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MATERIAL WASTE IN THE OPERATING ROOM AND ITS IMPACT ON SURGICAL SUPPLY EXPENDITURE: A NARRATIVE REVIEW

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ABSTRACT

Background: The operating room stands among the most resource-intensive departments in any hospital, and the supplies consumed during surgery make up a large share of institutional expenditure. Alongside their clinical value, these supplies carry a persistent burden of waste that quietly drains hospital budgets. Three forms of waste recur across the surgical literature: sterile materials that are opened for a procedure yet never used, stock that expires before it can be consumed, and instruments loaded into surgical trays that surgeons rarely touch. Each of these carries a direct financial cost through repurchase and disposal, together with indirect costs tied to storage, sterilisation, staff time, and the environmental footprint of surgical care. Cost awareness among the surgical team is frequently poor, and preference cards or instrument trays often go years without meaningful revision, allowing waste to accumulate unnoticed.

KEYWORDS: Operating room waste; Surgical supplies; Cost of surgery; Inventory management; Surgical instrument trays; Expired materials; Healthcare sustainability.

1. INTRODUCTION

The operating room is a demanding and high-pressure environment where surgical teams coordinate closely to deliver care that is both timely and safe. Within this setting, the efficient use of materials often receives less attention than clinical outcomes, yet the two are more closely linked than they first appear. Waste generated during surgery takes several forms, including supplies opened but never used, items that pass their expiry date on the shelf, and surplus instruments carried through sterilisation without purpose. Such waste clutters the workspace, lengthens turnover between cases, and adds pressure to already stretched surgical staff, while quietly inflating the cost of every procedure performed [1].

The financial weight of the operating room within a hospital is considerable. Surgical supply expenses account for a large proportion of total hospital supply spending, and the cost of operating room time is measured in the tens of dollars per minute once wages, benefits, and consumables are combined. Because the operating room is simultaneously the greatest cost centre and a primary source of hospital revenue, any inefficiency in how its materials are managed has consequences that ripple across the institution's finances. Reducing waste therefore offers a rare opportunity to lower cost without lowering the standard of care [2].

A central difficulty is that the people selecting supplies during surgery frequently have little idea of what those supplies cost. Surveys of surgeons, nurses, and technicians repeatedly show wide gaps between estimated and actual prices, and this lack of awareness makes it hard for the team to weigh the value of what they open. When cost is invisible, the safest habit is to over-prepare, and over-preparation is precisely what drives much of the waste seen on the scrub table. Building cost consciousness among the surgical team has thus become a recurring theme in efforts to curb surgical waste [3,4].

2. Surgical Supply Costs and the Economics of the Operating Room

Understanding waste first requires understanding the scale of the expenditure from which it is drawn. The operating room consumes a broad mix of direct and indirect costs, spanning personnel salaries, anaesthetic agents, disposable consumables, implantable devices, equipment maintenance, and the overhead of sterilisation, waste disposal, and infection control. Of these, surgical supplies form one of the heaviest single components, and their procurement is shaped by the need to keep teams fully equipped for every eventuality. This drive toward readiness, while clinically sensible, sits at the root of much unnecessary spending [5].

The cost of operating room time offers a useful lens on this expenditure. Analyses of acute care hospitals have placed the cost of theatre time in the region of tens of dollars per minute, with the largest share attributed to wages and benefits and a smaller but meaningful portion to surgical supplies. Because these figures vary by country, region, and the complexity of the procedure, the precise numbers differ from one setting to another, but the underlying message holds everywhere: time and materials in the operating room are expensive, and small inefficiencies compound quickly across a full surgical schedule [6].

Supply costs also vary sharply between specialties. Departments that rely on high-value implantable devices, such as orthopaedics and vascular surgery, show a very different cost profile from those dominated by disposable consumables, such as general surgery and gynaecology. This divergence matters because it means no single cost-control strategy fits every service. Implant-heavy departments benefit most from approaches that manage high-value, date-sensitive stock, while consumable-heavy departments gain more from standardisation and the reduction of opened-but-unused waste. Recognising these distinct patterns is the first step toward targeting interventions where they will have the greatest effect [7].

Broader work on hospital supply chains reinforces the point that the operating room is a natural focus for improvement. The surgical supply chain is characterised by unpredictability, fragmented responsibility, and complex relationships between departments, all of which produce stock-outs, hidden inventory, and waste. Studies of internal supply chain performance suggest that measuring these inefficiencies is itself a prerequisite for reducing them, since waste that goes unmeasured cannot be managed. This principle underpins each of the three waste categories examined in the sections that follow [8].

3. Unused Opened Materials in the Operating Room

Among the three categories of waste, unused opened materials are perhaps the most visible on the surgical field. These are the sterile supplies, gauze, sutures, and disposable items that a team opens in anticipation of a procedure but never actually uses. Once the sterile seal is broken, such items cannot be returned to stock, and so they pass directly from the shelf to the waste stream. The habit of opening more than is needed stems from a reasonable wish to avoid being caught short mid-operation, yet the cumulative cost of this caution is substantial [9].

Estimates of the proportion of opened supplies that go unused are striking. Surveys of surgeons have found broad agreement that operating room waste is a serious problem, with a large majority acknowledging its importance, and observational work suggests that roughly a quarter of single-use sterile supplies opened during surgery are discarded unused. The barriers to reducing this waste consistently include limited staff awareness, insufficient concern for the problem, and the time pressures of a busy theatre. Encouragingly, many surgeons express willingness to adjust their workflows once the scale of the waste is made visible to them [10].

The operating room's contribution to overall hospital waste amplifies these concerns. Surgical and delivery suites together generate a large share of total hospital waste, and the practice of over-preparing supplies is a principal driver. Beyond the immediate cost of discarded items, this waste carries an environmental dimension, since much of it consists of single-use plastics and other non-recyclable materials whose disposal adds to the ecological footprint of surgical care. Framing waste as both a financial and an ethical issue has helped some institutions build the case for change [11].

Preference cards sit close to the heart of this problem. These lists, intended to ensure that everything a surgeon might need is prepared in advance, are frequently outdated, poorly maintained, and padded with items requested years earlier to guard against rare contingencies. When a card calls for supplies that are seldom used, those supplies are opened case after case and thrown away, embedding waste into routine practice. Regular, data-driven review of preference cards has therefore emerged as one of the most direct levers for reducing opened-but-unused waste [12].

Several institutions have tested practical methods for surfacing this waste. One approach compares photographs of the scrub table at the start and end of a procedure, allowing teams to see at a glance which items were opened but never touched. This asynchronous image review offers a low-burden alternative to the traditional reliance on clinician memory or resource-heavy real-time observation, and it generates concrete data that can feed back into preference card revision and staff education. Such feedback loops help translate awareness into lasting behavioural change [13].

Recovery and donation programmes provide a complementary route. Clean, unused supplies that would otherwise be discarded can be salvaged and redirected, and where such programmes have expanded beyond the operating room into intensive care and trauma settings, the quantity and value of recovered materials have risen considerably. While these schemes do not address the root cause of over-preparation, they soften its financial and environmental consequences and reinforce a culture that treats surgical supplies as valuable rather than disposable by default [14].

4. Expired Materials and the Challenge of Inventory Control

The expiry of sterile supplies represents a quieter but equally costly form of waste. Unlike opened materials, which are lost at the point of care, expired items are lost on the shelf, often in storage areas that receive little scrutiny between stock checks. The operating room is especially prone to this problem because it holds a large and diverse inventory, much of it spread across multiple storage locations, and balancing availability against the risk of expiry is a delicate task. Items that move slowly yet must remain constantly available are the most vulnerable of all [15].

Poor inventory control lies behind most expired stock. Where monitoring is weak, items drift past their use-by dates unnoticed, and the presence of several storage locations increases the chance that some corner of the inventory is overlooked. Surgeons' requests for a wide array of items, many of which they alone use, further complicate the picture, as does the natural fluctuation in surgical case volume. Together these factors create conditions in which overstocking and expiry become almost inevitable without a deliberate system to prevent them [16].

The financial consequences are far from trivial. Structured inventory reviews have identified large sums tied up in excess stock, and expired products account for a meaningful portion of the potential savings available through better management. Applying quality-improvement methods to operating room stock has reduced both the value of inventory held and the volume of items lost to expiry, while also easing the time nurses spend preparing for cases. These gains show that expiry is not an unavoidable cost of doing business but a manageable problem with tangible returns [17].

Practical remedies centre on disciplined stock rotation and proactive monitoring. First-in, first-out practices ensure that older stock is used before newer arrivals, while systems that flag items approaching their expiry date allow staff to redistribute them to higher-demand areas before they are lost. Programmes that track and exchange supplies nearing expiry across clinics have achieved substantial reductions in discarded stock, demonstrating that even simple, low-cost interventions can meaningfully cut waste when applied consistently [18].

Technology extends the reach of these efforts. Perpetual inventory systems, barcode or radio-frequency tracking, and the integration of theatre scheduling with supply ordering all reduce the human error that allows items to expire. For high-value, low-turnover items, consignment arrangements offer a further safeguard, since the risk of expiry shifts back to the supplier and the hospital pays only upon use. Such strategies align inventory more tightly with genuine surgical demand, which is the surest way to keep expiry to a minimum [19].

Regulatory and safety considerations shape how expired materials are handled once identified. Although some evidence suggests that certain items could remain sterile beyond their labelled dates under event-related sterility principles, many institutions prohibit the use of expired stock outright, treating removal and disposal as the only acceptable course. This caution reflects the serious risks that compromised materials pose to patient safety, and it reinforces the value of preventing expiry in the first place rather than debating whether expired items might still be usable [20].

5. Excess Instruments in Surgical Sets

The third category of waste is less obvious than the first two because it generates no discarded packaging and no expired stock, yet it carries a hidden cost that recurs with every case. Surgical sets are frequently assembled with far more instruments than any single procedure requires, and studies across specialties have found that only a small fraction of the instruments in a tray are actually used. Each unused instrument must nonetheless be cleaned, sterilised, counted, and repacked, consuming staff time and resources without contributing to the operation [21].

The reported rates of underused instruments are remarkably consistent and remarkably high. Across a range of settings, only around thirteen to twenty-two per cent of the instruments on a tray are typically used during a case, leaving the substantial remainder to pass through the sterilisation cycle untouched. This redundancy inflates processing costs, lengthens preparation and counting times, and adds weight to trays that staff must lift and carry. The scale of the inefficiency makes instrument optimisation one of the most rewarding targets for waste reduction [22].

Reducing tray size yields benefits that extend well beyond the sterilisation department. Lighter trays are easier to handle and reduce the physical strain on nurses, a matter of real importance in major cases where sets can be heavy enough to require splitting into two. Fewer instruments also mean faster set-up, quicker counting, and a lower risk of the confusion that arises when a cluttered tray obscures the items a surgeon actually needs. In this way, streamlining serves both operational efficiency and staff wellbeing [23].

Lean methodology has become the dominant framework for achieving these reductions. By bringing surgeons and processing staff together to review usage data and agree on the minimum instrument set required for a procedure, hospitals have removed large numbers of redundant tools from their trays. Reported reductions of roughly a fifth to more than half of instrument counts have translated into meaningful annual savings, shorter processing times, and higher average instrument utilisation, all without any measured harm to surgical performance [24].

The methods used to identify redundant instruments vary in their balance of clinical judgement and data. Clinician review relies on surgeons flagging instruments they no longer use, mathematical programming draws on systematic usage analysis, and hybrid models combine the two with cost considerations. Comparative work suggests that each approach can achieve substantial reductions, with clinician-led review sometimes yielding the largest cuts, underscoring the value of engaging the surgical team directly in the optimisation process rather than imposing changes from outside [25].

Instrument optimisation also carries a notable environmental dividend. Cleaning and sterilising surgical instruments consumes energy, water, and packaging, so every instrument removed from a tray lowers the carbon and material footprint of the procedure. Studies applying tray optimisation have reported meaningful reductions in weight and in associated environmental impact alongside their cost savings, positioning instrument streamlining as a rare intervention that advances financial, operational, and sustainability goals simultaneously [26].

Despite these clear benefits, a standardised method for optimising trays has yet to be established, and implementation faces recurring obstacles. Surgeon preference, concern for the availability of rarely used instruments, and the effort required to revise long-standing sets all slow progress. Sustaining gains requires an ongoing review process rather than a one-off project, with surgical and processing teams meeting regularly to keep trays aligned with actual practice as procedures and preferences evolve over time [27].

6. Cost Awareness, Staff Engagement, and Organisational Culture

Running beneath all three waste categories is a common thread: the surgical team's limited awareness of what supplies and instruments actually cost. Cross-sectional studies of cost knowledge among surgical staff have found universal overestimation or underestimation of prices, with errors spanning several-fold in either direction and no reliable improvement with seniority or experience. When the true cost of an item is unknown, decisions about how much to open or stock are made without the information needed to weigh value against risk [28].

The appetite for better information is, however, strong. Despite their inaccurate estimates, the great majority of surgical personnel in these studies expressed a wish to know more about supply prices, suggesting that cost data is welcomed rather than resented when offered in a supportive spirit. This willingness creates an opening for intervention: providing regular, non-punitive feedback on the costs associated with individual practice can shift behaviour without provoking defensiveness, turning the surgical team into active participants in waste reduction [29].

Sustained change nonetheless depends on organisational culture as much as individual knowledge. Established routines run deep in surgical settings, and staff may resist new protocols for fear of compromising patient care or disrupting a trusted workflow. Overcoming this resistance calls for genuine engagement across departments, from surgeons and nurses to supply chain and administration, so that waste reduction is understood as a shared responsibility rather than an external demand. Leadership support is essential to secure the resources and priority that such initiatives require [30].

Monitoring and evaluation give these cultural efforts durability. Clear metrics allow teams to see whether interventions are working, to celebrate genuine progress, and to identify where further attention is needed. Without such measurement, gains tend to erode as attention drifts and old habits reassert themselves. Embedding waste data into routine reporting, ideally through service-specific dashboards drawn from existing electronic systems, keeps the issue visible and accountability alive long after the initial push has passed [31].

7. Technology and Data-Driven Approaches to Waste Reduction

Modern information systems have transformed the possibilities for managing surgical waste. Electronic health records now capture, in real time, which items are opened, used, or discarded during a procedure, generating a rich stream of data that can be analysed to reveal patterns invisible to the naked eye. When a circulating nurse documents opened and unused items directly into such a system, the resulting record becomes a foundation for both accurate billing and detailed waste analysis, allowing management to pinpoint where losses concentrate [32].

Intelligent tracking of instruments offers a parallel advance. Systems that follow surgical sets through cleaning, sterilisation, use, and reprocessing provide continuous visibility of instrument condition and utilisation, enabling teams to identify malfunctioning or redundant tools and to base optimisation decisions on evidence rather than impression. Such systems also support the standardisation of sets by revealing which instruments are consistently used together, guiding the design of leaner, procedure-specific trays [33].

Predictive analytics extend these capabilities further. By analysing historical consumption alongside surgical schedules and seasonal variation, data-driven systems can recommend optimised stock levels for individual items, replacing static reorder points with dynamic ones that respond to genuine demand. This forecasting reduces the overstocking that leads to expiry while guarding against the stock-outs that force last-minute, high-cost ordering, striking a balance that manual systems struggle to achieve [34].

Machine learning has begun to touch operating room efficiency in ways that reach beyond supplies. By improving the accuracy of surgical duration predictions, these methods sharpen scheduling, reduce idle theatre time, and ease congestion in recovery areas, all of which indirectly lessen the waste that flows from delays and rescheduling. As these tools mature, their integration with supply and instrument data promises a more comprehensive approach to efficiency in which waste reduction and workflow improvement advance together [35].

8. Lean and Six Sigma Frameworks in Surgical Supply Management

Many of the most successful waste-reduction efforts share a common methodological heritage in the lean and Six Sigma philosophies borrowed from manufacturing. These frameworks treat waste as any activity or material that consumes resources without adding value for the patient, and they provide structured tools for identifying and eliminating it. Applied to the operating room, they turn a vague sense that too much is being wasted into a systematic programme of measurement, analysis, and improvement [36].

Lean thinking classifies waste into recognisable types, from overproduction and excess inventory to unnecessary motion and waiting, each of which has a clear counterpart in the surgical setting. Preparing too many sterile supplies is overproduction; expired stock is wasteful inventory; searching for missing instruments is wasted motion; and delays between cases are waiting. Naming these forms of waste explicitly helps teams see inefficiencies they had previously accepted as normal, which is often the necessary first step toward addressing them [37].

The Six Sigma DMAIC cycle, which moves through defining, measuring, analysing, improving, and controlling a process, offers a disciplined route to sustained improvement. By measuring concrete variables such as turnover time and the interval between closing one case and cutting the next, teams can locate the specific points at which waste enters the workflow and test targeted changes against real data. Engaging a multidisciplinary group in this process ensures that improvements are grounded in the realities of the theatre and are more likely to endure [38].

Applied to supply chain management specifically, lean and Six Sigma methods have streamlined stock control, optimised inventory, and improved the availability of supplies at the point of use. Case studies applying these tools have reduced the value of stock held, cut the incidence of expiry, and shortened the time nurses spend preparing cases, demonstrating that the same principles which reshaped manufacturing can deliver measurable gains in the operating room when adapted thoughtfully to its particular demands [39].

9. Barriers to Implementation and Sustainability

For all the promise of these strategies, translating them into lasting practice remains difficult. The most persistent barrier is resistance to change, rooted in deeply established routines and in a legitimate fear that altering processes might compromise patient safety or leave a team short of supplies at a critical moment. Because the stakes in surgery are so high, staff are understandably cautious about any change that could affect the conduct of an operation, and this caution must be respected rather than overridden [40].

Practical constraints compound this cultural resistance. Training staff on new systems demands time that a busy theatre can rarely spare, and team members differ in their comfort with new technology and procedures. Advanced inventory systems and reprocessing programmes often require significant upfront investment that not every facility can afford, and staffing shortages can undermine even well-designed initiatives by leaving no one with the capacity to manage them. These resource limitations frequently determine whether a promising idea ever reaches routine use [41].

Data and coordination challenges add a further layer of difficulty. New inventory systems must integrate with existing electronic records and supply chain platforms, a process that can be complex and slow, and their value depends on staff consistently entering accurate information. Waste reduction also demands coordination across departments whose priorities and communication styles differ, and miscommunication between surgical teams, supply chain, and administration can quietly derail otherwise sound plans [42].

Sustaining improvement over time may be the hardest challenge of all. Defining clear metrics to measure success is itself demanding, and without proper evaluation it is impossible to know whether a change has truly helped. Even successful initiatives tend to fade unless they are reinforced through ongoing monitoring and periodic review, which is why the most durable programmes build continuous evaluation into their design rather than treating waste reduction as a task to be completed and set aside. Regulatory requirements around sterilisation and reprocessing add a final constraint that any lasting solution must respect [43].

10. Synthesis and Directions for Future Work

Drawing the evidence together, a consistent picture emerges across the three categories of waste. Opened-but-unused materials, expired stock, and surplus instruments each arise from a blend of clinical caution, weak cost awareness, and inventory or tray configurations that have drifted out of step with actual practice. Although the mechanisms differ, the remedies overlap: better data, closer engagement with the surgical team, and disciplined systems for keeping supplies and instruments aligned with genuine need. This convergence suggests that a coordinated approach addressing all three categories together is likely to outperform piecemeal efforts aimed at any one alone [44].

The financial case for such an approach is compelling. Waste has been estimated to consume a considerable share of operating room supply costs, and the savings demonstrated by individual interventions, whether through preference card revision, inventory optimisation, or tray streamlining, are large enough to justify serious institutional investment. Crucially, these savings are achievable without any reduction in the quality or safety of care, since the waste being removed contributes nothing to the patient in the first place. This makes waste reduction one of the few cost-control measures that carries no clinical downside [45].

Yet the literature also reveals important gaps. Much of the evidence rests on single-institution studies with varied methods and metrics, which makes comparison across settings difficult and limits the confidence with which findings can be generalised. There is a particular need for standardised measures of waste and efficiency, so that hospitals can benchmark their performance against one another and so that the effectiveness of different interventions can be judged on common ground. Establishing such shared metrics would strengthen the field considerably [46].

Future research would benefit from longitudinal designs that track waste reduction over extended periods, since the true test of any intervention is whether its gains persist once the initial enthusiasm has passed. Cross-institutional collaboration offers a further opportunity, allowing hospitals to share successful practices, pool data for larger studies, and develop the standardised approaches the field currently lacks. Work of this kind would help move waste reduction from a collection of local successes toward a mature, evidence-based discipline [47].

Finally, the evidence points consistently toward the surgical team as the decisive factor in any lasting change. Technology and systems provide the tools, but it is the surgeons, nurses, and processing staff who decide, case by case, what to open, what to stock, and what to include in a tray. Equipping these individuals with accurate cost information, involving them genuinely in the design of solutions, and fostering a culture in which resource stewardship is valued may ultimately matter more than any single technical intervention. The path to a leaner, more sustainable operating room runs through the people who work within it [48].

11. CONCLUSION

Material waste in the operating room, whether through supplies opened and never used, stock that expires before it can serve a patient, or instruments carried needlessly through sterilisation, imposes a financial and environmental burden that hospitals can no longer afford to overlook, and this review has shown that the burden is both substantial and, to a large degree, preventable; the evidence across all three categories converges on a shared set of remedies built around accurate cost data, engaged surgical teams, disciplined inventory and instrument management, and the structured application of lean and quality-improvement methods, all of which can reduce waste meaningfully without compromising the safety or quality of care, so that the task now facing surgical leaders is less one of discovering what works than of committing to implement, measure, and sustain these proven strategies within a culture that treats every surgical resource as something worth conserving [48].

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