STUDENTS' CORNER
NARRATIVE REVIEW

The environment under the knife: A review of current Eco-surgical strategies and recommendations for Pakistan

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Abstract

The healthcare sector at its core is based on the fundamentals belief to do no harm and bring about betterment in the lives of the people. Paradoxically, hospitals are one of the leading contributors to pollution, greenhouse gas (GHG) emissions and toxic waste material worldwide. Surgical care delivery is quite resource intensive, consuming significant amount of energy and equipment as well as producing large quantities of waste. With climate change being a global priority, it is crucial that hospitals re-evaluate the environmental impact of such practices. The current review was planned to identify areas of improvement in surgical care in terms of sustainability, as well as describe efficient and innovative strategies for hospitals in Pakistan to lessen their impact on the environment. The implementation of the 5 R's strategy for surgical care (Reduce, Reuse, Recycle, Rethink and Research) as well as general measures to improve energy efficiency, waste management and inter-sectoral collaboration will provide significant benefits to the environment and advance efforts to creating a more sustainable future for surgical healthcare in Pakistan.

Keywords: General Surgery, Environmental Monitoring, Environmental health, Surgery Department, Hospital, Healthcare Delivery.

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Introduction

Healthcare institutions are amongst the leading contributors of waste products, even in a country as developed as the United States of America (USA) where they produce more than 4 billion pounds of waste each year.[1] Unsurprisingly, operating theatres and delivery rooms account for more than two-thirds of waste produced by hospitals, most of which is disposed through incineration or in landfills.[1] As safe-keepers of the health of humanity and responsible citizens of the world, it is the unquestionable responsibility of healthcare practitioners to commit towards reducing the disastrous environmental impact of the healthcare industry.

The term eco-surgery refers to the embodiment of an ecological approach to surgical healthcare,[2] which includes reducing energy consumption, using resources and raw materials judiciously, and decreasing environmental pollution.[1] The growing importance of eco-surgery is evident worldwide in the emergency of several global initiative to fulfill this purpose, such as the Green Guide for Healthcare[3] and Leadership in Energy and Environmental Design for Healthcare.[3] However, although institutions in developed countries such as USA have begun to take steps towards developing greener surgical practices,[1] developing countries like Pakistan have much ground to cover. Achieving environmentally sustainable surgical care on a global level requires urgent and focused commitment from countries across the world, including lower-middle-income countries (LMICs) like Pakistan. The added incentive to LMICs for achieving greener surgical practices is that this invariably comes with significant cost-savings.[1] Thus, aim of this review was to summarise current eco-surgical practices worldwide, with special focus on the role of hospitals in eco-surgery, and suggest initial recommendations to achieve an environmentally friendly surgical healthcare system in Pakistan.

Strategies to Negate Environmental Hazards: Several structural, behavioural, and procedural measures can reduce the deleterious effects of surgical procedures on the environment, and are discussed below with regards to the 5 R's strategy: Reduce, Reuse, Recycle, Rethink and Research[4,5] as summarized in Table-1.

Reduce: Every surgical procedure generates substantial amounts of waste, including surgical gowns, paper, masks, rubber gloves, and sutures, and judicious usage can lead to significantly significant reductions in waste. A "lean and green" surgical project in America resulted in 5.06 pounds lesser waste per operative case,[6] while a Hospital in the UK saved an incredible 19,000 kg of plastic

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Table-1: General Strategies to Combat Environmental Impact.

Reduce	• "Lean and green" surgical projects like in America[5]
	• Reducing consumption of plastic gloves
	• Reformulation of surgical kits[1]
	• Preventing over-supply of items[1]
	• Purchasing supplies from vendors who provide eco-friendly items[4]
	• Following international guidelines for PPE specific to each surgery
	• Reducing energy consumption by switching off surgical devices when not in use[1]
	• Implementing energy efficient heating, lighting, air-conditioning[4]
	• Gradual shift to renewable energy sources[3]
	• Promoting use of alcohol-based sanitizers instead of scrubbing when unnecessary[6]
	• Pedal devices operated by foot for scrubbing[3,7]
	• Scrubbing without using a brush reduces plastic waste[9]
Reuse	• Re-usage of surgical equipment by autoclaving[4]
	• Reusable sharp containers[4]
	• Using reusable items instead of disposable items like drapes or gowns[6]
Recycle	• Appropriate waste collection, transport, handling, segregation, and disposal[3,12]
Rethink	• Opting for one-stage surgical procedures which in the past have been done in two stages[6]
	• Alternative techniques for anaesthesia, instead of anaesthetic gases[12]
	• Use of broad-spectrum prophylactic antibiotics must be rethought[6]
	• Tele-consultation services to save travel and associated pollution from vehicles[1,3]
	• Medical documentation can be computerized for paperless records[3]
Research	• Evidence-based eco-surgical strategies and interventions[1]
	• Formation of interdisciplinary groups for regular audits
	• Educational and awareness programmes

in less than year by simply reducing consumption of plastic gloves. Manufacturers can be urged to reformulate surgical kits, such as for surgical equipment or protective gear, by removing unnecessary items and minimizing plastic usage.[4] Over-supply of items can be prevented by implementing regular audits evaluating demand and usage.[4] Moreover, orders should be placed only when items are needed in bulk, to reduce packaging, travel costs, and carbon emissions from transportation.[7] Importantly, hospitals should prefer purchasing supplies from vendors who provide eco-friendly items and operate eco-friendly businesses.[1] With regards to use of personal protective equipment (PPE), international guidelines should be followed specific to each procedure, rather than using all possible PPE for each surgery.

Reducing energy consumption is simple and beneficial. The simple measures of switching off ventilators and surgical equipment/devices when not in use, and ensuring appropriate regulation of temperature, resulted in a 2,000,000 kg annual decrease in carbon emissions across six hospitals in the UK.[4] In addition, implementing energy efficient heating, lighting, air-conditioning, sterilization, waste disposal, and infrastructural design can drastically reduce energy costs.[1] Moreover, a gradual shift to renewable energy sources, such as solar energy, would go a long way in achieving eco-friendly surgical practice in the future.[7]

Likewise, promoting use of alcohol-based sanitizers instead of hand washing or scrubbing when unnecessary, can help reduce water consumption.[2,4,5] NICE guidelines recommend that alcohol-based hand rubs be used for disinfection post-surgery if one's hands are only slightly dirty.[8] Moreover, pedal devices operated by foot save considerable amounts of water (only 6.7L per scrub),[2,7,9] and scrubbing without using a brush is also considered safe and reduces plastic and paper waste.[10] Education to surgeons and OR staff regarding appropriate eco-friendly measures to prevent surgical site infections have decreased water consumption by 2.7 million liters/year at a hospital in the US.[11]

Reuse: Re-usage of surgical equipment and re-processing of single use devices is still an area of utmost caution, due to the lack of standardized quality of autoclaving and other disinfecting methods. However, no increased health risk from the use of reprocessed devices has been reported so far,[1,12] and reprocessing reduces waste significantly but in addition to cutting costs.[1]

There are several items that can be safely reused, such as sharp bins, suture-packaging, and packaging and wrapping, all of which can help reduce waste significantly.[7] Reusable sharp containers reduce waste by approximately 34,000 pounds in a 1000-bed hospital.[1] Two hospitals in the US reduced waste by 23,000 kg/year by shifting to washable scrubs and reusable surgical gowns.[1,5] There is no benefit of using disposable items like drapes or gowns where reusable ones are available, as this can help tons of plastic.[2]

Recycle: A quarter of waste from surgeries and ORs can be recycled.[5] Often, hazardous/infectious and non-hazardous waste is not segregated, resulting in mass incineration and increased in emission of greenhouse gases.[4,7] Raising awareness and training staff for appropriate waste collection, transport, handling, segregation, and disposal is important to allow efficient recycling.[7,13] As per guidelines, health waste is segregated into 5 categories to allow for separate disposal and treatment: infectious (blood, vomitus, body fluids etc.), sharps (injections, needles etc.), radioactive, pharmaceutical and general non-hazardous waste (paper, gowns etc.).[1] However, general non-hazardous waste frequently ends up in the bag for infectious waste only, mostly due to a lack of awareness, leading to increased treatment costs and decreased recycling.[1]

Rethink: Re-framing surgical healthcare delivery can prove to be beneficial for the environment. Future surgeons should be trained and encouraged to opt for one-stage surgical procedures which in the past have been done in two stages. This is more eco-friendly, as it allows shorter hospital stay, reduced expenditures, lesser operating time, decreased drug usage, and lesser utilization of PPE.[2] Similarly, implementation of alternative techniques for anaesthesia, instead of anaesthetic gases, can decrease their ecological impact.[13] Use of broad-spectrum prophylactic antibiotics must be rethought,[2] with their clinical benefit weighed against the harm they pose to the environment in terms of increasing antimicrobial resistance.

Lastly, at times, unprecedented events like the COVID-19 pandemic open the door to several hitherto underutilized options. Surgical tele-consultation services help save travel and associated pollution from vehicles.[4,7] Moreover, it is high time that medical documentation be computerized for paperless records.[7]

Research: Research is the foundation for evidence-based eco-surgical strategies and interventions.[4] Particularly important is the evaluation of the safety, environmental impact, and cost-effectiveness of measures pertaining to recycling, reusage, and waste reduction.[2,13,14] Formation of interdisciplinary groups for regular audits and evaluation of eco-surgical interventions, along with a focus on educational and awareness programmes, are essential in achieving eco-friendly surgical healthcare.

Development of Environmentally Protective Surgical Techniques: In evaluating the environmental impact of surgery, studies have compared the cost effectiveness and carbon footprint of surgical procedures across many sub-specialties. Cataract surgery is the most frequently conducted surgical procedure globally and has a variety of techniques: phacoemulsification, manual small-incision cataract surgery (MSICS), and femtosecond laser-assisted cataract surgery (FLACS).[15] There is great variability in global waste production in cataract surgery, with phacoemulsification producing between 0.19-4.27 kg of solid waste and 41-130 kg carbon dioxide equivalents (COe) per case, while MSICS produces between 0.18-2.29 kg of solid waste and 40-119 kg COe per case.[16] MSICS has also proven more cost-effective than phacoemulsification,[15,17,17] while FLACS is the least cost-effective,[15] suggesting that the use of MSICS could prove effective in low-resource setups.

It is important that newly introduced surgical innovations confer ecological advantages, in addition to clinical and cost benefits. The SOFT COAG is a novel and unique mode of the electrosurgical unit, which may be used to control intraoperative bleeding.[19] By generating "joule heat" and automatically regulating output voltage, SOFT COAG denatures proteins without producing carbonization of tissue. This allows intraoperative haemostasis while significantly reducing the use of suturing for intra-operative, lowering both costs and waste production. In addition to improving the efficiency of treating intra-operative bleeds, the SOFT COAG can be autoclaved and reused around 100 times providing a great ecological advantage over single-use sutures in everyday operations.[19] Additionally, a study utilized a new BiClamp reusable sealing instrument along with the SOFT COAG as an alternative to automatic staples in pulmonary resection operations.[20,21] Within the trial, it was assessed that the BiClamp is an effective alternative to the conventional mechanical stapler in separation of unseparated interlobular fissures in pulmonary lobectomy.[20] In addition to having comparative operative time, intraoperative bleeding, and postoperative complications, use of the BiClamp reduced the operative cost, environmental impact, and carbon emissions associated with mechanical staples.[20,21]

Minimally invasive surgery has displayed lower overall CO2 emissions than open surgery,[22] should be the approach of choice wherever possible. However, artificial intelligence-based robotic surgery, which is making great strides, has substantially inferior cost-efficiency and greater waste production.[23] In light of the ever-evolving field of surgery, there is need for adequate prioritization of the environmental benefit of newer surgical techniques, equipment, and procedures.[23]

Role of Hospitals in Eco-Surgery: Despite being havens of healing, hospitals worldwide are responsible for considerable amounts of hazardous emissions and toxic waste products. In today's climate, it is crucial that hospitals re-evaluate their responsibilities in relation to environmental sustainability, in order to preserve nature for current and future generations.[24,25] In recent years, the advent of various initiatives and organizations such as Healthcare without Harm and Coalition for Green Health Care have been vital in introducing and promoting the concept of the "Green hospital".[26] Several hospitals around the world have already begun implementing measures to reduce their environmental footprint.[27] Recommendations for hospitals in Pakistan are summarized in Table-2.

Policies and Measures: One of the first steps to a more ecofriendly health care system is the development of robust policies. Energy efficiency is one such area of improvement. The health sector consumes significant

Table-2: Specific Recommendations for Eco-Friendly Surgery in Pakistan.

Type of Intervention	Specific measures that can be taken
Policies and Measures	◆ Energy Efficiency • employ conservation policies to reduce energy consumption by a certain percentage in every year[28] • assess baseline emissions and develop appropriate action plans[24] ◆ Waste Management • develop a detailed waste management system[29] • Employ the use of sustainable non-burn treatment technology[28] • Purchase recycled, reusable products • Adopt formal environmental management systems adhering to EMAS or ISO standards[30]
Structural Modifications	◆ Alternative Energy • Invest and install renewable energy sources, such as solar panels, wind turbines and CHP technology[27] ◆ Built Environment • Prioritize incorporating sustainable elements in the hospital design e.g Day lighting, green roof systems, natural ventilation[27,28] • Install energy-efficient lighting, thermal insulation and water conserving equipment • Retrofit outdated equipment[31,32]
Education	◆ Create awareness of the importance of environmental protection measures among employees ◆ Engaging the workforce through newsletters and holding environmental action days[24,31] ◆ Organize go green campaigns and encourage efficient use of resources ◆ Encourage workers to walk or use bicycles and public transportation whenever possible[27,31] ◆ Adopt waste reduction and recycling practices[28]
Performance Measurement	◆ Define goals pertaining to environment protection and employ relevant strategies ◆ Outline indicators to measure the success of the strategies employed[32]
Collaboration	◆ Create awareness among policy makers and legislative bodies about the detrimental effects of climate change ◆ Health ministries must enforce climate friendly policies and develop action plans at national and international levels ◆ Agencies financing health care construction should ensure funds are utilized for development of ecofriendly health facilities ◆ Incorporate environmental health policies into hospital accreditation standards[27,28]

amounts of fossil fuels and contributes to considerable greenhouse gas (GHG) emissions. Hospitals must aim to establish an energy usage baseline, as well employ energy conservation policies to reduce energy consumption by a certain percentage in every year.[28] In addition, hospitals must periodically assess their contribution to pollution and greenhouse gas emissions and develop action plans for reducing it.[24] Moreover, it is important that hospitals develop a detailed waste management system, laying out the protocol to be followed on the special handling, segregation, storage and transportation for hazardous wastes.[29] Non-burn treatment technology can be used to ensure that the waste is disposed of in an economical, safe and environmentally sustainable manner.[28] In addition, implementation of standard purchasing practices such as buying reusable instead of disposable products, or recycled ones, and prohibiting the purchase of materials containing toxic elements such as mercury and PVC.[27] Lastly, adopting formal environmental management systems adhering to EMAS (Eco-Management and Audit Scheme) or ISO standards is a good practice for hospitals to monitor quality assurance and carry out informed actions.[30]

Structural Modifications: Hospitals should consider investing in sources of clean and renewable energy, such as solar panels and combined heat and power (CHP) technology, whereby waste heat produced from on-site electricity generation can be captured and utilized as thermal energy for heating purposes.[27] In addition, hospitals can plan energy efficiency into the hospitals infrastructure by installing meters to measure electricity consumption, using thermal insulation and conserving water by installing efficient faucets and toilets. Wherever possible, hospitals must prioritize sustainable and eco-friendly designs and plans for hospital infrastructure. Day lighting, green roof systems, natural ventilation and gardens and supporting the use of local, using recyclable materials for construction are a few examples.[27,28] Furthermore, hospitals should employ the use of ecofriendly technology by setting up cogeneration units, installing inverter air conditioners, and retrofitting outdated equipment.[31,32]

Performance Measurement: For hospitals, measuring environmental performance is an invaluable tool to assess and reflect on the effectiveness of current policies for environmental sustainability. Following the framework proposed by Blass et al,[33] the first step is to define goals pertaining to environment protection, after which robust strategies are deployed. The effectiveness of these

strategies are measured by selecting performance indicators that are measurable, valid and controllable.[33,34] These could include electrical power consumption, water withdrawal from source, direct and indirect greenhouse emissions, and unit weight of waste material.[32] Performance data should then be compiled and used to inform future decisions and formulate improved strategies.

Education: Healthcare systems can only achieve environmental sustainability with the cooperation and dedication of the workforce involved. Hospitals should aim to make hospital staff and the general public aware of the importance of environmental protection measures and the health sector's role in mitigating climate change. Engaging the workforce through announcements via newsletters, holding environmental action days, and organizing "go green" campaigns" could help embed the concept of environmental sustainability into the hospitals culture.[24,31] Moreover, hospitals should also encourage workers to walk or use bicycles and public transportation whenever possible to limit emissions, or to take the stairs instead of elevators to reduce electricity usage.[27,31] Hospitals could also introduce periodic training programme to teach healthcare workers proper waste management and disposal, and constructively correct bad practices and educate employees about their behaviour.[32] Lastly, hospitals should develop institution-specific waste reduction policies and regularly educate employees about the importance of their role in achieving institutional targets.

Collaboration: Around the world, environmental sustainability policies are either insufficient, poorly funded or entirely absent. It is crucial now more than ever that health systems, government agencies and policymakers take action to reduce the impact of the healthcare sector on the environment. Health ministries must create awareness among policy makers, and governing and legislative bodies, about the detrimental effects of climate change and healthcare sector's role in mitigation. They must also enforce climate friendly policies and develop action plans at national and international levels. Multilateral and bilateral aid agencies that finance health care construction should ensure that funds are utilized to promote the development of ecofriendly health facilities. Institutions that accredit hospitals are encouraged to incorporate environmental health policies into their accreditation standards, thus promoting green hospitals and fostering environmental sustainability. The healthcare sector should collaborate with stakeholders and strengthen cross-disciplinary partnerships to ensure that mitigation measures are not just limited to healthcare facilities, but extend to other sectors as well.[27,28]

Conclusion

The daily surgical procedures in hospitals have a drastic impact on the environment that goes unnoticed and unaddressed. Small measures at surgical and hospital level can pave the roadway to eco-friendly surgery practices. Establishment of waste management systems, creating awareness, modifying the current structure, utilization of eco-friendly surgical techniques, and implementation of 5R's (reduce, reuse, recycle, rethink and research) can prove to be vital. Although it might be challenging for Pakistan, but gradual changes can help make a better future.

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