The environmental impact of health care: Environmental Sustainability in Orthopaedic Surgery

Gaina Arsakhanova[1,*], *Dmitry* Odarchenko[2], and *Kureysh* Khamchiev[3]

[1]Kadyrov Chechen State University, Grozny, Russia
[2]Omsk State Medical University, Omsk, Russia
[3]Astana Medical University, Astana, Kazakhstan

Abstract. Orthopaedic surgery, while crucial for improving patients' quality of life, can also have a significant environmental impact. This paper explores the concept of environmental sustainability in orthopaedic surgery, focusing on the environmental footprint of materials, energy usage, waste generation, and overall practices within orthopaedic operating rooms and clinics. It examines various strategies for promoting sustainability in orthopaedic surgery, including material selection for implants, reducing carbon emissions, conducting life cycle assessments, implementing eco-friendly practices in operating rooms, and advocating for green initiatives within the orthopaedic community. By addressing these environmental concerns, orthopaedic surgery can contribute to broader efforts towards environmental sustainability in healthcare while continuing to provide high-quality patient care.

1 Introduction

In Russia, climate change is responsible for a mortality rate of over 250,000 fatalities annually, with air pollution causing over eight million deaths. The healthcare sector, ranking second only to the food production industry, significantly contributes to the global carbon footprint. Healthcare activities produce carbon dioxide (CO2) and other greenhouse gases (GHG), collectively known as carbon dioxide equivalents (CO2e), which contribute to climate change by trapping heat in the atmosphere. Within Russia, the healthcare system generates approximately 4% to 5% of the nation's total GHG emissions, amounting to an estimated 25 megatonnes of CO2e annually. Waste production is also a significant concern, with over 500,000 tonnes of waste generated annually, a quarter of which comes from the healthcare sector. Operating rooms (ORs) are particularly wasteful, accounting for about 20% to 33% of a hospital's total waste. This waste is often disposed of in landfills or incinerated, contributing to environmental pollution and posing risks to soil and water quality. Additionally, ORs are highly resource-intensive, consuming three to six times more energy than other areas of the hospital. In response to these challenges, global initiatives such as the Paris Agreement aim to limit global warming, with national strategies like the

*Corresponding author: gistologiya58@mail.ru

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'Greener NHS programme' in the Russia addressing climate change within healthcare systems. The principles of sustainability, including the 5R strategy (reduce, reuse, recycle, rethink, and research), are increasingly being implemented in healthcare settings to mitigate environmental impact [3]. Efforts to improve waste segregation, conduct life-cycle assessments, and optimize surgical practices have shown promising results in reducing carbon emissions and resource wastage. However, there remains a need for more research specifically focused on orthopedic surgery to better understand and address its environmental impact and promote sustainable practices in the field.

2 Research methodology

The scoping review followed the Preferred Reporting Items for Systematic Review (PRISMA) Extension for Scoping Reviews protocol and was registered with the International Prospective Register of Systematic Reviews (PROSPERO). It adhered to the five-stage scoping review process outlined by Arksey and O'Malley, with adaptations from Levac et al. and the Joanna Briggs Institute [6,7]. The primary objective was to assess existing literature on the environmental impact and sustainable practices in orthopedic surgery, with a secondary aim of identifying barriers to implementing sustainable changes. After screening for relevance and removing duplicates, eligible articles underwent full-text review by two independent reviewers. Any conflicts were resolved through discussion with senior authors. Data from included articles were extracted and organized into a spreadsheet, covering study characteristics, environmental issues addressed, barriers, and recommendations. Articles were categorized based on the environmental issues they discussed.

3 Results and Discussions

The initial search yielded 3,138 results. After removing 473 duplicate records, 2,611 were excluded following the title and abstract screening. Following the full-text review, 41 articles were further excluded, leaving a total of 13 articles for final analysis. No additional articles were identified through a search of the reference lists of included articles or the grey literature search [2].

Three main environmental issues were identified: waste management, carbon emissions, and water usage. Nine studies focused on waste management, three on carbon emissions, and one on water usage [4].

Waste Management:

Nine articles investigated waste segregation in practice. Across these studies, the total waste generated ranged from 6.4 kg to 213.8 kg per procedure, with different proportions for various waste streams. Total hip arthroplasties (THAs) and total knee arthroplasties (TKAs) were found to generate the highest amount of waste per case compared to other procedures.

Recycled waste was reported in six studies, totaling 196.292 kg, with arthroplasty and pediatric orthopedic procedures generating a significantly higher proportion of recyclable waste.

Carbon Emissions [5]: Three studies examined the carbon emissions generated by orthopedic activities. Baxter et al. investigated CO2 emissions generated by frequently used items across hand surgery procedures, reporting a range of 7.8 kg to 28.8 kg of CO2 emissions. Leiden et al. compared emissions from disposable and reusable instrument sets, while Curtis et al. compared emissions between face-to-face and non-face-to-face outpatient appointments.

Water Usage:

One study examined water usage, but further details were not provided in the text.

Overall, the studies highlighted various aspects of environmental impact and sustainable practices within orthopedic surgery, focusing on waste management and carbon emissions in particular [8].

All studies addressed barriers to implementing sustainable changes within orthopedic surgery. The most commonly cited barrier, mentioned in eight studies, was a lack of appropriate infrastructure to support sustainable changes. Following this, five studies identified a lack of knowledge or training as a significant obstacle.

Table 1. Barriers to environmentally sustainable changes in orthopaedic surgery

Article	Lack of understanding of environmental impact	Lack of understanding of benefits of sustainable practices	Lack of training or knowledge	Lack of appropriate infrastructure	Lack of incentive	Resistance to change	Unclear guidelines or policies
Alam et al (2008)				X			X
Baxter et al (2021)	X	X			X	X	
Curtis et al (2021)				X			
De Sa et al (2016)			X				X
Hennessy et al (2021)			X	X			
Kooner et al (2019)			X				X
Lee et al (2012)				X		X	
Leiden et al (2020)				X			
Potgeiter et al (2020)				X		X	
Shinn et al (2017)	X	X		X	X		X
Southorn et al (2013)		X	X				
Stall et al (2011)	X	X	X	X			
Thiel et al (2017)						X	

Waste management, including disposal and recycling, presents a significant challenge within orthopedic surgery [9]. The classification of waste varies among studies due to differing institutional policies, leading to varying proportions of waste across the studies. The highest proportion of hazardous waste reported in our review exceeds global standards, posing environmental risks.

A substantial portion of waste, up to 80% during the perioperative period, is generated before the patient enters the operating room. Packaging materials contribute significantly to regulated waste, but if correctly segregated, they could be recycled safely. Several studies reported recycling streams, but some did not include materials like paper or cardboard, and none addressed metals or glass. Recycling waste, particularly metals and glass, could substantially reduce carbon emissions. Procedures such as total hip and knee arthroplasties generate significant waste, much of which could potentially be recycled [10].

Blue wrap, a commonly used material in surgical settings, is currently underutilized for recycling despite its significant contribution to waste. Reusable surgical linens, although not widely adopted, have demonstrated environmental advantages over disposable alternatives.

Carbon emissions from orthopedic activities are another area of concern. While some studies have measured emissions from specific items or procedures, comprehensive assessments are lacking. Factors such as energy use for HVAC systems and anesthesia activities contribute significantly to carbon emissions. Telemedicine has emerged as a promising tool for reducing emissions by minimizing patient travel, although it cannot replace all in-person appointments.

Water usage is also an important consideration. Studies have shown that simple measures like using alcohol hand rubs and turning off taps when not in use can lead to significant water savings without compromising hygiene standards [11].

Despite the potential benefits, implementing sustainable changes in orthopedic surgery faces several barriers. A lack of infrastructure, including inadequate waste collection and recycling facilities, is a common challenge. Resistance from staff due to concerns about

changes to practice and workload implications also impedes progress. However, there is growing willingness among surgeons to engage in education, training, and research to address these issues and drive sustainable practices forward.

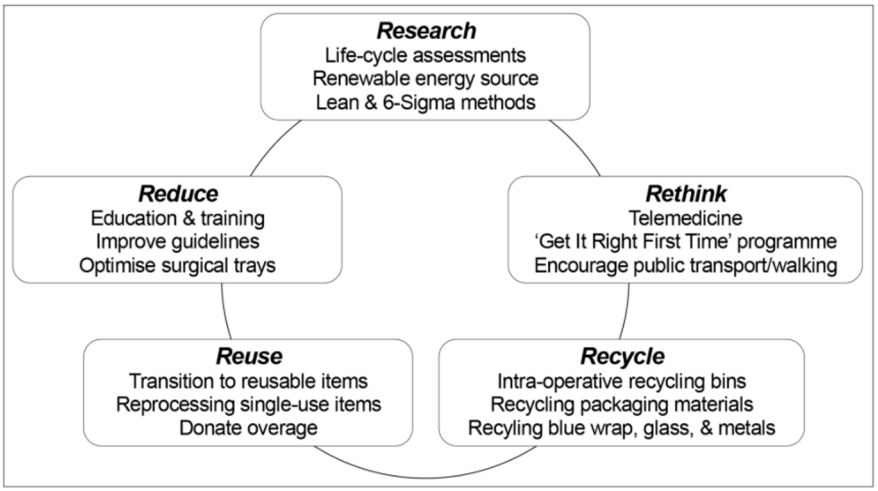

Fig. 1. Summary of actions for change using the '5 R' strategy.

4 Conclusions

The 5 R strategy, focusing on reducing, reusing, recycling, rethinking, and researching, holds significant promise for improving environmental sustainability in orthopedic surgery. Education and training programs can enhance waste segregation practices, reduce biohazardous waste generation, and increase recycling rates in operating rooms. Improvements in waste segregation policies and the establishment of intraoperative recycling bins can further promote recycling practices. Collaboration with waste management companies can facilitate the recycling of less common items like blue wrap, metals, and glass.

Optimizing surgical trays, transitioning to reusable items, and reprocessing single-use orthopedic devices can effectively reduce waste generation. Surplus items from orthopedic operating rooms can be donated to organizations supplying them to areas in need. Life-cycle assessments play a crucial role in informing environmentally sustainable decision-making.

Strategies to reduce resource consumption, such as minimizing water wastage and upgrading HVAC systems for energy efficiency, can significantly benefit the environment. Embracing new technologies like telemedicine can further reduce carbon emissions.

Further research is needed to identify safe and efficient ways to implement environmentally sustainable changes in orthopedic surgery while ensuring high-quality care and patient outcomes. Although this review primarily focused on waste management, future studies should explore the environmental impact of other aspects of orthopedic surgery. Collaboration among stakeholders is crucial to achieving a 'greener' specialty and mitigating the effects of climate change for the benefit of our environment.

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