Carbon Footprint and Sustainability in the Operating Room: What to Know on the Road to Becoming a Green Operating Room*

Ameliyathanede Karbon Ayak İzi ve Sürdürülebilirlik: Yeşil Ameliyathane Olma Yolunda Bilinmesi Gerekenler

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ABSTRACT

The biggest threat to global health in the 21st century is climate change. Greenhouse gas emissions, one of the biggest causes of climate change, originate 4 to 10% from healthcare services. These emissions cause negative environmental impacts by increasing the carbon footprint. Operating rooms, with their large share in energy and resource consumption, make the biggest contribution to the increase in carbon footprint in healthcare services. Transforming operating rooms into green operating rooms that adopt and implement measures against climate change significantly contributes to maintaining and improving global health, protecting natural resources, and ensuring sustainability. In order to reduce emissions from operating rooms, reusable products should replace single-use products, medical and surgical gas usage should be reduced, and the right anesthesia and sterilization methods should be selected. In addition, reducing the length of hospital stay, waste and energy consumption, and digitalizing documentation and communication are additional measures to lower emissions. In reducing the carbon footprint and ensuring sustainability, it is crucial that these practices are understood and adopted by the operating room team and that green operating rooms are created. This study aims to examine the carbon footprint in the operating room in line with the literature, practices, and sustainability to reduce the carbon footprint and to convey what needs to be known on the way to becoming a green operating room.

Keywords: Carbon footprint, Climate change, Operating room, Sustainability, Green operating room

ÖZ

XXI. yüzyılda küresel sağlık için en büyük tehdit iklim değişikliğidir. İklim değişikliğinin en büyük nedenlerinden biri olan sera gazı emisyonlarının %4 ila 10'u sağlık hizmetlerinden kaynaklanmaktadır. Bu emisyonlar, karbon ayak izini artırarak olumsuz çevresel etkiye neden olmaktadır. Sağlık hizmetlerinde karbon ayak izinin artışına en büyük katkıyı, enerji ve kaynak tüketimindeki büyük pay ile ameliyathaneler sağlamaktadır. Ameliyathanelerin iklim değişikliğine karşı önlemler alan ve uygulayan yeşil ameliyathanelere dönüştürülmesi küresel sağlığın korunması ve iyileştirilmesine, doğal kaynakların korunmasına ve sürdürülebilirliğin sağlanmasına önemli katkı sağlamaktadır. Ameliyathane kaynaklı emisyonları azaltmak için tek kullanımlık ürünler yerine tekrar kullanılabilir olanlar tercih edilmeli, tıbbi ve cerrahi gaz kullanımının azaltılmalı, doğru anestezi ve sterilizasyon yöntemleri seçilmelidir. Ayrıca; hastanede kalış süresinin, atıkların ve enerji tüketiminin azaltılması, dokümantasyon ve iletişimin dijitalleştirilmesi emisyonların azalmasını sağlayan diğer önlemlerdendir. Karbon ayak izinin azaltılmasında ve sürdürülebilirliğin sağlanmasında, bu uygulamaların ameliyathane ekibi tarafından anlaşılması, benimsenmesi yeşil ameliyathenelerin oluşturulması büyük öneme sahiptir. Bu çalışmanın amacı ameliyathanedeki karbon ayak izini literatür, uygulamalar ve sürdürülebilirlik doğrultusunda inceleyerek karbon ayak izini azaltmak ve yeşil ameliyathane olma yolunda bilinmesi gerekenleri aktarmaktır.

Anahtar Kelimeler: Karbon ayak izi, İklim değişikliği, Ameliyathane, Sürdürülebilirlik, Yeşil ameliyathane

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Introduction

The World Health Organization (WHO) declared in 2018 that climate change is the greatest threat to global health in the 21st century.[1] The sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC) reported that human-induced greenhouse gas emissions will cause global warming. Climate change affects all aspects of both natural and human systems, including the physical environment, socioeconomic conditions and health system functioning.[2] Problems related to climate change include changes in weather patterns, increases in atmospheric carbon dioxide (CO_2) and infectious diseases, decreases in biodiversity and deterioration of public health. It is estimated that approximately 3.6 billion individuals reside in regions highly susceptible to climate change. From 2030 to 2050, climate change is projected to result in approximately 250,000 extra fatalities annually due to malnutrition, malaria, diarrhea, and extreme heat. Direct health-related damages (not including expenses in related sectors such as agriculture, water, and sanitation) are expected to range from 2-4 billion dollars per year by 2030.[2]

Carbon dioxide (CO2) is the primary greenhouse gas produced by human activities and has the most significant impact on global warming.[3] To understand carbon emissions, some concepts are necessary. One of these concepts, the carbon footprint, is the definition of the CO_2 equivalent of greenhouse gases emitted into the atmosphere as a result of human activities, organization or a country, measured in carbon dioxide equivalent (CO_2e).[4,5] CO_2e is a unit of measurement that describes the impact of many greenhouse gases in a common unit. The carbon footprint includes not only the measurement of greenhouse gases but also the analysis of the "life cycle" of the product, from production to consumption. The continuity of a product's production and consumption process highlights the concept of sustainability. Sustainability is the capacity to ensure permanence. For something to be sustainable, the triple nature of sustainability-environmental, social and economic factors-must be met. The proper use of natural resources, protection of the ecosystem, and support of present and future well-being are important.[4]

One of the largest contributors to CO_2 and other greenhouse gases, which are primarily responsible for climate change, is healthcare provided in hospitals. Globally, the healthcare sector is responsible for approximately 4-5% of greenhouse gas emissions, which are the main driver of climate change.[6] This rate reaches 7-10% in developed countries.[7] This information highlights the importance of reducing the carbon footprint and adopting sustainability in healthcare.[5] The World Health Organization leads the Alliance for Transformative Action on Climate and Health (ATACH) and brings together multiple health and development partners to assist countries in fulfilling their commitments to low-carbon health systems.[2,8] It is also implementing an action plan to protect health from the impacts of climate and more environmentally sustainable health systems that reduce carbon emissions and improve health.[2]

To prevent catastrophic health effects and prevent millions of deaths due to climate change, the worldwide temperature increase should be limited to 1.5°C.[2] To reduce the effects of climate change and slow global warming, many countries have agreed to halve their greenhouse gas emissions by 2030 to keep the global average temperature increase below 2°C and achieve a zero carbon footprint.[9] In China, regulations for monitoring greenhouse gas emissions within the scope of the European Union harmonization process came into force in 2014. For example, the zero-carbon footprint of the National Health Services (NHS) in England has greatly advanced, which it committed to achieving by 2040, with a carbon emission reduction of 580 kt in 2021.[10]

Surgery is one of the clinical activities that has caused the greatest increase in the carbon footprint. In particular, operating rooms (ORs) constitute a large share of the energy and resource consumption of

healthcare institutions.[11,12] The literature highlights that ORs have "3-6 times more energy consumption than the entire hospital" and contribute significantly to the emissions associated with healthcare service delivery.[12,13] Moreover, they are responsible for high levels of waste production; greenhouse gas emissions; and air, water and pharmaceutical pollution. As an environmentally friendly operating room (OR), the measures taken/to be taken in ORs play a major role in reducing the carbon footprint, preventing climate change and developing a sustainable environment.[14]

Carbon Footprint in the Operating Room

The carbon footprint in ORs is caused by energy use; the use of consumables, equipment, and instruments, both disposable and reusable, used in the pre- and postoperative periods; and the use of anesthetic gases, fuel, water, and waste.[15] ORs constitute approximately 20-30% of a hospital's waste.[12] The carbon footprint of a surgical procedure in the United Kingdom (UK), excluding the direct contribution of anesthetic gases, is estimated at 24 kg of CO_2 equivalent (CO_2e) per hour of surgery.[15,16] Moreover, this calculated carbon footprint can vary depending on the patient's needs, clinical condition, type of surgery and geographical location.[16-18] Reducing or ensuring the sustainability of products used in resource-intensive units such as ORs, such as the commitments of 18 countries to achieve net zero-carbon healthcare, is an important step in meeting environmental sustainability targets.[8,13]

As the demand for surgical procedures increases in developing countries, the global emissions and waste generated from surgeries are anticipated to grow. Addressing this demand will lead to significant environmental repercussions due to the extensive production of surgical infrastructure and equipment. Consequently, it is crucial to develop effective strategies to evaluate and reduce the environmental impact of surgical interventions to ensure sustainable healthcare delivery in the future.[17,18] Furthermore, determining the specific carbon footprint of surgery will facilitate the identification of targeted interventions.

Research has reported that the average carbon footprint of products used for carpal tunnel decompression is 12.0 kg CO_2e, that for tonsillectomy is 41 kg CO_2e, that for inguinal hernia repair is 11.7 kg CO_2e, that for cataract surgery is 86.62 kg CO_2e, that for knee arthroplasty is 85.5 kg CO_2e, that for laparoscopic cholecystectomy is 20.3 kg CO_2e, that for rotator cuff repair is 334.61 kg CO_2e, that for transurethral resection of bladder tumors is 131.8 kg CO_2e, that for tonsillectomy is 7.5 kg CO_2e, and that robotic and laparoscopic surgery cause more carbon emissions than open surgery does.[13,19-22] In the literature, robotic laparoscopy has a carbon footprint of 40.3 kg CO_2e, which is greater than that of laparoscopy (29.2 kg CO_2e) and laparotomy (22.7 kg CO_2e).[23] Approximately two-thirds of the carbon footprint across the dataset is attributed to single-use products. Single-use equipment and medical devices (average contribution of 24%) and individually wrapped reusable instruments (average contribution of 24%) are considered to have a high carbon footprint.

In systematic reviews examining the impact of surgical interventions on the carbon footprint, three main factors have been reported: (1) energy consumption, (2) anesthesia, and (3) disposable products.[13,24] In this article, the content is presented more comprehensively.

Reprocessing of Single-Use Products and Reusable Products

In the past, the use of single-use products in surgical procedures has been associated with a reduction in the incidence of surgical site infections. The preference for single-use products over reusable products is a negative practice in terms of sustainability. Precautions taken against surgical site infections, which are

among the most common and costly postoperative complications, are among the most resource-intensive infection prevention initiatives. WHO guidelines recommend mechanical cleaning and the use of the highest possible decontamination methods, especially if Creutzfeldt–Jakob disease or its variant is suspected.[25] This risk has led to the use of disposable products being preferred over errors that may occur during sterilization. However, one study reported that, compared with disposables, reusable laryngoscope handles and blades did not differ in terms of the risk of developing iatrogenic infection.[26,27] The use of disposable products, on the other hand, leads to increased waste production, consumption of resources, and an increased carbon footprint.[28]

Reducing single-use equipment in ORs significantly contributes to reducing the carbon footprint.[29,30] Compared with their single-use equivalents, reusable products are estimated to have a lower carbon footprint. At this point, it is important to reduce the number of products used in ORs, prefer repair services to make them reusable, and support recycling.[31]

In the literature, the consumables and instruments in the sets used in surgery should also be reviewed, and the instruments and consumables not used by the team should not be opened.[22,32] Considering that material costs constitute 56% of the total OR budget, preparing and inspecting reusable products according to strict disinfection and sterilization rules is a recommended practice for reducing the carbon footprint.[33]

Perioperative Textile Products

Disposable perioperative textiles (surgical gowns, surgical tablecloths, etc.) have significantly worse environmental outcomes than reusable perioperative textiles do. The use of disposable perioperative textiles increases energy consumption and the carbon footprint by 200–300%. In a life cycle calculation in the literature, choosing reusable surgical gowns instead of disposable surgical gowns was reported to reduce energy consumption by 64% and the carbon footprint by 66%.[34]

The USA Centers for Disease Control and Prevention (CDC) reports that there are no scientific data showing that there is a difference between disposable and reusable perioperative textile preferences in preventing surgical site infections.[35] A study in the literature reported that surgeons prefer reusable surgical gowns for reasons such as ease of use and superiority in protection, but 80% of the hospitals in the USA where the study was conducted do not offer the use of reusable surgical gowns.[36] In this context, examining the current situation of ORs and reducing the use of disposable perioperative textiles with the use of reusable surgical clogs, surgical gowns and surgical caps are important.[37]

Sterilization

When the use of reusable products in the OR is considered, sterilization and the waste generated by this process should be considered.[4] A previous study reported that the sterilization of 255 pieces of laparoscopic reusable instruments (Veress cannulas, trocars, etc.) required the use of 76.5 liters of cleaning agent, 5249 kWh of energy, 373 m3 of water, and 4569 liters of steam; the use of disposable instruments resulted in the generation of 295.8 kg of household waste and 375.8 kg of plastic waste.[38] Another study reported that CO_2e emissions and water usage of reusable sets are largely due to sterilization and decontamination.[39] A study conducted in the UK reported that alcohol-based peeling solutions provide superior decontamination compared with traditional washing methods, saving 931,938 liters of water per year.[40] It was also reported that sterilizers that are not working and are on standby continue to use electricity and water and that 26% of electricity and 13% of water can be saved by turning off idle machines.[41]

Considering these studies, it is important to develop and implement sterilization and decontamination strategies that have low carbon emissions and consume less water and energy in the preparation of tools and decontamination materials for reuse.[4] However, studies on the carbon emissions of sterilization and decontamination are insufficient in the literature.

Energy Consumption

More than half of the carbon footprint of healthcare comes from energy consumption. Operating rooms use 3–6 times more energy per m^2 than whole hospital spaces do. This high energy consumption is attributed mainly to running the heating, ventilation, and air conditioning (HVAC) system at full capacity around the clock, seven days a week. While HVAC systems in hospitals account for 40% of healthcare emissions, they account for 90–99% of the energy consumption of ORs.[12] The management of HVAC systems is important for reducing the carbon footprint by saving energy.[36]

A suggestion for the ecological use of HVAC systems could be to turn off or reduce the HVAC system when ORs are not in use, either during periods of less circulation (nights, weekends, etc.). In the literature, HVAC cuts made at night and on weekends in 19 out of 22 ORs were reported to reduce HVAC energy consumption by 50%.[12] In the same study, organization was achieved by leaving the HVAC system in three emergency ORs.[12] In addition, reducing the air exchange rate from 30 to 6 in ORs that are at rest and returning it to the old air circulation before starting to use does not cause a significant difference in bacterial density; therefore, reducing the air exchange rate in ORs that are at rest provides a possible energy cost of 70%.[42-44] The issue that should be considered here is that the HVAC system should be turned on 30 minutes before the surgery starts. The HVAC system, which is completely turned off for 10 hours, ensures that the levels of particles and bacteria in the air reach acceptable levels 30 minutes after it is turned on again.[44] With these recommendations, the carbon footprint can be reduced owing to the correct management of the HVAC system.[45]

The use of radio frequency identification (RFID) technology in ventilation and air conditioning systems is also an important development. RFID, an automatic identification and data capture technology that interacts with the HVAC system, can be used to reduce energy consumption in the OR. RFID technology can control the ventilation and heating rates of an HVAC system by obtaining information about the number of personnel in the OR and the status of the surgery. A pilot study conducted in Taiwan reported that radio frequency identification technology can provide approximately 50% energy savings compared with a normal ventilation system.[46] The technology is activated when the first employee enters the OR and when the OR is needed in an emergency. In this way, energy savings are achieved while the air quality of the OR can be maintained with an automatic system.[46]

Considering that the need for ventilation and air conditioning systems is associated with the geography of the hospital, the contribution of the geography where the OR is located and the geography-specific measures to be taken to the carbon footprint are important issues. A comparison of energy consumption in regions with different weather conditions in Toronto, Calgary and Sacramento revealed that electricity consumption for cooling is five times greater in Sacramento, whereas gas use for heating is significantly greater in Calgary.[47] At this point, buildings where the OR is located should be well insulated to balance heat.[48] In addition to ventilation and air conditioning systems, the high-quality lighting used in ORs and the continuous use of electrical equipment also contribute negatively to the carbon footprint. In addition, conventional lighting used outside ORs has a large negative effect on the carbon footprint. Preferring LED

lighting instead of conventional lighting contributes positively to reducing the carbon footprint.[4,10] The NHS has also implemented this practice.[10]

Although it is not possible to reset the carbon footprint due to the nature of ORs, it is possible to reduce it with correct management. In the Glasgow Declaration to Improve Environmental Sustainability in Anesthesiology and Intensive Care, the optimization of HVAC systems, lighting and electrical equipment, sustainable energy production and prevention of energy loss were among the priority issues regarding energy consumption.[49] Accordingly, the applicability of the determined strategies is affected by the country's development level. While developed countries have adopted green operating room practices more quickly, this process is slower and more difficult in developing and underdeveloped countries. The reason for this is seen as inadequate financial resources and waste management systems, infrastructure problems, and insufficient awareness of environmentally friendly health services in developing and underdeveloped countries. However, increasing global environmental awareness and investment resources and supporting them with legal regulations will accelerate the spread of these practices.[50,51]

Anesthesia

Medical gases are needed to provide anesthesia/analgesia, assist in surgery, and ensure the operation of medical devices. Among these, oxygen (O_2), CO_2, nitrous oxide (N2O), and volatile anesthetic agents are frequently used in ORs. Inhalation anesthetics account for approximately 5% of hospital carbon emissions.[11] While only 5% of inhalation anesthetics are metabolized and eliminated from the patient's body, 95% are released into the atmosphere through the cleaning system of the anesthesia machine. The widespread use of inhalation anesthetics results in a high carbon footprint.[52] Therefore, it is important to choose anesthetic gases with a low carbon footprint risk in terms of climate change. To understand the effects of anesthetic gases on the climate, it is necessary to know the global warming potential (GWP) value. The relative warming effect of gas in the atmosphere is evaluated with respect to the GWP. CO_2 has a GWP of 1 and is used as a reference gas in determining the residence time of gases in the troposphere.[11]

The general environmental impact of anesthesia can be reduced by using low-carbon footprint inhalation agents and gas purification systems and preferring regional or total intravenous anesthesia.[29,30] In the literature, a two-group comparison of 47,157 surgeries in which intravenous anesthesia was used with both intravenous and inhalation anesthesia revealed that the use of only intravenous anesthesia reduced the carbon footprint by 20 times.[53] In the literature, in three different ORs where the carbon footprint was monitored for a year, anesthetic gases and energy consumption constituted the largest sources of greenhouse gas emissions, which supports this information.[12] In the same study, the surgical carbon footprint was reported to be 7–9 million tons per year, and anesthetic gas emissions increased 10-fold with the use of desflurane.[12] The emission from one bottle of desflurane is equivalent to the emission of 440 kg of coal.[10] Therefore, the transition from desflurane to lower carbon alternatives such as sevoflurane is one of the important changes.[10]

In the Glasgow Declaration to Improve Environmental Sustainability in Anesthesiology and Intensive Care, the preference for low-flow anesthesia, limiting the use of fluorinated gases and N2O, and choosing the right anesthesia are among the priorities.[49] In addition, it is predicted that the correct disposal of nitrous oxide can significantly reduce emissions. It is estimated that 30% of nitrous oxide remains in canisters after use. However, its recycling and environmentally friendly disposal are difficult. A new application or method is needed.[10]

One of the controversial issues is the frequency of change in anesthesia breathing circuits. No difference was observed in terms of bacterial load when anesthesia breathing circuits were changed and disinfected once every 24 hours, 48 hours or 7 days. Therefore, longer change intervals are recommended to reduce the carbon footprint and ensure sustainability.[54]

Use of Gases

Inhalers used for respiratory problems increase carbon emissions. Most of the emissions come from the propellant gas in metered-dose inhalers used to deliver more of the medication itself. A solution could be to design inhalers with low-carbon propellants. Another solution could be to use dry powder inhalers, which are clinically equivalent to the inhalers in use and have lower carbon emissions. A 30% switch to dry powder inhalers has been suggested to reduce CO_2e per year by 374 kt.[10] The National Institute for Health and Care Excellence (NICE) supports switching to low-carbon inhalers in its 'Asthma Patient Decision Aid'.[10]

Insufflation, which is used to expand the field of view in laparoscopic surgeries, also increases carbon emissions. Owing to the difference in surgical techniques, no carbon emission reduction recommendations have been included in the literature for this situation.

Medical Waste

Waste from the OR is considered high risk, as it can cause infection and injury. It is important to separate medical waste into at least five categories: biological waste, sharps waste, medicines, radioactive materials and general household waste to facilitate recycling. In particular, the high waste caused by single-use products brings the concept of recycling to the agenda in terms of sustainability in the OR.[52] However, excess contaminated waste can prevent the recycling of OR waste. In addition, current recycling technologies cannot separate hazardous materials from recyclable materials.[55] Considering the presence of contaminated medical waste, uncontaminated medical and nonmedical waste in the OR and their impact on the carbon footprint, the separation of uncontaminated and recyclable waste is highly important for reducing the carbon footprint. Uncontaminated medical and nonmedical waste can be recycled with methods that have lower carbon emissions because it does not pose any biological, chemical, radioactive or physical hazard. However, contaminated medical waste cannot be recycled and is mostly incinerated because of its potential to spread disease. At this point, the method of disposal of waste is also highly important. It has been reported that 21–65 kg of CO_2e is produced during the recycling of hospital waste, 569 kg of CO_2e is produced when it is decontaminated via an autoclave before low-temperature incineration via waste-to-energy, and 172–249 kg of CO_2e is produced during low-temperature incineration via waste-to-energy. It has been reported that the largest carbon emission of 1074 kg CO_2e occurs due to the burning of waste at high temperatures.[56]

In this context, implementing an effective waste management program and training and supervision of OR staff is an important initiative in reducing and recycling waste.[4] In the literature, 56% of OR staff do not know which items are recyclable, and more than 60% of them say that the greatest obstacles to recycling are a lack of hospital support and inadequate training.[57]

Propofol, which is used in anesthesia, is the most wasted drug. Emergency drugs such as atropine, epinephrine, and ephedrine are among the drug groups with the highest unused drug volumes.[58] Considering the volume of water used in the production of drugs and the water resources they mix with when discarded, there is a negative environmental impact.[11] Reducing drug waste was also among the priority issues in the Glasgow Declaration to Improve Environmental Sustainability in Anesthesiology and

Intensive Care.[49] In 2003, the Stockholm County Council established an environmental risk classification of drugs to reduce drug deposits in air, water, and soil. In this way, the environmental effects of drugs were determined to be between 0 and 9 according to the persistence-bioavailability-toxicity (PBT) index.[59] According to this index, propofol is 9 PBTs; ondansetron and buprenorphine are 6 PBTs; midazolam and bupivacaine are 5 PBTs; fentanyl, metoprolol and ketorolac are 4 PBTs; and lidocaine is 3 PBTs.[59] Propofol is an intravenous anesthetic drug with a PBT value of 9, and it has been recommended that it be destroyed by burning via a special process with a carbon filter.[60]

Documentation and Communication System

In documentation and communication, instead of paper systems, choosing more environmentally friendly and waste-free digital systems is an important step in reducing the carbon footprint. Maintaining surgical clinics and OR health care records and information systems on an electronic basis and supporting the digitalization of clinical and operational workflows and communications are important practices in becoming green ORs.[10] The digital documentation system will reduce paper consumption, waste and large-volume storage areas. This will contribute to a reduction in the concrete area ratio in the physical planning of health institutions.

Hospitalization Duration for Surgical Patients

Twenty-nine percent of the carbon footprint is due to hospitalization.[15] Minimizing the hospitalization time of inpatients is an application that can reduce the carbon footprint.[61] Preoperative and postoperative expert multidisciplinary team evaluations and continuous and effective communication with patients reduce the number of surgical cancellations and early diagnoses of complications. As a result, prolonged hospitalizations are anticipated to be reduced.[62] In the literature, increasing the number of staff involved in the preoperative evaluation in the day clinics of a university hospital reduces daily cancellation rates.[61]

Another recommendation is to plan surgery as a daily case unless there is a contraindication for low-complexity procedures (such as total hip and knee arthroplasty).[62] Here, it is important to have good institutional daily surgery infrastructure and for the practice to be adopted by the surgical team to be sustainable.[62]

Conclusion and Recommendations

Many practices in the OR increase the carbon footprint. The preferences of disposable consumables, instruments, surgical textiles in the OR, anesthesia, the energy consumption load of HVAC systems, medical waste, prolonged hospitalization periods, documentation and communication systems causing waste are the main factors that increase the carbon footprint.

Preferring reusable instruments and surgical textiles, using anesthesia and sterilization methods with low carbon footprints, using energy-efficient HVAC systems, separating the recyclable part of waste, digitizing the documentation and communication system, planning practices that reduce hospitalization time, and planning initiatives that reduce surgical and medical gas emissions can be listed as environmentally friendly practices that support sustainability and reduce the carbon footprint on the way to becoming a green OR. For these practices to be understood and adopted by the surgical team, informing and training the staff has a key role.

To achieve these goals, health authorities and policymakers can set sustainability standards, create guidelines, and offer financial incentives to become green operating rooms. Additionally, encouraging

research and innovation into anesthesia and sterilization methods with a low carbon footprint, adopting practices that will enable patients to recover faster, and accelerating the transition to digital systems can significantly reduce the environmental impact of healthcare. Sustainability training also ensure that these environmentally friendly practices are effectively implemented and will help to spread such practices.

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Author Contributions

Öykü Kara: Design, data collection and processing, interpretation, literature review, writing the article, critical review.

Ezgi Seyhan Ak: Idea/concept, supervision, interpretation, writing the article, critical review.

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