An Environmental Analysis of Reusable and Disposable Surgical Gowns

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ABSTRACT

Surgical gowns help protect patients from exposure to microorganisms and serve as personal protective equipment for perioperative staff members. Medical textiles, including surgical gowns, are available as reusable and disposable products. Health care facility administrators and leaders who endeavor to use environmentally sustainable practices require current data for decision making. This study analyzed all activities from the extraction of fossil materials from the earth to the end-of-life disposal of reusable and disposable surgical gowns. The researchers included calculations for laundry and wastewater treatment operations and compared the environmental effects of the two surgical gown systems. The study results showed that selection of reusable gowns rather than disposable gowns reduced natural resource energy consumption (64%), greenhouse gas emissions (66%), blue water consumption (83%), and solid waste generation (84%). Perioperative nurses can use this information to assist facility leaders as they make informed decisions related to gown system selection.

Key words: *surgical gown systems, medical textiles, health care environmental sustainability, life cycle assessment, cradle-to-end-of-life.*

Medical textiles comprise many patient care items, including bed linens, personal protective equipment, dressings, and implantable surgical devices (eg, suture, mesh).[1] Reusable and disposable surgical gowns protect perioperative personnel from microorganisms and contamination related to the patient's body fluids. The gowns also protect patients from microbial contamination by surgical personnel. When making decisions to purchase reusable or disposable materials, perioperative leaders should consider such factors as cost,[2] clinical usability,[2] contractual agreements,[2] and environmental sustainability.[2,3] Perioperative nurses should work with facility leaders to address "perioperative practices that negatively affect the environment."[4] To realize quantifiable environmental improvements, nurses and other health care professionals require data to support their decisions.[3] Researchers use *life cycle assessments* (LCAs) to quantify and standardize the effects of products on the environment.

PURPOSE OF THE STUDY

The purpose of this study was to evaluate reusable and disposable surgical gowns to provide transparent, scientific, and complete environmental comparisons. We designed the study with the goal of attaining comprehensive results with which reusable and disposable suppliers could agree. The detailed objectives of the study were to

- quantify and compare the environmental impacts of *surgical gown systems* (ie, manufacturing, processing, and disposal of reusable and disposable surgical gowns) in the North American market;
- quantify the importance of activities within the life cycle; and
- analyze the results for better understanding about the important parameters (ie, reusable and disposable gown weight, laundry energy, blue water recovery).

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The scope of our study included analyzing the complete supply chain for both types of surgical gown systems. This *cradle-to-end-of-life* (CTEOL) analysis included researching material acquisition (ie, natural resources), product creation, use and reuse in the health care setting, laundering, sterilization, end-of-life disposition of gowns and packaging, and all transportation in each of these stages.

RESEARCH QUESTION

We asked the following research question: Are there quantitative differences in the environmental impacts of reusable and disposable surgical gown production and management over the complete life cycle, from supply chain to end-of-life disposition?

SIGNIFICANCE TO NURSING

Perioperative leaders and facility administrators include perioperative nurses in the decision-making process for the acquisition of many surgical supplies, equipment, and other devices in the OR. Because this study provides information about the environmental impact of surgical gowns, perioperative nurses and leaders can use the results when selecting surgical gowns for their practice areas. The comparative data should help clarify nurses' understanding about environmental consequences related to disposable products. After reviewing this article, nurses may consider reviewing environmental impact study results of other surgical products.

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LITERATURE REVIEW

An LCA study provides a detailed analysis of possible environmental impacts of products and processes during the life of the product.[5] Pharmaceutical researchers have studied and consistently use LCA technology in efforts to reduce environmental footprints through process optimization.[6-14] Other researchers have used LCAs to quantify the environmental impacts of medical equipment (eg, computerized tomography scanners,[15] steam sterilizers),[16] obstetrical[17,18] and gynecological procedures (eg, hysterectomies),[19] and textiles (eg, isolation gowns).[20]

Six life cycle studies compared reusable and disposable surgical textiles between 1993 and 2011.[21] Results showed that reusable surgical textiles outperformed disposable alternatives for several indicators, including energy and water consumption, greenhouse gas and volatile organic emissions, and solid waste generation at the time of disposal. An additional 2015 LCA study of 15 custom disposable surgical packs resulted in the design of a *green custom pack* but did not evaluate the reusable surgical products it included.[22]

The literature of comparative studies for surgical gowns and drapes consistently concludes that reusable textiles result in a lower environmental footprint than disposable textiles. However, the life cycle stages and environmental impact parameters assessed in the studies are inconsistent, and a more in-depth evaluation of reusable and disposable gowns with specified parameters is needed.

OPERATIONAL DEFINITIONS

For the purposes of this study, we defined the *surgical gown* as a single-piece, long-sleeved, size extra-large garment with the Association for the Advancement of Medical Instrumentation's Level 3 barrier protection rating. We converted the material and energy (eg, mechanical, electrical) flows derived in the *life cycle inventory* (LCI) analysis to four environmental impact indicators in the *life cycle impact assessment*.

1. We defined *natural resource energy* (NRE) as the total energy value of all the fuels used, including all losses from extraction, combustion, and delivery of fuels. We classified energy use into four categories: electricity, steam, diesel fuel, and high-temperature heating fluid. Natural resource energy is expressed as megajoules (MJ); 1 MJ = 0.277 kilowatt hour (kWh).
2. *Global warming potential* (GWP) is a calculation that represents the effect of greenhouse gas emissions (ie, direct process emissions and indirect emissions from energy production and transportation) on the environment. The calculation involves multiplying greenhouse gas emissions by impact factors. Global warming potential is expressed as kilograms of carbon dioxide equivalents (kg of CO_2 eq).

3. *Blue water consumption* is defined as any water that is removed from and not returned to the water supply (ie, lost to evaporation, contained in the product).[23,24] Water consumers often return some water to the environment in acceptable condition for reuse. The life cycle calculations include the effect of treating contaminated wastewater. Blue water consumption is expressed as kilograms of blue water.
4. *Solid waste generation* is the mass of solid sent to a landfill or for incineration. In this study, the solid waste measurement included the surgical gown's mass, biological waste, and any nonrecycled packaging. Solid waste generation is expressed as a kilogram of waste generated at the point of use.

METHODS

We conducted an LCA of reusable and disposable surgical gown systems according to standards from the International Organization for Standardization.[25,26] First, we defined the goals and scope of the study. Next, we catalogued all relevant material and energy flows within the system boundaries to complete the LCI analysis. During the third step, we calculated the environmental impacts and indicators from the material and energy flows developed in the previous step to complete the life cycle impact assessment. Finally, we interpreted and discussed the results.

We conducted a market analysis to identify the properties of reusable and disposable gowns. We examined 11 reusable and 7 disposable gowns to determine the characteristics of representative surgical gowns and analyzed the gown material composition, packaging, geographical locations of manufacture, laundry and sterilization technologies, and disposal practices. We used the results of the market analysis to determine the characteristics of market-representative reusable and disposable surgical gown systems from which a representative reusable gown was compared with a representative disposable gown in the LCA.

For convenience, we decided to specify the basis of comparison as 1,000 uses of a gown in an OR setting. The reusable surgical gown system CTEOL cycle included the manufacture, delivery, and disposal of 16.7 gowns that were used and reprocessed (ie, laundry, sterilization, associated transport) 60 times each. The disposable surgical gown system CTEOL cycle included the manufacture, sterilization, delivery, and disposal of 1,000 gowns.

We conducted a life cycle assessment of reusable and disposable surgical gown systems according to standards from the International Organization for Standardization.

We used the Environmental Clarity, Inc, LCI Database to evaluate the life cycles of both surgical gown systems. The inventories included a summary of material and energy inputs and outputs for a given manufacturing process or service and were summed to provide a complete assessment of the gown uses. The reusable surgical gown system analysis required 140 unique manufacturing steps (each step represents one facility), and the disposable surgical gown system required 105 unique manufacturing steps. We grouped the manufacturing steps into six categories representing the major activities in the life cycle. They included

- gown manufacture and supply chain,
- packaging manufacture and supply chain,
- laundry,
- sterilization,
- use phase transport, and
- end-of-life.

RESULTS

The US Food and Drug Administration regulates surgical gowns as Class II medical devices, and gown labeling indicates the product meets strict testing standards to ensure performance in the OR.[27] Manufacturers work to design products that meet permeability requirements. The manufacturers use different fabrics to maximize comfort for the wearer and meet critical zone requirements (ie, the sleeves from the cuff to approximately the elbow and front of the gown must provide at least Level 1 protection).

Historically, manufacturers produced reusable surgical gowns from woven cotton fabrics. However, these fabrics did not resist liquid penetration and all-cotton fabrics have been replaced by cotton-polyester (PET) blended fabrics and full PET fabrics.[28] We performed a market analysis

Table 1. Characteristics of 18 Surgical Gowns Marketed in the United States

Trait of Material	Reusable	Disposable
Weight range, g	338-560	136-253
Representative weight, g	474	224
Weight standard deviation, g	76	40
Fabric material, noncritical zones	Woven PET	Nonwoven PET
Fabric material, critical zones	Knit PET with ePTFE barriers (70%) Knit PET with PU barriers (30%)	Polypropylene film
Dye material	Green disperse dye	Green pigment
Uses before downgrade or disposal	60	1
Disposal practices	Landfill or recycling	Landfill or recycling

PET = polyester; ePTFE = expanded polytetrafluoroethylene; PU = polyurethane.

and found that the majority of modern reusable surgical gowns are composed of woven PET fabric in the noncritical zones and knit PET fabric in the critical zones (Table 1). Barrier fabric reinforces the knit polyester in the critical zones. Our analysis found that two principal barrier fabrics dominate the market. Expanded polytetrafluoroethylene liquid resistant barriers in Level 3 surgical gowns account for approximately 70% of the current North American surgical gown market uses, and polyurethane breathable barrier membranes account for the remaining 30%. This ratio may change as the market changes.

Disposable surgical gowns are made from nonwoven fabrics (eg, PET, polypropylene).[29] Our market analysis found that most modern disposable surgical gowns are composed of nonwoven PET fabric in the noncritical zones and nonwoven polypropylene fabric in the critical zones.

The manufacturing process of 1,000 market-representative 224-g disposable surgical gowns consumed 23,958 MJ of NRE, released 1,495 kg of CO_2 eq, and consumed 1,058 kg of blue water. This analysis included all activities from natural resource extraction through production and delivery of the final surgical gown. The environmental indicators for 1,000 uses of a 474-g reusable gown were 2,366 MJ of NRE, 143 kg of CO_2 eq, and 69.7 kg of blue water, representing significant decreases compared with disposable gowns (Table 2).

Packaging Manufacture and Supply Chain

Usually surgical gowns are sent to hospitals as part of a surgical pack that may contain other reusable or disposable surgical items, but they also may be individually wrapped. For our study, we considered three levels of packaging for individually wrapped surgical gowns: primary packaging to enclose a single gown, secondary packaging to enclose multiple gowns, and tertiary packaging to enclose multiple items on a shipping pallet. The disposable gowns had an insert paper, low-density polyethylene (LDPE) sterilization bag, and spunbond meltblown spunbond polypropylene central supply room wrap as primary packaging. Secondary packaging for 48 gowns included an LDPE plastic wrap and corrugated box, and a linear (LDPE) pallet wrap functioned as the tertiary packaging for 30 boxes on a pallet. Pallets were included in transportation energy calculations but were reused many times. Thus, the manufacture of pallets was excluded because a negligible quantity was required.

Laundry personnel received new reusable gowns in separate packaging and packaged the gowns for sterilization before providing them to hospitals. The sterilization packaging for reusable gowns comprised an ethylene methacrylate copolymer sterilization bag, insert paper, and central supply room wrap paper. The secondary packaging was a reusable aluminum cart, and the tertiary packaging was a high-density polyethylene cover.

We calculated that a market-representative reusable surgical gown requires the manufacture of 36.1 g of packaging, while a market-representative disposable gown requires 57.8 g of packaging. Packaging manufacturing accounted for approximately 13% of the total energy consumption and greenhouse gas emissions of reusable gowns and accounted for 8% of energy consumption and emissions of disposable gowns. Improvements in packaging

Table 2. Comparison of Environmental Indicators for Reusable and Disposable Surgical Gowns Assessed in Cradle-to-End-of-Life Analysis

Stage of Life Cycle	NRE, MJ		GWP, kg of CO_2 eq		Blue Water, kg		Solid Waste, kg	
	Reusable 1,000 Uses	Disposable 1,000 Gowns	Reusable 1,000 Uses	Disposable 1,000 Gowns	Reusable 1,000 Uses	Disposable 1,000 Gowns	Reusable 1,000 Uses	Disposable 1,000 Gowns
Gown manufacturing and supply chain	2,366	23,958	143	1,495	69.7	1,058	0-7.90	224
Packaging manufacturing and supply chain	1,246	2,040	76.7	121	56.7	36.6	35.5	40.3
Laundry	4,821	–	278	–	57	–	0	–
Sterilization	343	89.0	19.8	6.26	1.39	2.38	0	0
Use phase transport	596	53.5	38.7	3.47	0	0	0	0
End-of-life	23.9	149	1.40	10.9	0	0	0-0.00842	0.505
Total	9,396	26,289	557	1,636	185	1,097	35.5-43.4	265
Reduction from selecting reusable system, % of disposable system	64		66		83		84-87	

NRE = natural resource energy; MJ = megajoule; GWP = global warming potential; kg of CO_2 eq = kilogram of carbon dioxide equivalents.

manufacturing efficiency could lead to environmental improvements for surgical gown systems.

Laundering

We analyzed utility data from 21 US and Canadian companies to develop a profile of North American industrial laundry practices (Table 3). The facilities processed a wide variety of items, including surgical gowns, drapes, linens, and other medical textiles. The total energy consumption and metered water consumption are consistent with the findings of researchers who studied industrial operations that laundered isolation gowns, automotive wipes, and restaurant napkins.[30]

Table 3. Analysis of Utilities Use in Laundry Operations in 21 US and Canadian Companies

Energy Consumption	Range	Average
Metered water consumption per kg clean textiles, kg	6.5-20	11
Total natural gas consumption per 1,000 kg clean textiles, MJ (kWh)	3.2-7.7 (0.89-2.1)	5.8 (1.6)
Total electricity consumption per 1,000 kg clean textiles, MJ (kWh)	0.60-5.2 (0.17-1.4)	1.0 (0.28)
Total energy consumption per 1,000 kg clean textiles, MJ (kWh)	4.0-10 (1.1-2.8)	6.8 (1.9)

MJ = megajoule; kWh = kilowatt hour; kg = kilogram.

We assumed one laundry operation per use for reusable surgical gowns. Thus, 1,000 gown uses included the laundry process for 1,000 gowns that weighed 474 g each. The laundry operation included washing, rinsing, and drying. The material inputs to the process were soiled surgical gowns, water, and chemical detergents and rinse agents.

When hospital personnel send gowns and other items to a laundry facility, the items usually contain some water. Most of the metered water used in laundry operations is returned to the water supply via a wastewater treatment plant (WWTP). For each kg of cleaned gowns, approximately 11 kg of fresh water enters the system and approximately 11 kg of fresh water exits to the WWTP.

We analyzed eight loads of gowns separate from other items at two laundry facilities. When laundry facility personnel received the gowns, there was 0.05 kg of water per kilogram of dry gown. The laundry facility personnel weighed each of the loads after washing and before placing the load in the dryer, and the gowns weighed 1.17 kg per kilogram of dry gown. Thus, the net water use was 0.12 kg of water per kilogram of dry gown. Assuming 1,000 uses, 81 kg of water is evaporated and 24 kg is returned to the water supply via the soiled gowns. The net blue water use in the laundry is 57 kg per 1,000 uses. Disposable gowns are not laundered and therefore have no blue water consumption. In addition, any water on the gowns after use is not recovered. The laundry operation accounted for 51% of the energy consumption and 50% of the greenhouse gas emissions for the reusable surgical gown system.

We have a larger general dataset of laundry parameters, which specifies the wet weight of laundry into the dryer is 1.44 kg wet per kilogram out of the dryer. Although this dataset is based on additional data, it also is more general than other datasets and not specific to surgical gowns. In the sensitivity analysis, we included a scenario with this higher value for evaporated water.

Sterilization

Laundry operators typically provide sterilization services. When needed, perioperative personnel should sterilize reusable surgical gowns according to the manufacturer's instructions for use.[31] When gown manufacturers recommend steam sterilization, the most common methods are gravity-displacement cycles and dynamic-air-removal cycles.[31] Perioperative personnel should refer to the sterilizer manufacturer's recommendation for cycle parameters (ie, temperature, duration).[32] In this study, industrial laundry partners provided energy requirements for sterilization that they based on standard temperatures and times. The methods may differ slightly with regard to the required exposure temperature and time, but reusable gowns are generally exposed to steam at 121° to 135° C (250° to 275° F) for 3 to 30 minutes, followed by a 1- to 30-minute drying cycle. Manufacturers sterilize disposable surgical gowns using a variety of methods (eg, ethylene oxide,[33] irradiation[34]). In this study, the disposable gowns were sterilized with ethylene oxide.

The steam sterilization process for reusable gowns accounted for 4% of the energy consumption, 4% of the greenhouse gas emissions, and 1% of the blue water consumption of the CTEOL cycle. The ethylene oxide sterilization process for disposable gowns accounted for 0.3% of the energy consumption, 0.3% of the greenhouse gas emissions, and 0.2% of the blue water consumption. Thus, improvements in sterilization technology would lead to only small life cycle benefits for both reusable and disposable gowns.

End-of-life

Reusable and disposable surgical gowns have substantially different end-of-life pathways. Both gowns contain synthetic polymers and will be landfilled or incinerated. In this study, the gowns were assumed to be landfilled, but the effect on the overall comparison of these end-of-life options was quite small. These textiles are essentially inert in the landfill environment. However, the end-of-life process for reusable gowns includes laundering and transfer of biological waste (ie, fluids, tissue, blood) to an aerobic treatment system (ie, WWTP) after each laundry step. For disposable gowns, the biological waste remains with the gown and is transferred to an anaerobic landfill resulting in methane and CO_2 emissions. We accounted for this difference in the LCA.

Reusable and disposable surgical gowns have substantially different end-of-life pathways.

At the end of 60 surgical cycles, health care personnel may remove reusable gowns from surgical procedure use and redesignate them for use in nonsurgical processes. After reuse, the gowns are ultimately landfilled. In life cycle practice, the firm or activity that landfills the material receives the environmental impacts of landfilling. For complete transparency in this study, we provide end-of-life results for reusable gowns for the endpoint cases of 0% and 100% reuse in other industries. In the case of 0% reuse, the transport and landfilling of gowns is included. In the case of 100% reuse, all activities of collection, reuse, and eventual disposition are excluded from the results.

The landfill process included collection, transportation, and processing of gowns from the health care facility to the landfill. We included the landfill processing of the biological waste on the gowns in our analysis.[35-39] Biological waste decomposes and releases methane and CO_2 in the landfill. A portion of the methane is recovered and burned to generate energy. The remainder of the methane and all of the CO_2 are emitted into the environment. The energy consumption and greenhouse gas emissions of the landfill processes accounted for less than 0.5% of the life cycle totals for reusable and disposable surgical gown systems. Although the landfill did not contribute to blue water consumption, it was the final repository for all solid waste from both surgical gown systems. Each reusable gown use accounted for 35.5 to 43.4 g of waste delivered to the landfill, comprised of 0 to 7.90 g of gown, 35.5 g of packaging, and 0.00842 g of biological waste. The ranges are representative of the cases of 0% and 100% reuse in other industries. Each disposable gown accounted for 265 g of waste delivered to the landfill, comprising 224 g of gown, 40.3 g of packaging, and 0.505 g of biological waste.

Transportation

Surgical textiles are global products that are subject to a wide variety of transportation scenarios. For the purposes of this study, we assumed reusable gown manufacturers used fabric produced in Europe to assemble the gowns in Canada before transporting them to suppliers in the United States. We also assumed that manufacturers in China produced fabric and assembled disposable gowns before transporting them to suppliers in the United States. The gown manufacturing and supply chain analysis includes all transportation in the materials supply chain and to the gown supplier.

The reusable surgical gown use phase includes gown transport to and from a laundry center and to and from a sterilization facility. The total transport was 140 miles round trip in a box truck. Use phase transport accounted for 6% of energy consumption and 7% of greenhouse gas emissions for the reusable surgical gown system and less than 0.5% in the same categories for the disposable surgical gown system. All transportation activities (ie, supply chain and use phase transportation) of both types of gowns accounted for 8% of the NRE consumption for reusable surgical gowns and 13% of the NRE consumption for disposable surgical gowns. We assume alternate transportation scenarios would not affect these results.

DISCUSSION

We assumed that reusable surgical gowns were used 60 times before disposal. We approximated that each reusable gown weighed 474 g, and each disposable gown weighed 224 g. Therefore, the mass of reusable gowns produced was 96% lower than the mass of disposable gowns produced. This mass reduction directly reduced solid waste generation and indirectly provided significant environmental savings. Conversely, reusable gowns required additional energy for laundry operations and associated transport. However, the benefit of producing fewer gowns more than offset the environmental burdens of the laundry.

Reusable surgical gowns had less adverse environmental impact than disposable surgical gowns in all four indicator categories (Figure 1). When compared with disposable gown use, the use and processing of reusable gowns resulted in approximately 64% less energy use (NRE) and

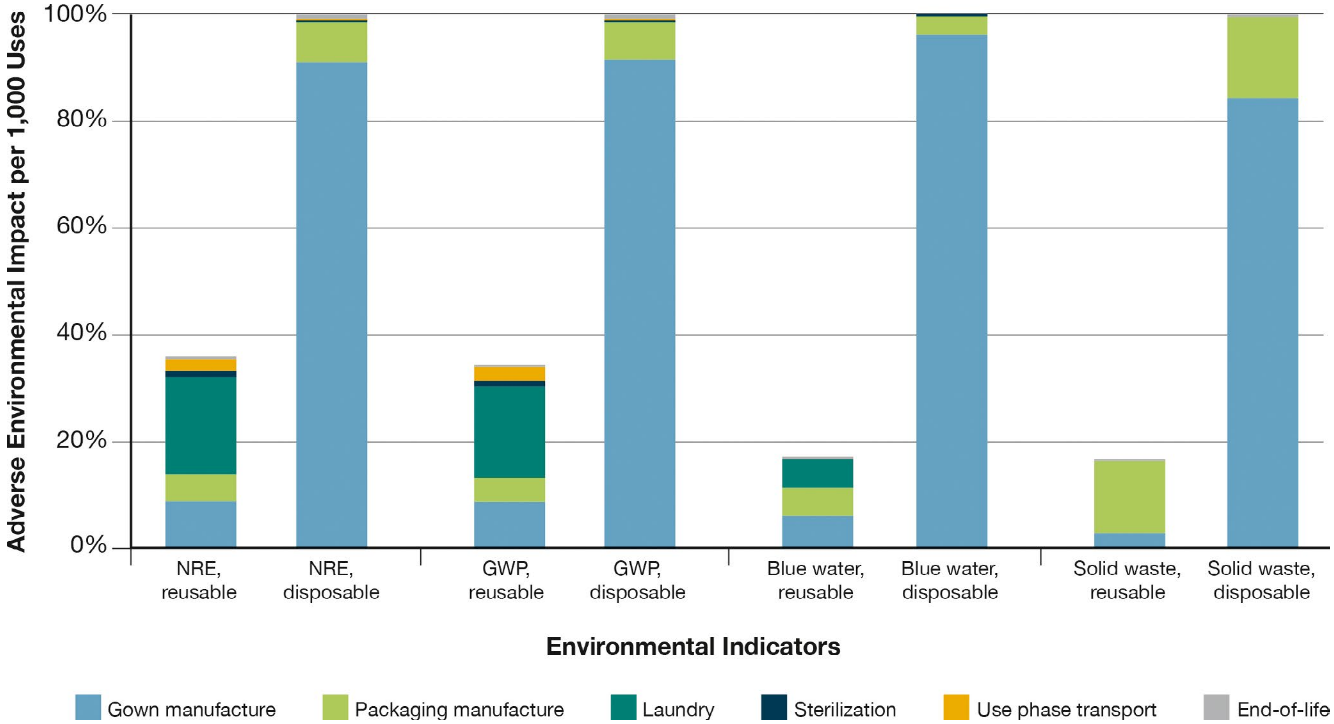

Figure 1. Comparison of environmental impact of reusable and disposable surgical gowns. NRE = natural resource energy, GWP = global warming potential.

Key Takeaways

- Perioperative nurses can provide input to perioperative leaders and facility administrators about surgical products, including gowns. Although information about environmental sustainability should be provided, minimal data is available regarding the environmental impact of reusable and disposable surgical gowns.
- This study evaluated the environmental impact of reusable and disposable surgical gowns related to natural resource energy, global warming potential, blue water consumption, and solid waste generation.
- The study findings indicated that using reusable gowns reduced natural resource energy consumption by 64%, greenhouse gas emissions by 66%, blue water consumption by 83%, and solid waste generation by 84% when compared with disposable gowns.
- Reusable gowns may have less effect on the environment than disposable gowns. Perioperative nurses can use this information when recommending surgical gown product changes in their work environments.

avoided approximately 66% of greenhouse gas emissions associated with disposable gowns. This study showed that the reusable surgical gown system used approximately 83% less water (blue water) than the disposable surgical gown system. This result differs from some published information that indicates reusable garments are more water intensive. However, information in published literature may not use the principle that recommends including blue water and water consumed during supply chain processes to determine water consumption.[23] Compared with the disposable surgical gown system, the reusable surgical gown system also reduced approximately 84% of surgical gown–related landfilled waste. The reduction in all categories is related to the manufacturing and transport energies required for disposable gowns. The study results show that the weight of the disposable gown affects the life cycle results. For example, a 10% weight decrease results in approximately a 9% decrease in all four categories. Thus, as the weight of the disposable gown approaches 70 g, the NRE and GWP for the disposable and reusable surgical gowns become almost even. The lightest disposable gown measured was 136 g. For reusable gowns, a weight decrease had a similar effect to disposable gowns. When the gown is 10% lighter, there is approximately an 8% decrease in the assessed categories.

Another factor affecting life cycle results for the reusable surgical gown is laundry processing efficiency. For example, a 10% decrease in laundry energy consumption results in approximately a 5% decrease in NRE and GWP. Therefore, inefficient laundry processes that consume energy in excess of industry norms could have a negative environmental impact.

The water balance in the laundry includes savings from recovered water content in the soiled gowns. This savings was measured in an industrial laundry facility and is the best estimate of a real-world process. In addition, the water evaporated in the dryer was based on a limited dataset of surgical gown loads. As a sensitivity analysis, we calculated blue water consumption for reusable gowns without any water recovery in the laundry, using a more generic value for water evaporated in the dryer (0.44 kg per kilogram dry). When no water was recovered during laundering and this more generic estimate of evaporated water was used, reusable gown use represents a blue water savings of 69% compared with disposable gowns.

We assumed that the disposable gowns were manufactured in China and transported to the United States. We also assumed that the Chinese energy modules were identical to those in the United States. Thus, the only difference was an added transportation step, which accounts for 8% of the disposable gown energy. If the disposable gowns were manufactured in the United States, the reusable gowns would still result in NRE savings of 61% and GWP savings of 63%.

The results of this study are consistent with the partial life cycle studies previously reported in the literature for gowns and other garments.[20,30] Thus, the current study adds to the body of evidence that shows the environmental superiority of reusable surgical gowns.

Limitations

We did not include surgical gown comfort as a metric in this study, although it is a factor for scrubbed surgical team members. In addition, we did not include any economic measurements in this study. Although the reusable gowns use less blue water than disposable gowns, the lack of data on water content of soiled gowns limits the accuracy of the blue water comparison. Also, not all disposable gowns are produced in China or sterilized with ethylene oxide. Further, the packaging of disposable and reusable gowns varies. Therefore, additional limitations for disposable surgical gowns include data related to the location of production, sterilization method, and packaging. However, we showed that the effect of these factors on the environment is minor relative to the environmental savings achieved by selecting reusable gowns. Finally, for reusable surgical gowns, costs associated with laundering and sterilizing may vary based on the availability of laundry and sterilization facilities.

RECOMMENDATIONS FOR FUTURE RESEARCH

Surgical gowns have critical zones with advanced breathable polymers to restrict fluid flow that protect perioperative personnel. With the effective removal of expandable polytetrafluoroethylene as an available material, more complete life cycle data on the substitute critical zone materials are needed. Studies comparing perioperative staff member comfort when using reusable versus disposable surgical gowns may provide additional information for perioperative leader and staff member consideration. Additional research on the water content of soiled gowns may increase the accuracy of blue water comparisons. Because environmental benefits may be conferred by the use of reusable textile items, additional LCAs of other textile and nontextile items found in health care facilities (eg, gloves, hair coverings, shoe covers) could provide information to purchasing decision makers.

CONCLUSION

This study analyzed and compared the six stages of the life cycle of reusable and disposable surgical gown systems. The reusable surgical gown system consumed less energy, had a reduced GWP, reduced blue water consumption, and reduced solid waste generation. Perioperative and facility leaders can use these results to address environmental sustainability concerns related to surgical gown waste.

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