decrease in anesthesia waste following the implementation of waste reduction procedures.^{2,5,11} The rest of the studies focused on general OR waste. The highest cost reduction of 72.2% was achieved in the study by Fraifeld et al. (2021). However, Bouthors et al. (2019) reported a negative impact of recy-

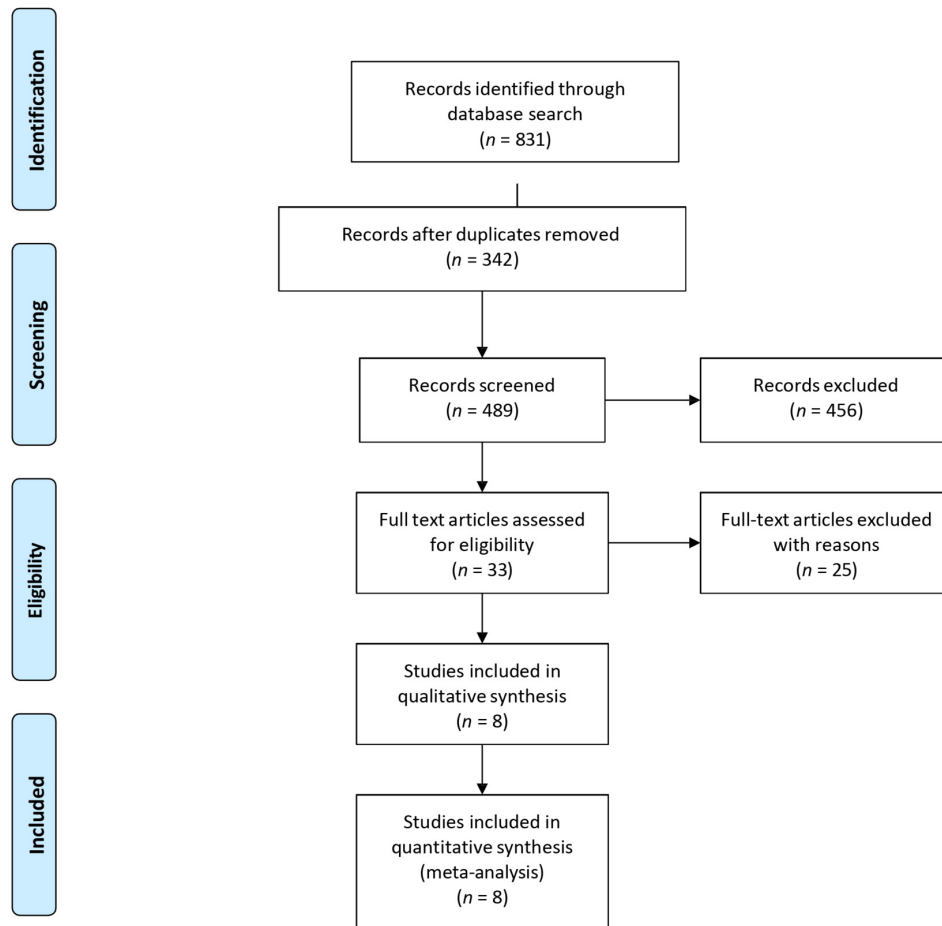


Figure 1. Article selection in the systematic review process

cling on waste and cost reduction. Overall, the results show a beneficial impact of surgical packs revision on hospital cost savings and waste generation.

3.5. SYNTHESIS OF RESULTS

The findings of this study show the positive significant impact of revision of surgical packs in ORs on waste reduction and cost savings. A pooled prevalence of 21.8% was reported for cost savings. On the other hand, waste reduction across the studies had a pooled prevalence of 8.06%. The heterogeneity observed between studies was primarily due to the outcomes of the study by Bouthors et al. (2019) that reported huge negative outcomes of recycling on cost savings and

waste reduction. Despite the outlier study, the overall heterogeneity was low, indicating that the interventions led to improvements in cost savings and waste management.

4.0. DISCUSSION

Operating rooms are key contributors to the hospital wastes problem. In this study, a systematic review was conducted to assess the efficacy of revised surgical packs in resolving this problem. Of the eight studies that met the inclusion criteria, seven showed a significant improvement in cost

savings and waste reduction following the revision of surgical packs. The studies suggest that anesthesia waste could be minimized through quality improvement and use of revised surgical packs. The results of the present study show that simple strategies such as safe recycling and revising of surgical packs could have important implications in hospital waste management. The strategies may be implemented in other settings beyond the operating room for sustainable healthcare management. Moreover, the findings of this study suggest the need for managers of healthcare institutions to take active interventions towards reducing waste production through the simple methods highlighted in this study. However, careful consideration should be taken when recycling surgical packs to ensure that the costs associated with sterilization does not exceed the costs of single-use packs.

5.0. CONCLUSION

This study demonstrates the evidence for sustainable surgical practices in the operating room. The majority of studies analyzed in this systematic review show that simple revisions of surgical packs could have substantial impacts on cost savings and waste reduction in ORs. Hence, surgical centers should implement interventions aimed at customizing surgical packs for sustainable waste management.

Table 1. Characteristics of articles analyzed in the systematic review

Authors (Year, Country)	Study design	Setting	Participants	Interventions	Main Results
Bouthors et al. (2019). ⁷ France	Quasi-experimental prospective study	OR of a university hospital	Patients	Reusable surgical packs	Single-use packs had less waste and greater cost savings compared with reusable packs
Braschi et al. (2022) ⁸ USA	Pre-post study	OR in an urban county hospital	Surgeons	Revised surgical packs. Eliminating unused surgical items	Significant cost savings; significant waste reduction
Fraifeld et al. (2021). ² USA	Pre-post design	ORs at a various hospitals	Surgeons	Waste segregation initiative	Positive impact on waste and hospital costs
Thiel et al. (2019) ⁵ USA	Pre-post study	Surgery center at a university hospital	Surgeons, Patients	Design of custom packs	Custom packs had significantly less waste and costs compared with standard packs
Park et al. (2021). ⁹ USA	Pre-post design	OR at a children's hospital	Pediatric surgeons and patients	Surgeons' awareness, reusable surgical items	There was a significant reduction in total costs of surgical procedures
Perrego (2017). ¹⁰ USA	Pre-post design	OR of a medical center in Delaware	Perioperative staff including nurses, surgeons, and technicians	Waste management educational program	The intervention led to a 41% reduction in waste generation. Annual cost savings of \$11,900
Wyssusek et al. (2022). ¹¹ Australia	Pre-post study	OR in a women's hospital	Surgeons	Quality improvement with educational program and system changes	Significant cost savings, net waste reduction
Yalamanchi et al. (2022) ¹² USA	Pre-post design	OR at an academic medical center	Surgeons, OR nurses, technicians, supply chain analysts	Quality improvement initiative, revised surgical trays	Significant cost savings reported from the intervention

Table 2. Risk of bias across the studies in the systematic review

Authors (Year, Country)	Selection bias	Study design	Intervention integrity	Drop out	Analyses	Overall assessment
Bouthors et al. (2019) ⁷	Moderate	Low	Low	Low	Low	Low
Braschi et al. (2022) ⁸	Low	Moderate	Moderate	Low	Low	Low
Fraifeld et al. (2021) ²	Low	Low	Low	Low	Low	Low
Thiel et al. (2019) ⁵	Moderate	Low	Low	Low	Low	Low
Park et al. (2021) ⁹	Low	Low	Low	Moderate	Low	Low
Perrego (2017) ¹⁰	Low	Low	Moderate	Low	Low	Low
Wyssusek et al. (2022) ¹¹	Moderate	Low	Moderate	Low	Moderate	Moderate
Yalamanchi et al. (2022) ¹²	Low	Moderate	Moderate	Low	Moderate	Moderate

Table 3. Cost savings and waste reduction in individual studies

Authors (Year)	Cost savings	Waste reduction
Bouthors et al. (2019) ⁷	-314.3%	-3,400%
Braschi et al. (2022) ⁸	47.63%	10.34%
Fraifeld et al. (2021) ²	72.2%	72.7%
Thiel et al. (2019) ⁵	55%	13%
Park et al. (2021) ⁹	43%	56%
Perrego (2017) ¹⁰	62.3%	41%
Wyssusek et al. (2022) ¹¹	58.33%	95.63%
Yalamanchi et al. (2022) ¹²	31.64%	42.1%

Table 4. Random effects of individual studies

Study	Cost savings		Waste reduction	
	Effects	% Weight	Effects	% Weight
Bouthors et al. (2019) ⁷	-0.156	0.1422	-0.4558	0.1422
Braschi et al. (2022) ⁸	0.395	0.0138	-0.085	0.0138
Fraifeld et al. (2021) ²	0.177	0.0482	0.211	0.0482
Thiel et al. (2019) ⁵	0.146	0.0415	0.107	0.0415
Park et al. (2021) ⁹	0.213	0.0235	0.209	0.0235
Perrego (2017) ¹⁰	0.344	0.0304	0.177	0.0304
Wyssusek et al. (2022) ¹¹	0.311	0.1073	0.168	0.0291
Yalamanchi et al. (2022) ¹²	-0.018	0.0192	0.096	0.0192
Fixed effect (pooled)	0.218		0.0806	
95% CI	(0.09717, 0.33973)		(-0.0352, 0.19648)	

Widespread adoption of these practices could help to resolve the persistent challenges of waste production in the healthcare sector.

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