Quantifying Solid Waste Production and Sustainability Barriers in Pediatric Orthopaedic Surgery: A Mixed-Methods Study

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INTRODUCTION:

Operating rooms are major contributors to hospital waste, with orthopaedic surgery producing up to 60 percent more disposable material than other surgical specialties. Pediatric orthopaedic procedures may uniquely contribute to this burden due to specialized implants, packaging, and single use instruments. However, few studies have quantified the waste from specific pediatric orthopaedic surgeries. While many surgical materials are technically recyclable, institutional recycling remains inconsistent and unregulated. Misclassification of hazardous waste, high implementation costs, and workflow concerns often prevent sustainable practices. As climate change increasingly impacts health, surgical waste reduction has become a pressing issue.

A previous Canadian study reported high proportions of recyclable waste in pediatric orthopaedics; however, those findings were based on a small number of spinal cases, limiting generalizability. Most US data on surgical waste comes from adult arthroplasty, leaving a significant gap in pediatric orthopaedic surgery. Our study aims to measure solid waste generation across four common pediatric orthopaedic procedures and gather perspectives from surgical staff on sustainability practices.

METHODS:

We conducted a prospective waste audit at two affiliated pediatric hospitals from December 2024 to March 2025. Twenty surgeries were included: five each of elbow pinning, ACL reconstruction, pelvic osteotomy, and spinal fusion. Waste was weighed using a handheld scale, and categorized into recyclable, non-recyclable, and linen waste. Waste was measured during two periods: preoperative (opening of carts to skin prep) and intraoperative (post prep to room cleanup). Operative time was also recorded.

In addition, a 30 question survey was distributed to surgeons, scrub techs, and circulators involved in each case. Survey topics included perceptions of OR sustainability, barriers to waste reduction, and suggestions for improvement. Quantitative data were analyzed using R. Survey responses were reviewed for common themes using inductive coding.

RESULTS: The average solid waste generated per procedure was 15.02 kg (standard deviation 9.26). Posterior spinal fusion produced the highest waste (29.49 kg), followed by pelvic osteotomy (13.40 kg), anterior cruciate ligament reconstruction (9.96 kg), and elbow fixation (7.24 kg) (Figure 1). None of this waste was recycled at the primary study sites. Extrapolated to institutional surgical volumes, these four procedures contributed an estimated 5.03 metric tons of solid waste in our hospital system in 2024. Waste volume strongly correlated with operative time (R^2 = 0.86, Figure 2). Survey responses (n=13; 39% response rate) identified unnecessary opening of supplies and lack of recycling infrastructure as key contributors to waste (Table 1). Participants reported minimal sustainability education but expressed interest in institutional support to improve practices.

DISCUSSION AND CONCLUSION:

This is the first US study to assess solid waste in multiple pediatric orthopaedic procedures, utilizing quantitative waste measurements and qualitative staff feedback. Our findings show substantial waste generation, particularly in longer, more complex pediatric surgeries. No waste was recycled, contrasting with prior international data. Our study found average waste production to be 2.5 times higher than previously reported in the literature, highlighting substantial variation across healthcare systems and countries.

Survey responses underscored the disconnect between individual awareness and institutional action. While most staff supported sustainability, barriers included unclear policies, limited training, and financial concerns. Preference card optimization and supply control were repeatedly cited as high yield strategies. If our institution had recycled even 40 percent of waste from these four procedures, over 2 metric tons could have been diverted from landfills, preventing up to 7 tons of carbon dioxide equivalent emissions.

Limitations include small sample size, single institution scope, and exclusion of non solid waste sources. Nonetheless, the study highlights a critical need for structured sustainability programs in pediatric orthopaedic surgery. Institutional leadership, standardized recycling, and frontline staff engagement are essential next steps.

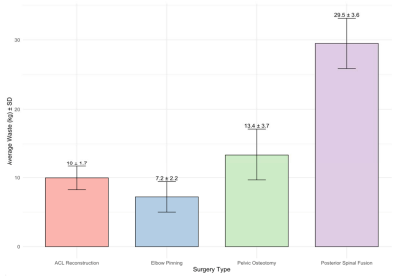

Figure 1. Average Waste by Procedure. Bar graph showing average mass of solid waste produced by procedure type (ACLR - red, elbow pinning - blue, pelvic osteotomy - green, posterior spinal fusion - purple) and standard deviation. N = 5 per procedure.

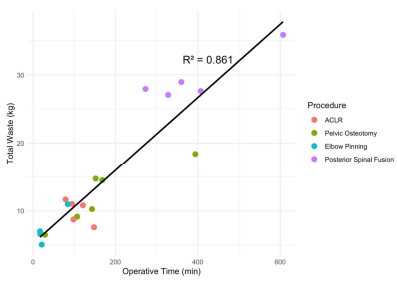

Figure 2. Relationship Between Operative Time and Total Mass of Waste. Scatter plot displaying total waste per procedure (ACLR - red, elbow pinning - blue, pelvic osteotomy - green, posterior spinal fusion - purple) versus total operative time.

Table 1. Summary of Survey Responses on Environmental Sustainability in OR

Survey Question	Response Summary (n = 13)
What is your position?	Fellow (2, 15.4%) Attending (4, 30.8%) Circulator (5, 38.5%) Scrub Tech (2, 15.4%)
Age group	20–29 years (1, 7.7%) 30–39 years (6, 46.2%) 40–49 years (4, 30.8%) 50–59 years (0, 0.0%) 60–69 years (2, 15.4%) 70+ years (0, 0.0%)
Gender identity	Female/Woman (8, 61.5%) Male/Man (5, 38.5%)
Awareness of waste disposal processes in the OR	Yes (4, 30.8%) No (9, 69.2%)
Presence of sustainability recognition/incentive programs	No (13, 100%)
Tracking of OR environmental metrics	No (13, 100%)
Involvement in preference card optimization (non-surgeons)	Yes (7, 63.6%) No (4, 36.4%)
Belief that OR waste contributes significantly to climate change	Yes (10, 76.9%) Maybe (2, 15.4%) No (1, 7.7%)
Estimated % of unused single-use sterile supplies per case	34.3% ± 13.2%
Estimated % of surgical waste recycled	15.3% ± 14.3%
Satisfaction with environmentally friendly practices	Very satisfied (1, 9.1%) Somewhat satisfied (1, 9.1%) Unsure (3, 27.3%) Somewhat unsatisfied (3, 27.3%) Very unsatisfied (3, 27.3%)
Awareness of current or upcoming sustainability initiatives	Yes, already begun (0, 0.0%) Yes, upcoming (1, 9.1%) No (2, 18.2%) Unsure (8, 72.7%)
Perceived barriers to increasing OR sustainability	Lack of incentive (9, 81.8%) Lack of leadership support (8, 72.7%) Lack of information/knowledge (7, 63.6%) Cost (5, 45.5%) Inconvenience (5, 45.5%) Lack of resources/tools (4, 36.4%) Lack of time (4, 36.4%) Staff attitudes (4, 36.4%) Handling contaminated materials (2, 18.2%) Reprocessing requirements (2, 18.2%) "We simply do not" (1, 9.1%) No perceived barriers (0, 0.0%)