

## ***Bibliometric Analysis of Scientific Publications on Environmental Sustainability in Operating Rooms***

***Naciye KAYA<sup>1</sup>, Meryem YAVUZ Van GIERSBERGEN<sup>2</sup>***

### **Abstract**

*This study aims to conduct a comprehensive bibliometric analysis of scientific publications on environmental sustainability in operating rooms, identifying key research trends, country-author collaborations, influential publications, and thematic structures in the field. A bibliometric analysis was conducted using the Web of Science Core Collection, which serves as both a database and an indexing platform. The dataset was obtained by searching English-language articles using the keywords “operating room,” “environmental sustainability,” and “green surgery”. A total of 162 eligible articles published between 1998 and 2025 were included. Data were analyzed using quantitative bibliometric techniques and visualized through VOSviewer software (version 1.6.19). The analysis included 162 publications, with a notable increase in research output over the last decade. The United States emerged as the most productive country, while Surgical Endoscopy and Other Interventional Techniques was identified as the most prolific journal. The most cited article was by Thiel et al. (2017), focused on cataract surgery and life cycle assessment, with 173 citations. Co-citation and co-authorship analyses revealed that authors such as McGain, Sherman, and Eckelman played central roles in the field. Two main thematic clusters were identified: (1) environmental impacts of surgical processes, (2) carbon footprint and life cycle assessments. The average number of citations per publication was 13.84. The findings highlight an increasing academic interest in sustainable operating room practices, with growing focus on reducing the carbon footprint, optimizing waste management, and implementing life cycle assessment methodologies. Future studies should aim to adopt a more holistic sustainability perspective, incorporating ethical, economic, and political dimensions. Interdisciplinary collaborations and policy-level engagements will be crucial for advancing green practices in surgical environments.*

**Keywords:** *Bibliometric analysis, carbon footprint, environmental sustainability, green surgery, operating room*

1. Balıkesir University, Department of Medical Services and Techniques, First Aid and Emergency Program, Balıkesir. Email: naciye.ercan@balikesir.edu.tr, <https://orcid.org/0000-0003-4540-1900>
2. Ege University, Faculty of Nursing, Department of Surgical Nursing, Izmir. Email: meryemyavuz2010@gmail.com, Phone: 0232 3105537, <https://orcid.org/0000-0002-8661-0066>

Received : 01.09.2025

Accepted : 18.12.2025

---

**Cite This Paper:** Kaya, N., & Yavuz Van Giersbergen, M. (2025). *Bibliometric analysis of scientific publications on environmental sustainability in operating rooms. Eurasian Journal of Health Technology Assessment, 9(2), 108-116.*

## 1. Introduction

Climate change poses one of the most urgent global health threats of the 21st century (WHO, 2023; Romanello et al., 2024). According to recent reports, including The Lancet Countdown, the adverse health effects of climate change are accelerating and now impact populations in every region (Watts et al., 2023). Paradoxically, healthcare systems not only endure the consequences of climate change but also contribute significantly to it. Globally, health systems account for approximately 4.4% of carbon emissions, reaching up to 8.5% in the U.S. and 5.4% in the U.K. (Karliner et al., 2019). Operating rooms (ORs) are among the most resource-intensive units in hospitals. They produce 20–33% of total hospital waste and consume large amounts of energy and materials. Key contributors to this footprint include single-use materials, sterilization processes, and volatile anesthetic gases (MacNeill et al., 2017; Plezia et al., 2024; Kara et al., 2025).

Environmental sustainability in healthcare encompasses more than just environmental conservation it includes ethical, economic, and institutional dimensions (Zurynski et al., 2022). Leading nations have initiated efforts to green their health systems. For instance, the NHS aims to reach net zero emissions by 2040 for directly controlled emissions and by 2045 for broader emissions (NHS England, 2022). In Australia, the removal of desflurane from hospital formularies demonstrates effective policy-level interventions (NSW Health, 2024). Despite rising interest, scholarly attention to environmental sustainability in ORs remains limited and fragmented. Existing studies often center on waste audits, case reports, or carbon assessments, with minimal attention to overarching research structures, trends, and networks. To address this gap, this study applies bibliometric methods to systematically map the landscape of OR-focused sustainability research, identifying knowledge clusters, productive authors, and areas requiring further investigation.

## 2. Methods

This descriptive bibliometric study was structured according to Donthu et al.'s four-stage approach: defining research scope, selecting the bibliometric method, data collection, and analysis/reporting (Donthu et al., 2021). Bibliometric analysis is a quantitative method used to evaluate the intellectual structure of a research field and is commonly conducted for two main purposes: performance analysis (e.g., productivity and citation impact) and science mapping (e.g., conceptual, intellectual, and social structures). In this study, both aims were considered. The Web of Science Core Collection was preferred over databases such as Medline and Scopus because it offers comprehensive citation indexing, high-quality curation standards, and wide interdisciplinary coverage, which make it particularly suitable for bibliometric and citation-based analyses. Additionally, WoS provides consistent metadata and advanced searching options, ensuring reproducibility and enabling reliable performance and science-mapping analyses. The dataset was retrieved from the Web of Science Core Collection on July 1, 2025, using the advanced search string: TS= ("operating room" OR "surgical theatre" OR "surgical setting" OR "perioperative") AND TS= ("environmental sustainability" OR "green surgery" OR "eco-friendly surgery" OR "sustainable surgery" OR "waste management" OR "carbon footprint" OR "low-carbon healthcare" OR "sustainable healthcare"). To ensure clarity and consistency in interpretation, only English-language articles were included. Of the 222 records retrieved, 162 satisfied the inclusion criteria and were subjected to analysis. Data was exported to Microsoft Excel and analyzed using VOSviewer (v1.6.19). Descriptive statistics (e.g., publication counts, citation averages) were calculated. Co-authorship, keyword co-occurrence, and co-citation networks were visualized to reveal structural relationships in literature.

### 3. Results

A total of 162 articles published between 1998 and 2025 met the inclusion criteria. There was a marked increase in the number of publications after 2015, with the sharpest rise occurring in the last five years. This trend reflects a growing academic and clinical awareness of the environmental impact of operating rooms (ORs) and the increasing importance of sustainability in healthcare.

#### 3.1. Publication Characteristics

The majority of articles were research-based (original research, reviews, or methodological studies), with few studies focusing on policy or implementation science. The most frequently contributing country was the United States (n=70), followed by the United Kingdom (n=17), Italy (n = 14), the Netherlands (n = 13), Australia (n = 12), France (n = 12) and Canada (n = 11) (Figure 1).

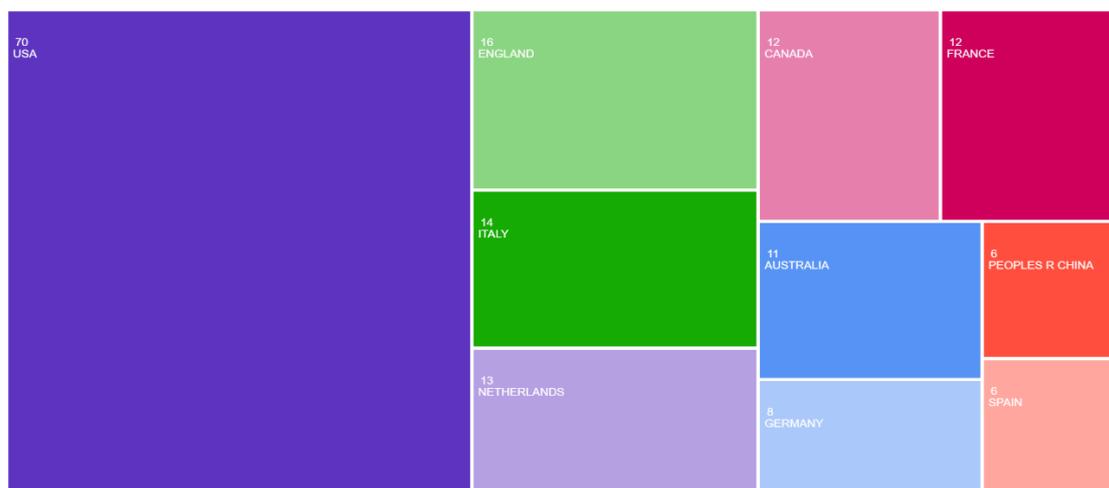


Figure 1. Number of publications by country

In terms of journals, Surgical Endoscopy and Other Interventional Techniques published the highest number of articles (n=7). Other key journals included Sustainability, Anesthesia & Analgesia, BMJ Open, and Journal of Cataract and Refractive Surgery (Figure 2).



Figure 2. Distribution of journals by number of publications

### 3.2. Authorship and Collaboration

Co-authorship analysis revealed clusters of collaborative authors predominantly centered in Europe, North America, and Oceania. Authors such as Sacher Frederic, Julie Boussuge-Roze, and Grinberg Daniel were among the most frequently collaborating authors (Figure 3).

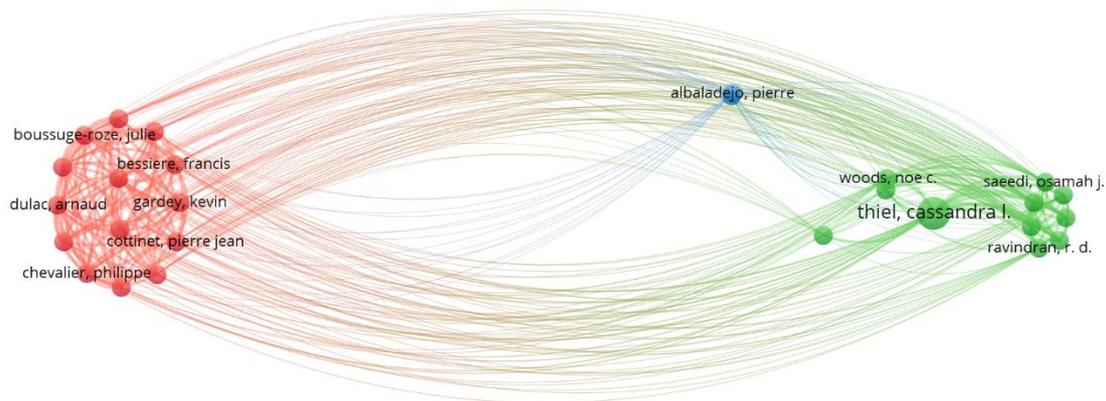


Figure 3. According to bibliometric matching analysis, the relationship between authors

### 3.3. Thematic Structure

Keyword co-occurrence analysis revealed three main thematic clusters (Figure 4).

#### Cluster 1: Environmental Impacts and Operating Room Processes

This cluster focuses on operating room practices and their environmental impacts, particularly hospital and operating room waste, anesthetic gas emissions, and resource use. Frequently occurring keywords include “waste management,” “sustainability,” “surgery,” and “environmental impact.”

#### Cluster 2: Carbon Footprint, Climate Change, and Environmental Sustainability

This cluster highlights macro-level environmental assessment and mitigation themes, with prominent keywords such as “carbon footprint,” “climate change,” “recycling,” “waste reduction,” and “environmental sustainability.”

#### Cluster 3: Operating Room Emissions and Life-Cycle Assessment

This cluster reflects studies examining operating-room-related greenhouse gas emissions and life-cycle-assessment-based evaluations in perioperative settings. Core keywords include “operating room,” “greenhouse gas,” and “life cycle assessment.”

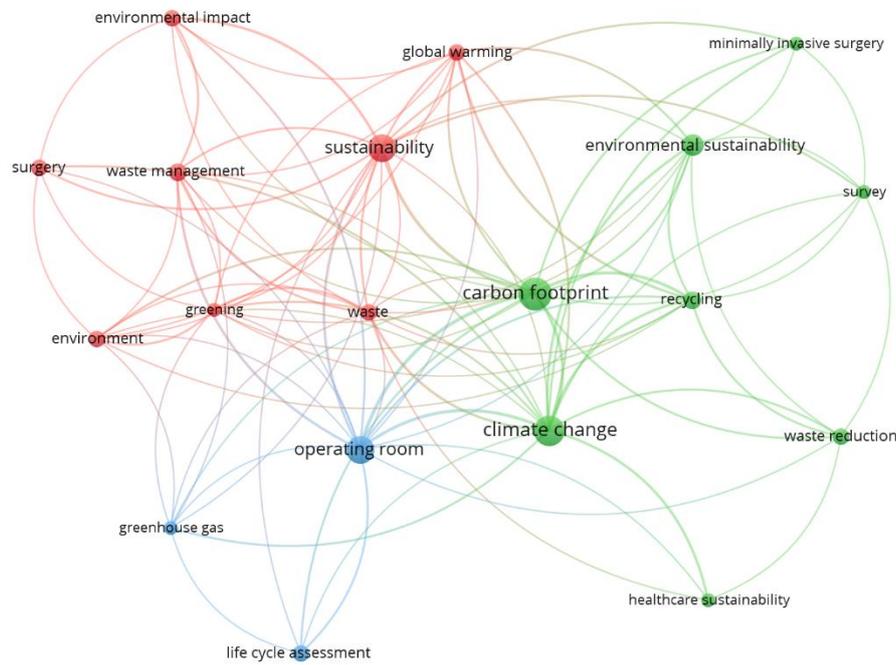


Figure 4. Distribution of keywords by keyword usage

### 3.4. Institutional and Country Networks

VOSviewer's visualization of country collaborations showed that Anglophone countries dominated the co-authorship networks, with the U.S., UK, and Australia forming strong partnerships (Figure 5). Institutions such as the University of Melbourne, University of Oxford, and Yale University were prominent contributors. Despite global interest, representation from low- and middle-income countries (LMICs) was sparse.

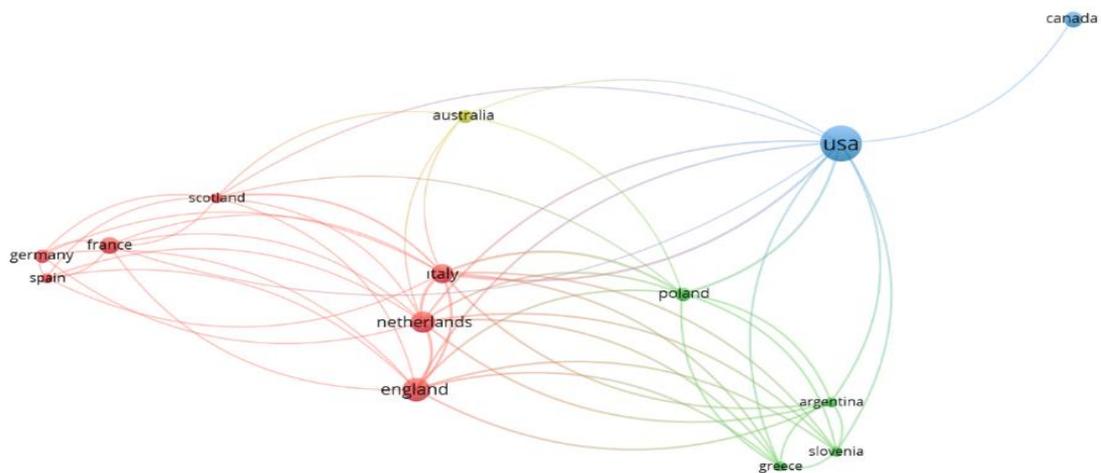


Figure 5. International Collaboration Network on Surgical Environmental Sustainability Publications

### 3.5. Citation Analysis

The average citation per article was 13.84, with the highest cited paper being Thiel et al. (2017), with 173 citations (Table 1A). In the nursing domain, only four studies directly focused on nursing roles in environmental sustainability. The most cited among these was by Vozzola et al. (2020), which performed an LCA of reusable vs. disposable surgical gowns (89 citations). Perrego (2017) was notable for demonstrating the effectiveness of perioperative staff education in reducing regulated medical waste.

Table 1. Data on the most cited authors and publications

Authors	Number of citations	Journal	Year	Publication title
Thiel et al.,	174	Journal of Cataract and Refractive Surgery	2017	Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility
Kwakye et al.,	168	Archives of Surgery	2011	Green Surgical Practices for Health Care
Thiel et al.,	152	American Journal of Public Health	2018	Strategies to Reduce Greenhouse Gas Emissions from Laparoscopic Surgery
Wormer et al.,	125	American Surgeon	2013	The Green Operating Room: Simple Changes to Reduce Cost and Our Carbon Footprint
Guetter et al.,	101	American Journal of Surgery	2018	Greening the operating room
Vozzola et al.,	89	AORN Journal	2020	An Environmental Analysis of Reusable and Disposable Surgical Gowns
Stall et al.,	81	Canadian Journal of Surgery	2013	Surgical waste audit of 5 total knee arthroplasties
McGain et al.,	75	Anesthesia and Analgesia	2012	A Survey of Anesthesiologists' Views of Operating Room Recycling
Chang et al.,	67	Journal of Cataract and Refractive Surgery	2020	Survey of cataract surgeons' and nurses' attitudes toward operating room waste
Alsved et al.,	67	Journal of Hospital Infection	2018	Temperature-controlled airflow ventilation in operating rooms compared with laminar airflow and turbulent mixed airflow

## 4. Discussion

This bibliometric analysis demonstrates that environmental sustainability in operating rooms has become an emergent yet underexplored field. The increasing trend in publications post-2015 correlates with growing global urgency regarding climate change and the healthcare sector's contribution to environmental degradation. The disproportionate environmental burden of surgical units -due to their intensive use of energy, water, and single-use items- has likely driven this academic attention.

### 4.1. Interpretation of Thematic Clusters

The three thematic clusters identified offer insight into the maturity and scope of the field:

Cluster 1 reflects operational sustainability, how day-to-day practices (e.g., waste segregation, material selection, use of disposables) affect the environment. These studies often provide audits and baseline data but may lack broader system integration.

Cluster 2, focusing on carbon footprints and life cycle assessments, suggests a methodological turn toward quantification. LCA provides objective tools for comparing products (e.g., reusable vs. disposable instruments) and practices (e.g., types of anesthesia). However, its adoption remains limited to high-resource settings due to its complexity and data requirements.

Cluster 3, includes studies that quantify operating-room-related greenhouse gas emissions and apply life-cycle assessment (LCA) to perioperative care. These studies compare reusable and single-use equipment and clinical practices in terms of carbon, energy, and waste outcomes, providing the methodological basis for environmentally informed decision-making. However, most LCA research remains concentrated in high-income settings and a limited range of procedures, highlighting the need for broader, context-sensitive studies.

### 4.2. Nursing and Interdisciplinary Gaps

Despite nurses being central to perioperative care, only four articles directly addressed nursing perspectives or interventions. This highlights a missed opportunity: perioperative nurses are uniquely positioned to lead sustainability practices, from advocating reusable sets to managing waste segregation at source. Studies like Perrego (2017) and Vozzola et al. (2020) show that nurse-led interventions can yield tangible environmental benefits, but this role remains under-researched.

Interdisciplinary collaboration is another gap. Most highly cited studies stem from anesthesiology, environmental sciences, or surgical domains. There is a pressing need to integrate environmental scientists, economists, ethicists, engineers, and nurses into a trans-disciplinary research framework.

### 4.3. Regional Disparities

The geographical skew in publications, heavily weighted toward the U.S., UK, and Australia, raises concerns about the equity and transferability of findings. LMICs, where resource optimization is a daily reality, are underrepresented despite their potential to contribute practical insights into sustainable practices (e.g., sterilization, reuse, minimal-waste techniques).

#### 4.4. Challenges and Future Directions

Several barriers impede the widespread implementation of sustainable practices in ORs:

- Cost perceptions: Reusable items are often seen as costlier upfront despite their long-term savings.
- Resistance to change: Surgeons and hospital administrators may be reluctant to alter familiar workflows (Pinheiro et al., 2024).
- Lack of standardized metrics: While tools like LCA exist, they are not universally applied or understood (Almukhtar et al., 2024).

To overcome these barriers, the following strategies are recommended:

- Integrate sustainability topics into perioperative education and credentialing programs (Johnson et al., 2024).
- Encourage hospital green committees to include OR representatives (Beloeil & Albaladejo, 2021).
- Develop institutional dashboards that track environmental indicators (e.g., waste per procedure, anesthetic gas usage) (MacNeill et al., 2017).
- Strengthen policy frameworks by aligning hospital accreditation standards with environmental performance (Dolchni et al., 2024).

## 5. Conclusion

This bibliometric analysis provides a comprehensive overview of the academic landscape on environmental sustainability in operating rooms. Research in this area has grown in visibility and thematic richness, yet important gaps remain, especially regarding nursing involvement, LMIC perspectives, and the integration of systems-level policy. The findings underscore the urgent need for interdisciplinary, context-sensitive, and scalable approaches to embed sustainability into surgical practice.

### Acknowledgement

We would like to thank the reviewers and the editorial board for their contributions to the publication process.

### Ethical Approval

This article does not contain any research requiring ethical approval.

### Financial Resources

During this study, no financial and/or moral support was received from any pharmaceutical company, any company that supplies and/or produces medical devices, equipment, and materials, or any commercial company that has a direct connection to the research topic and that could negatively affect the decision to be made regarding the study during the evaluation process.

### Conflict of Interest

Regarding this study, the authors and/or their family members have no potential conflict of interest with respect to this study, including membership in or affiliations with scientific or medical committees, consultancy, expert witness status, employment in any company, shareholding, or similar status.

## References

1. Almukhtar, A., Batcup, C., Bowman, M., Winter-Beatty, J., Leff, D., Demirel, P., Porat, T., & Judah, G. (2024). Barriers and facilitators to sustainable operating theatres: a systematic review using the Theoretical Domains Framework. *International journal of surgery (London, England)*, 110(1), 554–568. <https://doi.org/10.1097/JS9.0000000000000829>
2. Beloeil, H., & Albaladejo, P. (2021). Initiatives to broaden safety concerns in anaesthetic practice: The green operating room. *Best Practice & Research Clinical Anaesthesiology*, 35(1), 83–91. <https://doi.org/10.1016/j.bpa.2020.07.010>

3. Dolcini, M., Ferrè, F., Brambilla, A., & Capolongo, S. (2025). Integrating environmental sustainability into hospitals performance management systems: a scoping review. *BMC health services research*, 25(1), 764. <https://doi.org/10.1186/s12913-025-12928-x>
4. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
5. Johnson, S. M., Marconi, S., Sanchez-Casalogue, M., Francis, N., Huo, B., Alseidi, A., Alimi, Y. R., Pietrabissa, A., Arezzo, A., Frountzas, M., Bellato, V., Potapov, O., Barach, P., Rems, M., Bello, R. J., Nijhawan, S., Oslock, W. M., Sathe, T. S., Hall, R. P., Miller, B., ... Sylla, P. (2024). Sustainability in surgical practice: a collaborative call toward environmental sustainability in operating rooms. *Surgical endoscopy*, 38(8), 4127–4137. <https://doi.org/10.1007/s00464-024-10962-0>
6. Kara, Ö., & Ak, E. S. (2025). Carbon footprint and sustainability in the operating room: What to know on the road to becoming a green operating room. *Lokman Hekim Journal of the History of Medicine and Folk Medicine*, 15(2), 389–399. <https://doi.org/10.31020/mutfd.1549201>
7. Karliner, J., Slotterback, S., Boyd, R., Ashby, B., & Steele, K. (2019). Health care’s climate footprint: How the health sector contributes to the global climate crisis and opportunities for action. *Health Care Without Harm*. <https://noharm-global.org/documents/health-care-climate-footprint-report>
8. MacNeill, A. J., Lillywhite, R., & Brown, C. J. (2017). The impact of surgery on global climate: A carbon footprinting study of operating theatres in three health systems. *The Lancet Planetary Health*, 1(9), e381–e388. [https://doi.org/10.1016/S2542-5196\(17\)30162-6](https://doi.org/10.1016/S2542-5196(17)30162-6)
9. NHS England. (2022, July). Delivering a “net zero” National Health Service – July 2022 update (Green Plan update B1728). <https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2022/07/B1728-delivering-a-net-zero-nhs-july-2022.pdf> Access Date July 19, 2025.
10. NSW Health. (2024). Desflurane and environmental impact. Government of New South Wales. <https://www.health.nsw.gov.au/netzero/Pages/environmental-impact-desflurane.aspx>
11. Perrego, K. (2017). Improving staff knowledge of perioperative regulated-waste management. *AORN Journal*, 105(1), 85–91. <https://doi.org/10.1016/j.aorn.2016.11.005>
12. Pinheiro, O. L. R., Scavarda, A., & Machado, F. V. (2024). Sustainability in operating rooms: Awareness among health professionals. Seven Academic Publications.
13. Plezia, D., Sabol, V. K., Nelson, C., & Simmons, V. C. (2024). Improving waste segregation in the operating room to decrease overhead cost. *Quality Management in Health Care*, 33(1), 44–51. <https://doi.org/10.1097/QMH.0000000000000416>
14. Romanello, M., Walawender, M., Hsu, S.-C., Moskeland, A., Palmeiro-Silva, Y., Scamman, D., Ali, Z., Ameli, N., Angelova, D., Ayeb-Karlsson, S., Basart, S., Beagley, J., Beggs, P. J., Blanco-Villafuerte, L., Cai, W., Callaghan, M., Campbell-Lendrum, D., Chambers, J. D., ... Costello, A. (2024). The 2024 report of the Lancet Countdown on health and climate change: Facing record-breaking threats from delayed action. *The Lancet*, 404(10465), 1847–1896.
15. Vozzola, E., Overcash, M., & Griffing, E. (2020). An environmental analysis of reusable and disposable surgical gowns. *AORN Journal*, 111(3), 315–325. <https://doi.org/10.1002/aorn.12885>
16. Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Boykoff, M., ... Costello, A. (2023). The 2023 report of the Lancet Countdown on health and climate change: The imperative for a health-centred response in a world facing irreversible harms. *The Lancet*, 402(10417), 1976–2023. [https://doi.org/10.1016/S0140-6736\(23\)01859-7](https://doi.org/10.1016/S0140-6736(23)01859-7)
17. World Health Organization. (2023, October 12). Climate change: Key facts. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>
18. Zurynski, Y., Herkes-Deane, J., Holt, J., McPherson, E., Lamprell, G., Dammery, G., Meulenbroeks, I., Halim, N., & Braithwaite, J. (2022). How can the healthcare system deliver sustainable performance? A scoping review. *BMJ Open*, 12(5), e059207. <https://doi.org/10.1136/bmjopen-2021-059207>.