ENVIRONMENTAL / REUSABLE ARTICLES & STUDIES

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Surgical waste audit of 5 total knee arthroplasties

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Results presented in part at CleanMed 2010 (May 11–13, 2010, in Baltimore, Md.) and EcoCare 2010 (Oct. 18–19, 2010, in London, Ont.).

Results presented in whole at the Annual Meeting of the American Academy of Orthopedic Surgeons 2011 (Feb. 15–19, 2011, in San Diego, Calif.) and the 2011 Annual Meeting of the Canadian Orthopaedic Association (July 7–10, 2011, in St. Johns, NL).

Accepted for publication Sept. 6, 2011

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DOI: 10.1503/cjs.015711

Background: Operating rooms (ORs) are estimated to generate up to one-third of hospital waste. At the London Health Sciences Centre, prosthetics and implants represent 17% of the institution's ecological footprint. To investigate waste production associated with total knee arthroplasties (TKAs), we performed a surgical waste audit to gauge the environmental impact of this procedure and generate strategies to improve waste management.

Methods: We conducted a waste audit of 5 primary TKAs performed by a single surgeon in February 2010. Waste was categorized into 6 streams: regular solid waste, recyclable plastics, biohazard waste, laundered linens, sharps and blue sterile wrap. Volume and weight of each stream was quantified. We used Canadian Joint Replacement Registry data (2008–2009) to estimate annual weight and volume totals of waste from all TKAs performed in Canada.

Results: The average surgical waste (excluding laundered linens) per TKA was 13.3 kg, of which 8.6 kg (64.5%) was normal solid waste, 2.5 kg (19.2%) was biohazard waste, 1.6 kg (12.1%) was blue sterile wrap, 0.3 kg (2.2%) was recyclables and 0.3 kg (2.2%) was sharps. Plastic wrappers, disposable surgical linens and personal protective equipment contributed considerably to total waste. We estimated that landfill waste from all 47 429 TKAs performed in Canada in 2008–2009 was 407 889 kg by weight and 15 272 m^3 by volume.

Conclusion: Total knee arthroplasties produce substantial amounts of surgical waste. Environmentally friendly surgical products and waste management strategies may allow ORs to reduce the negative impacts of waste production without compromising patient care.

Level of evidence: Level IV, case series.

Contexte : On estime que les blocs opératoires génèrent jusqu'au tiers des déchets hospitaliers. Au Centre des sciences de la santé de London, les prothèses et les implants représentent 17 % de l'empreinte écologique de l'établissement. Pour analyser la production de déchets associés aux arthroplasties totales du genou (ATG), nous avons procédé à une vérification des déchets générés lors de ces chirurgies, afin d'en mesurer l'impact environnemental et de proposer des stratégies d'amélioration de la gestion des déchets.

Méthodes : Nous avons réalisé l'analyse des déchets produits lors de 5 ATG effectuées par un même chirurgien en février 2010. Les déchets ont été regroupés en 6 catégories : déchets solides normaux, plastiques recyclables, déchets présentant un biorisque, linge lavé en buanderie, objets tranchants et emballages stériles bleus. Nous avons mesuré le volume et le poids de chaque catégorie. Nous avons utilisé les données du Registre canadien des remplacements articulaires (2008–2009) pour estimer le poids et le volume totaux des déchets générés par toutes les ATG effectuées au Canada.

Résultats : La quantité moyenne de déchet chirurgicaux (à l'exclusion du linge lavé en buanderie) par ATG a été de 13,3 kg, dont 8,6 kg (64,5 %) étaient des déchets solides normaux, 2,5 kg (19,2 %), des déchets présentant un biorisque, 1,6 kg (12,1 %), des emballages stériles bleus, 0,3 kg (2,2 %), des substances recyclables et 0,3 kg (2,2 %), des objets tranchants. Les emballages de plastique, le linge chirurgical jetable et le matériel de protection personnelle jetable contribuaient énormément au volume total de déchets. Selon notre estimation, les déchets qui ont abouti au dépotoir suite aux 47 429 ATG effectuées au Canada en 2008–2009 totalisaient un poids de 407 889 kg et un volume de 15 272 m^3.

Conclusion : Les arthroplasties totales du genou engendrent des quantités substantielles de déchets chirurgicaux. Des produits plus écologiques et de meilleures stratégies de gestion des déchets permettraient aux blocs opératoires de réduire l'impact négatif des déchets produits, sans compromettre les soins aux patients.

Niveau de preuve : Niveau IV, série de cas.

In 2001, the Canadian health care sector generated 2.1% of Canada's total greenhouse gas (GHG) emissions and 1% of total solid waste.[1] In the United States, health care activities in 2007 contributed 8% of total U.S. GHG emissions and 7% of total U.S. carbon dioxide emissions.[2] Alarmingly, health care facilities in the United States continue to dispose of more than 4 billion pounds of waste annually, making the U.S. health industry the second-largest industrial contributor to landfills after the food industry.[3] Within a hospital, operating rooms (ORs) contribute disproportionately to health care waste production.[4] Although ORs occupy a proportionally smaller area of a health care facility, they are estimated to generate 20%–33% of total hospital waste.[5,6] In fact, a routine operation at a hospital produces more waste than a family of 4 produces in an entire week.[7]

Large joint arthroplasty is major contributor to OR waste production.[8] Prosthetics and implants contributed to 17% of the London Health Sciences Centre's ecological footprint in 2006.[9] Moreover, total joint arthroplasty is a frequently performed surgical procedure, with 47 429 total knee arthroplasties (TKAs) performed across Canada in 2008–2009.[10] Given the susbtantial ecological footprint associated with joint arthroplasties and the high frequency with which TKAs are performed, we sought to investigate waste production through a waste audit of 5 TKAs performed by a single surgeon. We hoped that the results of this audit would allow us to identify strategies to improve waste management practices.

Methods

A waste audit is a qualitative and quantitative assessment tool that examines the types, quantities and sources of waste produced. The results of a waste audit allow an institution to identify opportunities for improved waste management practices and to measure the impact of waste reduction strategies.[11] We performed a waste audit of 5 TKAs conducted at the London Health Sciences Centre, University Hospital, London, Ont. In this 343-bed hospital, 603 primary TKAs were performed in 2009. The Western University Research Ethics Board stated that this study did not require their approval.

The 5 TKAs were completed in February 2010 by a team led by the same orthopedic surgeon (D.N.). Operating room personnel varied among the TKAs, but they were informed of the procedure's inclusion in the waste audit to ensure all waste was disposed of in the OR for complete collection and analysis. For all 5 TKAs, the scrub team comprised the consultant surgeon, an orthopedic fellow, an orthopedic resident, a medical student and a scrub nurse.

We categorized surgical waste into 6 streams: normal solid waste, recyclable plastics, biohazard waste, laundered linens, sharps and blue sterile wrap (polypropylene wrap used to cover surgical products during sterilization). All discarded items were catalogued during the procedure in real time (see Table 1 for a complete catalogue from 1 TKA). Data collection commenced as soon as OR personnel began preparing for the TKA and concluded when personnel disposed of their surgical attire and personal protective devices.

After the TKA was completed and the patient left the OR, we weighed each waste stream and measured bag volumes. Waste was weighed on a digital scale accurate to 0.1 kg, and bag volume was approximated using a measuring stick accurate to 1 mm.

Statistical analysis

All data were stored and analyzed in Excel 2007 (Microsoft Corp.). We calculated the average weights of each waste stream and the average volume of the solid waste stream for the 5 TKAs. Data from the Canadian Joint Replacement Registry, of the Canadian Institute for Health Information, were used to extrapolate weight and volume estimates for all TKAs performed in Canada during 2008–2009.[10]

Results

The surgical waste (excluding laundered linens) from the 5 TKAs totaled 66.7 kg, of which 43.1 kg (64.5%) was normal solid waste, 12.8 kg (19.2%) was biohazard waste, 8.1 kg (12.1%) was recyclable blue sterile wrap, 1.5 kg (2.2%) was recyclables and 1.4 kg (2.0%) was sharps (Table 2). The average mass of surgical waste per TKA is provided in Table 3. The volume of normal solid waste (which is ultimately disposed of in landfills) from the 5 TKAs totaled 1.6 m^3. When extrapolated to all 47 429 TKAs performed in Canada in 2008–2009,[10] the estimated landfill waste was 407 889 kg by mass and 15 272 m^3 by volume (Table 3).

A variety of items were prepared and opened for surgery but remained unused at the end of the procedures. These items are referred to as "overage."[12] The total overage from the 5 TKAs comprised 45 green sterile towels, 16 sterile surgical gloves, 5 disposable surgical gowns, 4 inner wrappers from surgical gloves, 2 lengths of tubing and 1 small unsterile towel.

Several items contributed disproportionately by number to surgical waste. Per TKA, there was an average of 64 (range 59–73) plastic wrappers, 41 (range 37–52) sterile surgical gloves, 29 (range 30–43) green sterile towels and 10 (range 0–29) vinyl gloves. There were also disproportionate volume contributions from disposable surgical linens and personal protective equipment. Per TKA, there was an average of 5 (range 4–8) surgical gowns, 5 (range 2–8) surgical drapes and 3 (range 1–4) table covers.

Discussion

The results of this waste audit demonstrate that TKAs produce substantial amounts of waste (Fig. 1). We report that

per TKA, an average of 64.5% of waste per weight was normal solid waste requiring transport and dumping in a landfill and 19.2% was biohazard waste requiring high-energy treatment processes, including incineration. Only 14.3% of waste by weight was recycled (12.1% was recyclable blue sterile wrap and 2.2% was recyclable clear plastics). These

Table 1. Catalogue items from 1 total knee arthroplasty

Waste	Units	Waste	Units
Plastics		**Paper/cardboard**	
1000 mL bag (empty) of Ringer's lactate solution	1	Cardboard box with paper manual for Cement Erythromycin Kit	2
2% chlorhexidine antiseptic solution bottle (empty)	1	Cardboard box with paper manual for joint spacer (articular insert)	1
20 mL Luer Lock syringe	2	Miscellaneous paper	5
50 mL antibiotic fluid bag (empty)	1	Wrapper (inner) for surgical gloves	23
500 mL bag (empty) of NaCl solution	1	**Biohazard waste**	
Cement mixing stick	1	12″ × 12″ sponge	7
Cement mixing system and tubing	1	2250 mL suction fluids (filled)	1
Cement mixing system gun	1	8″ × 4″ gauze	6
Cement powder bags	2	Electrocautery and suction irrigator with tubing	1
Face shield	2	NaCl bag and tubing	1
Facial oxygen mask with tubing	1	**General nonrecyclable waste**	
Glove liners	2	Adhesive backings	5
Marking pen	2	Blue sterile wrap	1
Moulded inner packaging for joint prosthesis	8	Bulb syringe (for irrigation)	1
Sterile light handle covers	2	Disposable surgical gown	4
Tubing	1	Elastocrepe dressing	1
Vicryl suture pack	9	Excess cement (mixed and activated)	—
Wrapper (outer) for surgical gloves	23	Extremity drape	1
Wrapper for 1 L Tis-U-Sol container	1	Foley catheter kit	1
Wrapper for 1000 mL bag of Ringer's lactate solution	1	Gauze pads	5
Wrapper for 20 mL Luer Lock syringe	2	Gauze roll	1
Wrapper for 500 mL bag of NaCl solution	2	Mayo stand cover	1
Wrapper for cast padding	1	Miscellaneous tips	2
Wrapper for Cement Erythromycin Kit	2	Shoe cover	1
Wrapper for cement mixing system	1	Spinal anesthesia kit	1
Wrapper for disposable surgical gown with inner paper	4	Sterile surgical gloves	46
Wrapper for elastic bandage	1	Stockinette	1
Wrapper for filter straw	1	Surgical air warming blanket	1
Wrapper for flat epidural	1	Surgical face mask	3
Wrapper for glove liners	4	Table cover	3
Wrapper for hypodermic needle	1	U-drape	1
Wrapper for jet lavage tip	1	Virox wipe	2
Wrapper for limb positioning device	1	**Recyclables**	
Wrapper for marking pen	1	Moulded inner packaging for joint prosthesis	3
Wrapper for saw blade	1	Tis-U-Sol 1 L container	1
Wrapper for skin stapler	1	Irrigation tubing container	1
Wrapper for sterile knee pack	1	**Sharps**	
Wrapper for sterile light handle covers	1	Bovie tip	1
Wrapper for stockinette	1	Drain trochar	1
Wrapper for suction irrigator	1	Glass vial	6
Wrapper for suction irrigator tip	1	Needle	12
Wrapper for syringe	1	Needle tip	5
Wrapper for tourniquet	2	Red sharps container	1
Wrapper for U-drape	1	Scalpel blades	3
Wrapper for surgical air warming blanket	1	Stapler	1
Wrapper for Webril	1	Suture needles	13
Wrapper for wound drain	1	Syringe	4
Laundry		**Sterile blue wrap**	
Bed sheet	7	Extra-large	5
Gortex sheet	4	Large	5
Green sterile towel	31	Medium	3
Small unsterile towel	1	Small	1
Surgical gown	1		

results suggest that TKA waste at our institution is not being maximally recycled, as some hospitals have achieved recycling rates of more than 40% of their total waste stream.[13] A failure to maximally recycle increases the amount of waste ending up in landfills and increases hospital hauling and disposal costs. A hospital's disposal cost for a single ton of solid waste is about US$121.[14] Efficient recycling reduces waste disposal costs, and recycling has allowed some institutions to acquire lucrative revenue from industry for recycling paper, plastics and other materials.[13]

Our results also reveal that TKA waste at our institution is being improperly segregated into normal waste and biohazard waste streams. According to waste management experts, biohazard waste should not exceed 15% of total hospital waste.[15] In this study, we report that biohazard waste contributed 19.2% by weight of total TKA waste. This finding is consistent with those from previously published reports indicating that 50%–85% of waste that should be disposed of as normal solid waste is actually disposed of as biohazard waste.[13,16] In fact, a recent study of OR waste reported that nonhazardous waste contributed 92% of the weight of what was discarded as biohazard waste.[17] A failure to improperly segregate waste increases the amount of waste requiring special treatment by high-energy processes. These processes, including incineration, are harmful to the environment and human health and cost 10–20 times more than the disposal of normal solid waste.[13] In fact, some experts state that proper segregation of waste in the OR may have the single most substantial impact on the cost of disposal.[5] It is essential that awareness of improper surgical waste segregation is heightened to reduce waste production and operation costs.

We also report that TKAs at our institution are associated with considerable surgical overage. Overage refers to surgical items that are readied and opened for surgery but remain unused and are thereby wasted.[12] Surgical overage increases the turnover of OR inventory and results in increased waste output and disposal costs. A 1997 study projected that overage from all 14 719 000 surgical procedures performed in the United States in 1993 resulted in a loss of US$125 million.[12] The investigators of this study were able to reduce overage by 45% per surgical case by implementing an intervention that included an education program, reduction of overage generating setups and redesign of surgeon-specific supply pick lists.[12] We suggest that OR teams use a "just-in-time" industrial model for surgeons' nonemergent instrumentation and supply needs.[18] This would involve only opening surgical materials and instrumentation when there is a reasonable probability of these items actually being used. Considering that ORs must function efficiently to maximize a surgeon's operating time, the generation of overage is inevitable despite any encouraged reduction interventions. To divert these materials from landfill and reduce hospital disposal costs, several donation projects have collected these materials and distributed them as aid to the developing world. These projects include Project REMEDY at Yale University (www.remedyinc.org) and Operation Green, a program that we have initiated at our own institution (www.operationgreen.ca).

Our waste audit also reveals that certain surgical items contribute disproportionately by number to TKA surgical waste. We report an average of 64 plastic wrappers, 41 sterile surgical gloves, 29 green sterile towels and 10 vinyl gloves per TKA. The excessive amount of vinyl and surgical gloves used per procedure may be explained in part by the consultant surgeon's individual preference to use unsterile vinyl gloves for all members of the team assisting in patient positioning, particularly in situations requiring contact precautions. Moreover, it was the consultant surgeon's preference to double glove for all arthroplasties and to put on fresh sterile surgical gloves after draping and immediately before cementing components. The consultant surgeon also practices in an academic environment in which fellows, residents and medical students commonly scrub in for his cases. The excessive amount of waste produced by plastic wrapping may also be attributed to inefficient industrial packaging. Many surgical products delivered by industry are excessively packaged and double-wrapped in plastic. Hospitals must recognize that wasteful

Table 3. Average mass of waste streams and Canadian extrapolations for total knee arthroplasties (TKA), 2008–2009

Waste stream	Mass, kg/TKA	2008–2009 Canadian extrapolation, kg
Normal/landfill	8.6	407 889
Recyclables	0.3	14 229
Biohazard waste	2.5	118 572
Blue wrap	1.6	75 886
Laundered linens	7.8	369 946
Sharps	0.3	14 229

Table 2. Mass of waste streams for each total knee arthroplasty

Waste stream	Surgery 1, kg	Surgery 2, kg	Surgery 3, kg	Surgery 4, kg	Surgery 5, kg
Normal/landfill	9.3	8.3	9.2	7.7	8.5
Recyclables	0.2	0.4	0.0	0.5	0.5
Biohazard waste	1.4	1.8	2.8	3.6	3.2
Blue wrap	1.5	1.7	1.7	1.9	1.2
Laundered linens	6.5	6.9	7.3	8.6	9.7
Sharps	0.4	0.5	0.5	0.0	0.0

packaging increases both procurement and disposal hauling costs. Health care institutions have considerable purchasing power and should insist that companies modify their packaging practices to increase environmental and financial efficiency.[19] The sizeable usage of surgical gloves and green sterile towels should be further investigated, especially since these items accounted for much of the surgical overage associated with TKAs. It is plausible that the turnover of these items is excessive and that increased awareness and education about the waste produced by TKAs may decrease their usage.

Finally, we noted that surgical linens consisting of surgical gowns, surgical drapes and table covers contributed disproportionately to the volume of waste. Volume of waste is an important consideration in pushing a landfill to capacity.[5] Surgical linens are available as either disposable or reusable products, and our institution uses disposable products. About 80% of hospitals in the United States use disposable gowns, and surgical linens contribute 2% of all hospital waste.[20] One study reported that substituting reusable for disposable linen could reduce surgical waste volume by 53%.[5] Unfortunately, existing life cycle analyses comparing disposable and reusable surgical linens based on environmental and financial superiority are conflicting.[20–25] However, many of these studies are outdated, and a 2010 life cycle analysis reported that reusable surgical linens showed a clear environmental and financial advantage over disposable linens.[26] Although further research on this topic is needed, hospitals, including ours, should consider transitioning to reusable surgical linens to reduce the volume of surgical waste produced.

Limitations

We recognize that the major limitation of this study is that the results are largely specific to our institution, and even to the consultant surgeon's individual preferences. Nonetheless, we believe that this waste audit demonstrates that TKAs generate unacceptably large amounts of surgical waste. We identified that surgical waste associated with TKAs at our institution was not maximally recycled,[1] was improperly segregated[2] and was associated with substantial surgical overage.[3]

Fig. 1. Waste produced from 1 total knee replacement. Waste from left to right: 1 bag of blue sterile wrap, 2 bags of reusable linens, 1 bag of recyclable clear plastics, 1 sharps container, 1 bag of biohazard waste and 4 bags of regular solid waste.

Conclusion

Based on our study results, we have initiated several strategies, including establishing recycling programs, ensuring proper waste segregation, initiating overage recovery programs, educating our industrial partners about reducing excessive packaging and considering a transition to reusable surgical linens.

It is imperative that efforts to promote sustainable OR practices are strengthened worldwide.[4] The fundamental principles of decreasing waste in the OR are the same as the cornerstone strategies of waste minimization: reduce, reuse and recycle.[27] Successful waste reduction strategies rely on the establishment of an environmental stewardship team. This team allows all stakeholders to put forward their input in the greening process by involving cross-departmental membership from perioperative nursing staff, physicians, ancillary staff, environmental services, and the managers and administrators who oversee perioperative services.[17] There are also a number of organizations dedicated to "greening health care," including Health Care Without Harm (www.noharm.org), Practice Green Health (www.practicegreenhealth) and the Canadian Association of Physicians for the Environment (www.cape.ca). Leaders within the medical community have called for individual clinicians to educate themselves about green health care and promote more sustainable health care delivery.[28] It is critical to recognize that heightened environmental awareness delivered by dedicated organizations and clinicians will underlie the success of future endeavours to green ORs and health care in general. The emergence of sustainable waste management strategies combined with a growing interest in greening health care may allow ORs to reduce the negative impacts of waste production without compromising patient care.[4]

Competing interests: None declared for N.M. Stall and Y.K. Kagoma. J. N. Bondy declares travel assistance from the Schulich School of Medicine and the Ontario Medical Student Association. D. Naudie declares research and institutional support from Depuy, Stryker and Smith & Nephew; he is a paid consultant for Stryker and Smith & Nephew.

Contributors: All authors helped design the study, acquired data, reviewed the article and approved its publication. N.M. Stall, Y.K. Kagoma and D. Naudie analyzed the data. N.M. Stall and D. Naudie wrote the article.

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2013

Comprehensive Comparative Analysis between Reusable and Disposable Surgical Gowns and Drapes

EXECUTIVE SUMMARY

This analysis is an overview of the benefits a reusable gown and drape program provides and how it can help a healthcare facility achieve cost savings and meet environmental goals within the operating room.

Lac-Mac will demonstrate our products:

1. Meet ORNAC, OSHA and AORN recommended practices, CSA and AAMI Standards
2. Validate performance measurements
3. Reduce medical waste
4. Effectively demonstrate cost benefits

Evaluation Criteria	Reusable Drapes	Reusable Gowns
Barrier Effectiveness	Meets ASTM F1670	Meets ASTM F1671
Performance, Quality and Safety	Validated to 80 WDAs ISO 9001 Registered facility Regulated by Health Canada and the FDA	Validated to 75 WDAs ISO 9001 Registered facility Regulated by Health Canada and the FDA
Environmental Impact	Can reduce environmental waste by more than 73% by weight and 93% by volume compared with single-use	Can reduce environmental waste by more than 73% by weight and 93% by volume compared with single-use
Cost Benefits	While reusables demonstrate proven cost savings over single-use, total cost savings will vary based on regulated medical waste costs differing by region	While reusables demonstrate proven cost savings over single-use, total cost savings will vary based on regulated medical waste costs differing by region

WHY REUASABLES IN THE OPERATING ROOM

The operating room is critical to a hospital's success, and to its business model, responsible for generating between 40-60% of the facilities' revenue. The operating room is also a significant cost centre. It has been estimated that the OR can account for approximately 33% of the hospital's supply costs. Additionally, the OR is also a major source for producing medical waste, most notably by the use of disposable surgical products[1].

When considering how to reduce the volume of waste in the operating room, it makes sense to first revisit the old adage of Reduce-Reuse-Recycle.

When conducting a comparative analysis, surgical services managers need to consider the lifecycle costs of disposable items beyond the acquisition cost.

Disposable surgical gowns, towels, back table, mayo and basin stand covers are routinely used for most surgical procedures and disposed of as regulated medical waste after a single use. Studies have shown that using a 'common sense' approach to replacing these products with reusable textile items, which can typically be reused 75 times or more, can reduce surgical waste by an average of 65%.

Look for our Smart Start symbol to identify 'common sense' products which can easily be converted from disposable to reusable.

DECISION CRITERIA

When considering Reusables, protecting patient and surgical team is paramount.

Additionally, consider how Lac-Mac reusable surgical products contribute to:

- Protection and comfort for surgical team
- Protection and comfort for patient
- Driving cost reductions through efficiencies
- Managing continuing budgetary constraints
- Environmental responsibility
- Managing labour costs
- Positive patient outcomes
- Ease of use
- Reducing the need for supplementary products
- Reducing costs associated with lost/discarded instruments

Single-use surgical products:

- Offer poor thermal comfort
- Demonstrate inferior breathability
- Increase overall cost
- Are environmentally detrimental
- Demonstrate poor bursting strength, not resistant to tearing
- Increase the need for supplementary products
- Feature poor drapability
- Often manufactured with questionable ‘quality of labour’ and ‘good manufacturing practices’
- Responsible for direct relationship to an increase in discarded instruments

The Steps to a Successful Reusable Conversion[3]:

Step 1: Identify your Allies

A change in product and practice often means changing minds. In getting started, think about what the arguments against reusables might be. Consult with Infection Prevention department and demonstrate that reusable surgical linens meet both CSA and AAMI PB70 liquid barrier performance standards for protective gowns and drapes. Identify and address their concerns. If the healthcare facility has an organized Green Team, contact them and let them know you are making a case for reusables. Green Teams are often very supportive of this type of initiative.

Step 2: Develop a Baseline for Use of Disposables

Before being able to make a case for implementing a reusable program, it is important to be able to quantify how disposables are impacting the operating room and the environment.

Understanding the following will be important:

- What is the volume of custom packs the OR uses monthly?

  Materials Management or Operating Room Managers should be able to provide you with data concerning the number and kinds of OR packs being utilized.

- What single-use textile products are contained in each type of pack?

  An audit of different packs may be required in order to correctly identify disposable textile components within each pack. It will be important to quantify disposable surgical gowns by performance level, towels, size of back table and mayo stand covers, sheets and basin covers in each type of pack.

- How are disposables being disposed of?

  Also relevant to the baseline is determining whether all disposable textiles are currently being disposed of as regulated medical waste. If the facility has a strong RMW segregation program and is segregating disposable textiles as solid rather than medical waste, it will impact your baseline cost assessment. Contact Environmental Services to try and determine what the hospital is spending per pound (a Green Team may be able to assist here) on RMW and/or solid waste. Multiply your total monthly weight by the cost per pound for disposal. This cost will represent a savings when implementing reusables.

- What are the weights of the disposable textiles products?

  Once you have itemized the contents of each pack, gather a sample set of the disposable textile products, weigh the disposable textile items. Multiply these weights times the number of that kind of pack utilized monthly by the OR. This data should provide you with a fairly accurate assessment of the volume of disposable textiles leaving the hospital monthly.

- What are the item costs for the disposable textiles?

  In order to do a cost comparison, you will need to understand how much the disposable textile products are costing the healthcare facility. Because there are additional items within the pack which will not be eliminated, it is important to try and identify costing for just those disposable textile products being replaced rather than the entire pack. Be sure to include handling, packaging and sterilization costs. Multiply the cost in each pack by the number of packs of that type used monthly. Also recognize the common practices which would add to the supply cost, e.g. staff double draping or lining the back table with towels. These are additional supply costs which should be included in the total.

- Determine total cost for use of disposable textiles monthly

  Add the total waste management costs for disposable textiles to the total supply cost for disposable textiles to get the total current baseline cost.

Step 3: Work with your Reusable Supplier, Lac-Mac

The next step is to understand the alternative products which are available to replace the disposable textiles within the packs. Once comparable products have been determined, price quotes based on volume expectations can be provided.

Step 4: Compare Disposable vs. Reusable Pricing

Chart the baseline supply costs for the disposables against the projected costs for the replacement reusables including waste disposal costs. Although waste disposal costs are usually not assigned to the OR budget, it is a cost to the bottom line of the facility.

Disposable Surgical Textiles and Supplies	Reusable Surgical Textiles and Supplies
Total Supply Cost for Disposable Surgical Textiles and Supplies in existing OR custom packs monthly	Potential Supply Costs for Reusable Surgical Textiles and Supplies to replace Disposables
Any additional supply costs for "a la carte" disposable textiles, basins, pitchers for OR monthly	Any additional supply costs for "a la carte" reusable textiles and supplies for the OR monthly
Total pounds of waste generated by disposable surgical textiles and supplies from OR monthly	Savings from recovered instruments—estimated for a typical hospital to be well in excess of $20,000 per year*
Total costs for managing disposables as RMW, Hazardous waste or solid waste each month	In most cases, Reusables can be downgraded for alternate use at end of life
Total Costs of Using Disposable Surgical Textiles and Supplies, including hidden costs	Cost of Using Reusable Surgical Textiles, including Laundry and Sterilization

- A thorough understanding of cost considers all expenses associated with product acquisition, distribution, warehousing, and cost of disposal including hidden costs such as instrument loss. Also consider the need for additional supplementary products such as warming aids and absorbent towels.
- ORs routinely dispose of items included in single-use packs which are never used during the procedure.
- The overall goal is to source the most ***clinically acceptable*** products which offer the ***lowest total cost***.
- Individual cases seeking the most economical solution require individual assessment.

***Independent studies have identified instrument losses can in fact be in excess of $150,000 annually**.*

Step 5: Pilot Reusable Surgical Product Trial

There may be times when all concerns have not been alleviated for transitioning out of disposables and into reusables. In this case, it makes sense to pilot the new products. Based on the cost-comparison numbers provided, the healthcare facility will likely agree. Determine a reasonable pilot period for the trial.

Lac-Mac's experienced team of experts can assist you with fielding questions which may be asked by the OR staff before, during and after using the reusable products.

Other pilot projects and studies have resulted in increased clinician satisfaction and positive feedback. This, in addition to the cost-benefits, should result in moving the organization to a reusable surgical textile program.

Additional Considerations

While reusables typically have a higher acquisition cost but a lower cost-per-use than disposables, perioperative services should evaluate all the steps within the supply chain as well as the waste disposal costs in order to accurately assess a one-on-one comparison. When all the data has been gathered and considered, the cost-benefit for reusables will be clear.

In most cases, touch points between a single-use program and a reusable program have been found to be identical with no benefit observed for either program.

Single-Use Systems:

- Increase waste disposal costs.
- Add warehousing costs.
- Have costs associated with additional purchasing transactions.
- Contain hidden costs (instrument loss, requirement for supplement products such as warming aids, unused pack components, double draping to resist tearing).
- Often multiple-layering required with single-use drapes due to inferior tensile strength which poses risk for tearing.
- Require a high volume of product to support consistent supply.

Today's High-Performance Level 4 Reusable Surgical Gowns and Drapes provide an impervious barrier with one layer. The durability of reusable products result in labour savings associated with the reduction of time required to drape patients, by eliminating additional products associated with single-use double draping.

SURGICAL GOWN AND DRAPE CONSIDERATIONS:

- Barrier protection
- Compatibility with Infection Control mandates and practices
- Product quality and workmanship
- Comfort, breathability
- Product fit
- Quality control measures during product production
- Environmental impact
- Adherence to standards and guidelines
- Aseptic presentation and handling
- Drapability
- Durability
- Convenience and ease of use
- Design features
- Customization/substitution
- Flammability/risk for blue flame fires

Barrier Effectiveness for Reusables

The barrier materials used in Lac-Mac reusable surgical gowns and drapes are the key to providing an effective protection against liquids and microorganisms during a surgical procedure. Surgical gowns and drapes are considered Class II medical devices by the *Food and Drug Administration (FDA)*. Under the Medical Devices Act, these products must meet stringent standards.

The barrier effectiveness of Lac-Mac reusable gowns and drapes remain effective throughout the life of the product**.**

Claims regarding the number of times a product can be effectively reprocessed and reused are authenticated and validated by independent third party lab testing.

CSA and AAMI PB70 Standards for Barrier Protection[7,8]

The Canadian Standards Association (CSA) and the Association for the Advancement of Medical Instrumentation (AAMI) standard helps take the guesswork out of choosing the right barrier protection associated with risk for exposure to fluid, fluid spray and applied pressure, expected during a procedure. The AAMI standard requires manufacturers to classify and label their surgical gowns, drapes and certain other protective products with the level of barrier protection they provide.

As an example, the surgical team can don a gown identified as Level 4, and be assured it has been tested to meet the anticipated high risk levels for exposure to fluid, fluid spray and applied pressure.

The Standard has established the following as guidelines:

- A classification system using Levels 1-4 to identify class of barrier protection
- Liquid barrier performance is based on industry-accepted test methods and to guide manufacturers in appropriate labeling of their medical devices
- Surgical gowns and drapes shall be prominently labeled with its class of barrier performance
- No classification identified shall be considered non-protective
- Levels of classification are in accordance to the barrier performance properties specific to the critical zone(s), including seams and components
- Must meet flammability standard as defined in CFR16:Part 1610

Lac-Mac Reusable Advantage: Quality

- Lac-Mac surgical products are manufactured in our modern efficient North American factory using state-of-the-art equipment
- ISO 9001 registered facility
- Implemented the latest manufacturing technologies observing Lean Manufacturing philosophies, eliminating waste
- Products meet or exceed industry standards

Excerpts from Disposable vs Reusable Studies give Critical Assessment on the Quality of Disposables[5]

"The results indicate that the resistance to liquid penetration performance – sometimes even within the same product, strongly varies, which leads us to expect equally varying degrees of performance in other legally required tests, such as the resistance in the wet microbial penetration test."

"As a consequence, the widely held opinion that single-use materials are of homogenous quality and inherently "safe" may no longer be sustained."

"Both high and standard performance gowns were tested. Considerable differences were identified. They revealed that 50% of all the high performance disposable gowns had defects."

Reusable Advantage: Safety

- Surgical gowns are intended to be worn by operating room personnel during surgical procedures, to protect both the surgical patient and the operating room personnel from the transfer of microorganisms, body fluids, particulate matter, and other potentially infectious materials (OPIM) and associated microorganisms.
- Surgical drapes are also intended to inhibit the transfer of microorganisms, body fluids, and OPIM, and are used as a protective patient covering to isolate a site of surgical incision from microbial and other cross-contamination.
- The safety of patients and staff depend on selecting the correct level of protection best suited for the procedure.
- Proper use, care and adherence to manufacturers' recommended processing guidelines, will ensure continuous, safe, barrier integrity.
- Understanding the defined levels associated with performance will allow informed and consistent choices about the type of protective products best suited for the procedure at hand.
- Choose products which are latex-free.
- Experts consider it practically impossible, in clinically unrecognizable suspected cases of CJD (Creutzfeld-Jacob Disease) for the disease to be transmitted via reusable OR textiles. The use of reusable textile products in the OR is not associated with any danger of transmission of CJD.
- Reusable surgical products are performance validated to end of life.

Disposable Errors and Incidents - Safety

- A database search at the FDA produced the following results for one single-use supplier:

"In 10 years, there have been more than 1000 reported incidents involving disposable drapes, and more than 1000 reported incidents involving disposable gowns."

- Modification of Single-use drapes within the operating room theatre runs risk for generation of particulate, which is associated with granulomas and surgical site infection.

CSA and AAMI PB70 Standards /ORNAC and AORN Best Practice Recommendations for Reusable Surgical Linen

- Selection and use of barrier materials should be consistent with their intended purpose. Choosing the appropriate level of barrier protection for surgical gowns and drapes will provide the best opportunity to meet fiscal requirements, staff and patient safety and comfort.
- Manufacturers' written instructions for Product Care, Processing, Sterilization and Maintenance should be followed.
- Seams within the critical zone should be constructed to prevent the penetration and passage of potential contaminants. Seams are expected to meet the same level of protection in accordance with the performance claim. Microbial passage is not unidirectional. If liquids wick or transfer through pressure between sterile and non- sterile surfaces, one or both sides may become contaminated.
- Barrier materials should be as lint-free as possible.
- The sterility of items shall be measured by event-related rather than time-related practices.

Environmental Impact

"Medical waste is a necessary by-product of any hospital environment; however, the majority of regulated medical waste is produced in the OR from the use of disposable surgical supplies (i.e., surgical drapes, gowns and more)."

According to *Health Care Without Harm*, 4 million tons of general waste is produced by health care facilities in the United States each year. Using reusable surgical products provides a means to decrease regulated medical waste in the OR by an average total of 65% as well as reducing the cost of waste disposal. Disposing of waste, accounts for approximately 20% of a hospital's environmental services budget[2].

Waste issues begin with the purchasing department when materials are purchased that eventually become waste requiring disposal. Reducing the amount of disposable surgical materials purchased is an important step towards reducing the amount of regulated medical waste generated.

Statement made by a major Disposable Supplier:

"Decisions on which product to use should be based on other criteria such as clinical performance, patient and staff safety, and cost-effectiveness."

We agree that these are very important considerations; however, environmental respect is also of utmost importance and one which we cannot afford to overlook. Not only is it possible to quantify environmental benefits, but many lifecycle and product studies have successfully demonstrated that reusables **are** environmentally superior to disposables.

Additionally they are clinically preferred, offer equal or better patient and staff safety, and are more cost-effective.

Additional Environmental Considerations for a Single-Use Program

- Off-shore manufactured products generate a far greater carbon footprint.

  "In one hour, a single container ship entering port generates air pollution equivalent to that of 350,000 cars."

  http://factsanddetails.com/china.php?itemid=391&catid=10&subcatid=66

  "One giant container ship can emit almost the same amount of cancer and asthma-causing chemicals as 50 million cars"

  http://www.greencarreports.com/news/1020063_pollution-perspective-one-giant-cargo-ship-emits-as-much-as-50-million-cars

- Excessive, environmentally unfriendly packaging.
- Single-use products generate in excess of 75% more environmental waste.
- Single-use products are manufactured in China and other off-shore locations which contribute to massive global pollution due to lack of regulatory bodies and good manufacturing practices.

Statistics: *"About one third of the industrial waste water and more than 90% of household sewage in China is released into rivers and lakes without being treated. Water shortages and water pollution in China are such a problem that the World Bank warns of "catastrophic consequences for future generations." Water pollution is especially bad along the coastal manufacturing belt. In many cases factories fouling critical water sources are making goods consumed in the U.S. and Europe."*

http://factsanddetails.com/china.php?itemid=391

Hidden Costs

Instrument Loss:

With the rise in use of disposable surgical drapes came the rise in lost instruments which were inadvertently discarded with the linen. The annual costs to healthcare associated with these losses are staggering. Some valuations have been sited to be in excess of $150,000 annually.

The relationship of these costs are directly associated to the use of single use surgical drapes.

In an attempt to remedy these costly occurrences, hospitals have had to resort to implementing Instrument Detection Devices, geared to identifying metal objects within trash disposal sites. This equipment is being acquired to try and recover some of these costly instruments.

The cost of this detection equipment, as well as the cost of instruments which may still end up in our landfills needs to be recognized as costs directly associated with the use of disposable surgical products.

Advantages of Lac-Mac Reusable Products and Services

- Latex-free products and manufacturing
- Low cost-per-use
- Highly breathable for comfort, a physiological requirement
- Maintains thermal core temperature for both Surgical Team and Patient
- Industry-standard colour coding
- Bar Coding, Use Grid and/or RFID Chip for product traceability
- Less inventory and storage space required
- Product customization available
- Minimal packaging utilizing 100% recycled cardboard cartons
- Full size selection of gowns available
- Low-linting
- Unlimited pack configurations possible
- Levels of protection permanently identified on products
- Less time required to drape patient – no layering
- Education on draping techniques for standardization
- Waste management, gowns can be downgraded at end of use
- Support from our team of product experts
- Additional Reusable Drape Features:
  - universal draping system allows for adaptable fenestration
  - barrier section offers superior fluid management
  - directional arrows and lettering can be added to any drape product
  - tube/cord holders
  - bias indicators easily identify bottom of drape
  - fluid control pouches available

Lac·Mac

Your *Symbol* for Quality

AAMI PB70 and CSA Z314.10.1-10 Levels of Protection

LEVEL 1: Minimal Risk for exposure to Fluid, Fluid Spray and Applied Pressure

When tested for water resistance in accordance with AATCC 42 (impact penetration), all critical zone components shall have a blotter weight gain of no more than 4.5 grams (g), with an AQL of 4%. The test results shall be reported in the manufacturer's product technical information.

AATCC 42:2 < 4.5 g (AATCC: American Association of Textile Chemists and Colorists) (AQL - Acceptable Quality Level)

LEVEL 2: Low Risk for exposure to Fluid, Fluid Spray and Applied Pressure

When tested for water resistance in accordance with AATCC 42 (impact penetration) and AATCC 127 (hydrostatic pressure), all critical zone components shall have a blotter weight gain of no more than 1.0 (g), and a hydrostatic resistance of at least 20cm, with an AQL of 4%. The test results shall be reported in the manufacturer's product technical information.

AATCC 42:2 < 1.0 g AATCC:127:1998 > 20 cm

LEVEL 3: Moderate Risk for exposure to Fluid, Fluid Spray and Applied Pressure

When tested for water resistance in accordance with AATCC 42 (impact penetration) and AATCC 127 (hydrostatic pressure), all critical zone components shall have a blotter weight gain of no more than 1.0 (g), and a hydrostatic resistance of at least 50cm, with an AQL of 4%. The test results shall be reported in the manufacturer's product technical information.

AATCC 42:2 < 1.0 g

AATCC:127:1998 > 50 cm

LEVEL 4: High Risk for exposure to Fluid, Fluid Spray and Applied Pressure

When a surgical gown or other item of protective apparel is tested for resistance to bacteriophage Phi-X 174 in accordance with ASTM F1671, all critical zone components shall demonstrate passing results with an AQL of 4%. The test results shall be reported in the manufacturer's product technical information.

ASTM F 1671:2003 **Gowns**

(Standard test method for resistance of materials to the penetration of blood-borne pathogens)

ASTM F 1670:2003 **Drapes**

(Standard test method for resistance of materials to penetration by synthetic blood)

Both single-use and reusable surgical gowns and drapes are governed by the same regulatory standards covering performance claims, care &handling, labelling and overall safety practices. There are not more stringent regulations for one or the other.

Association for the Advancement of Medical Instrumentation – (2003) Liquid Barrier Performance and Classification of Protective Apparel and Drapes Intended for Use in Health Care Facilities

LINEN PROCESSING GUIDELINES:

CSA Standards for Laundry Facilities:

- Manufacturers shall supply a comprehensive maintenance and laundering instruction guide in support of all types of reusable surgical products provided.
- Instruction for efficacy protocol for validated barrier integrity of reusable surgical textiles including inspection and repair methods.
- A tracking mechanism from the manufacturer must provide recommendations for the number of times a product can be used. Bar Code labels, Use Grids and/or RFID chips should be marked each time products are laundered.
- Refer to CSA standard (*Table 2*) for Sample list of inspection criteria for stains.
- Chemicals perform essential functions in laundering processes including loosening soil, dissolving oily stains, and preventing redisposition of soil onto the textiles being washed. If chemicals are improperly used, they can damage textiles.
- Properly processed reusable surgical products pose no health risk to patient, surgical team or to our environment.
- All textiles shall be laundered before initial use.
- Care and maintenance procedures shall be designed and implemented to preserve the functional characteristics for reusable gowns and drapes.

Refer to the Lac-Mac "Manufacturer's Instruction for Use Binder", which is supplied to our customers, detailing instruction for maintenance, cleaning, sterilization, packaging and storage in support of our surgical products.

Reference: CSA Standards Association: Selection, Use, Maintenance, and Laundering of Reusable Textile Wrappers, Surgical Gowns, and Drapes for Health Care Facilities – Z314.10-03

"Gortex and Cotton Drapes/Gowns/Wrappers" – Published by a Disposable Supplier - Refuted by Lac-Mac

- Gortex deteriorates over time with washing and handling.

FALSE: *The barrier properties of our GORE® Surgical Barrier Fabric used in our Level 4 and Level 3 Surgical products is third party tested and validated to end of life.*

- Gortex has very specific washing requirements. Washing machines must be adjusted to accommodate special detergents, chemicals and timing.

FALSE*: There are no special machine adjustments required for processing products made with GORE® Surgical Barrier.*

- Gortex must be sterilized at a lower temperature than poly-cotton (gortex is an oil-based product; if the sterilizer is too hot the fibres expand and shrink to weaken and shrink the garment).

MISLEADING*: Surgical products made using GORE® are made using Polyester which is in fact a derivative of oil, like single-use products are, however sterilizing any product at too high a temperature may result in damage to the product.*

- Very dependent on quality of labour to "guarantee" barrier and sterility.

MISLEADING: Are they *suggesting that single-use products are NOT dependent upon quality of labour for barrier and sterility assurances? That is alarming.*

- Light table/light wand inspection is only as good as the training level of staff and the time this staff invests for the use of the light table – quotas of drapes per day.

TRUE*: Reusable products are light table/light wand inspected by trained employees providing jobs within the community for family, friends and neighbours.*

- No adhesives on drapes.

TRUE*: Our reusable drapes are not manufactured with adhesives, although adhesives and wash soluble tapes are available to complement our products.*

- No fluid collection pouches to support Occupational Health and Safety initiatives.

FALSE: *Lac-Mac manufactures various types of reusable drapes featuring fluid collection pouches.*

- It is difficult to launder Gortex to fully remove petroleum jelly, cement, mineral oil and body fat tissue: all of which are encountered every day in Operating Rooms. If these products cannot be removed then the drape must be disposed of according to CSA standards.

MISLEADING*: Surgical products made using GORE® Barrier Fabrics are easy to launder and most stains are readily removed during laundry processing. However, like any textile product, the composition of some stains renders them difficult or at times impossible to remove. CSA standard and AAMI ST65:2008 both include a list of "acceptable stains" which*

should be referred to if acceptability is in question. Only in the most extreme cases is disposal required.

- Linen gowns, drapes and bundles are larger and heavier than their single-use equivalents.

MISLEADING: *Reusable linen packs can be larger than single-use depending upon the composition and contents. It is difficult to make a blanket statement regarding pack size.*

- Touching a damp linen bundle contaminates it.

MISLEADING: *Following Best Practices Recommendations and Standards will ensure safe handling of sterile products*.

- Areas of linen in bundles may become overheated. Steam does not penetrate all linen materials the same, therefore the temperature is not the same throughout the bundle. This is why standards have size and weight restrictions for bundles.

MISLEADING: *Following standards and best practice, sterilization protocols will ensure complete, thorough and validated sterile bundles. Packs and bundles would not be released for use if sterility was in question.*

- Prions (known and unknown: i.e., CJD) do not respond to sterilization.

TRUE: *Adherence to recommended best practices is crucial and especially so when dealing with any case where Prions may be present.*

- Patches often fail the ASTM 1670 & 1671 standards for barrier.

FALSE: *Following our recommended patching guidelines will provide a secure non-fail patch. Patches made from the same Level of barrier material will perform to the same result as the barrier fabric to which they are applied.*

- Quality of steam may be an issue. Sometimes salts and residue become absorbed.

FALSE: *Steam sterilization is a validated and proven effective method for sterilization of reusable textile products*. *Facilities have controls in place and follow regulated protocols.*

- Cotton drapes have no barrier qualities.

TRUE/MISLEADING: *Most healthcare facilities have not used cotton as a barrier in more than 20 years. Lac-Mac does not manufacture any surgical products using cotton.*

Note:'Goretex' as indicated within the sited competitive document, is a brand associated with outerwear products, and should not be confused with GORE® Surgical Barrier fabric which is used within the Medical Products Division.

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A Comparison of Reusable and Disposable Perioperative Textiles: Sustainability State-of-the-Art 2012

Michael Overcash, PhD

Contemporary comparisons of reusable and single-use perioperative textiles (surgical gowns and drapes) reflect major changes in the technologies to produce and reuse these products. Reusable and disposable gowns and drapes meet new standards for medical workers and patient protection, use synthetic lightweight fabrics, and are competitively priced. In multiple science-based life cycle environmental studies, reusable surgical gowns and drapes demonstrate substantial sustainability benefits over the same disposable product in natural resource energy (200%–300%), water (250%–330%), carbon footprint (200%–300%), volatile organics, solid wastes (750%), and instrument recovery. Because all other factors (cost, protection, and comfort) are reasonably similar, the environmental benefits of reusable surgical gowns and drapes to health care sustainability programs are important for this industry. Thus, it is no longer valid to indicate that reusables are better in some environmental impacts and disposables are better in other environmental impacts. It is also important to recognize that large-scale studies of comfort, protection, or economics have not been actively pursued in the last 5 to 10 years, and thus the factors to improve both reusables and disposable systems are difficult to assess. In addition, the comparison related to jobs is not well studied, but may further support reusables. In summary, currently available perioperative textiles are similar in comfort, safety, and cost, but reusable textiles offer substantial opportunities for nurses, physicians, and hospitals to reduce environmental footprints when selected over disposable alternatives. Evidenced-based comparison of environmental factors supports the conclusion that reusable gowns and drapes offer important sustainability improvements. The benefit of reusable systems may be similar for other reusables in anesthesia, such as laryngeal mask airways or suction canisters, but life cycle studies are needed to substantiate these benefits. (Anesth Analg 2012;114:1055–66)

Perioperative gowns and drapes are available in reusable or disposable alternatives. Comparison of the reusable and single-use alternatives in the operating room (OR) has focused primarily on gowns, even though these comprise only about 30% of the weight of the surgical textiles used. The criteria for evaluating perioperative gowns and drapes include[1–3] (1) protection of health care workers and patients from surgical site or nosocomial infections, (2) comfort, (3) economics, (4) environmental life cycle analysis, and (5) jobs.

Literature was completely reviewed with Medline and Web of Science using the descriptors surgical gowns, cost of surgical gowns, and reusable versus disposable surgical gowns. The main limitation in the current literature comparing reusables and disposables is the repetition of old, now inadequate citations, which have coalesced into widely held perceptions.[4] The evolution of gowns and drapes, driven by new textile technologies and new required testing standards, means that we must set aside those comparisons of liquid and bacterial protection that do not reflect these changes. We should only use studies that cover current textile products and standards.[1,3,5] The new American National Standards Institute and the Association for the Advancement of Medical Instrumentation (AAMI) issued new testing standards for medical gowns and drapes in 2003.[5] This led to the introduction of gowns and drapes that comply with this standard. Experimental studies before 2000 of liquid and bacterial protection and infection with either reusable or disposables have limited relevance to currently available perioperative textiles. The early but frequently cited studies[6–15] often (1) compared materials now considered obsolete (cotton, cotton/polyester, muslin, pulp), (2) used tests that the Food and Drug Administration and independent laboratories demonstrated to produce inadequate results, (3) lacked transparency in whether similar functionality of the gowns was being studied, and (4) excluded published criticisms of the original results.

It is generally accepted that these older studies do not apply to currently available products.[2,3,16,17] The removal of older studies does not reflect badly on this earlier work, but simply recognizes that these do not apply to currently available products. Older studies also reflect economic, environmental, and manufacturing conditions that may lack relevance to contemporary products. The following discussions are based primarily on contemporary studies in reusable and disposable perioperative textiles. Unfortunately, there are so few recent homogeneous studies of gown and drape technology that quantitative meta-analysis was not feasible. Instead, a qualitative comparison of reusable and disposables was done for categories such as comfort, protection, and economics, using health care experts in these products to capture the central conclusions on similarities and differences.

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Accepted for publication January 23, 2012.

The author declares no conflicts of interest.

Reprints will not be available from the author.

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DOI: 10.1213/ANE.0b013e31824d9cc3

Table 1. Recommendation of Gowns for Various Surgical Conditions (Telford and Quebbeman[22])

	Surgical conditions[a]	
Operative site	<100 mL of blood loss and <2 h duration	>100 mL of blood loss and >2 h duration
Head and neck	Standard gown	Reinforced gown
Chest	Reinforced gown	Plastic reinforced gown
Abdomen	Plastic reinforced gown	Plastic reinforced gown
Perineum	Reinforced gown	Plastic reinforced gown
Extremity	Reinforced gown	Plastic reinforced gown
Skin and subcutaneous	Standard gown	Plastic reinforced gown

Generally, it appears that a standard gown is level 2, a reinforced gown is level 3, and a plastic reinforced gown is level 4.

[a] Applies to surgeon and surgical assistant; other operating room staff should wear protection 1 level below those designated here.

PROTECTION OF HEALTH CARE WORKERS AND PATIENTS FROM SURGICAL SITE OR NOSOCOMIAL INFECTIONS

Surgical gowns have a critical role in infection control.[3,18] Contemporary uses for and types of gowns and drapes have advanced substantially. Laufman et al.[1] grouped the large number of published surgical site infection risk factors into 5 categories based on earlier studies[16,19,20]: (1) surgical team discipline in aseptic practices, (2) patient health status, (3) preventative drugs and antiseptics, (4) design of the OR and procedures, and (5) protective devices of which gowns and drapes are 1 of 7 devices (sterilization, gas/vacuum, air-handling, mechanical and electrical devices, instrumentation, and gloves) in the OR.

Thus, the actual outcome of protecting patients and health care workers (or the failure of protection as an infection) by means of gowns and drapes is only partially due to the properties of these textiles. This contributes to the challenges of actually attributing infection to reusable or disposable gowns or drapes.

Surgical gown selection should be based on the type of surgery, because this dictates the level of required protection.[3] Lewis and Brown[21] and Telford and Quebbeman[22] list the surgical procedures and different levels of protection that are required, as shown in Table 1, a view shared by others.[16,23] The transition from inpatient to outpatient facilities, and the rapid development of minimally invasive surgery[23] also affect the comparison between reusable and disposable gowns and drapes. Unfortunately, few studies have tested the ability of contemporary gowns and drapes to reduce infection.

The AAMI together with the American National Standards Institute developed new standards[24] for liquid and viral protection with medical textiles, based on anticipated exposure (type of surgery). A 4-level hierarchy for gowns and drapes was used. The highest protection, level 4, uses both liquid and viral (hepatitis B, hepatitis C, and human immunodeficiency virus) penetration tests.[25,26] Next in decreasing order of liquid protection are levels 3, 2, and 1, which follow standards set by the American Association of Textile Chemists and Colorists.[27,28] The level of liquid protection corresponds to resistance to penetration of blood and other body fluids at increasing liquid pressures.

It is necessary that textile comparisons be made at the same level of penetration protection (e.g., reusable level 3 is compared with disposable level 3). This evidence-based comparison[17] is an appropriate basis for selecting perioperative textiles. Informed decisions on single-use versus reusable textiles cannot be made for products with different levels of protection.

Considering the large number of infection factors in the OR,[1] the actual role of gowns and drapes in surgery, and the ability to meet modern standards for control of penetration, there is little difference between currently available reusable versus disposable gowns.[3,16] The Centers for Disease Control (CDC)[29] and others[1] concluded that no data suggest important differences in reusable versus disposable gowns and drapes in preventing surgical site infections.[3] Furthermore, the general lack of any documented incident of bacterial contamination from permeation of a gown barrier reflects the similarity of reusable and disposable textiles in protecting health care workers and patients.[1,2,30,31]

Preferences among health care personnel for disposal products do not reflect the available scientific information and are often based on qualitative marketing claims. It is a challenge to help decision-makers understand the near equivalency of modern reusable and disposable textiles. There is also misconception related to multiple uses of a reusable gown or drape. For reusables, maintenance of permeability protection after each cycle of use[2,32,33] directly addresses the issue of continuing protection. Each gown or drape should be routinely tested by physical inspection and repellency testing. Greater access to the reusable service data showing continued fluid protection can be effective in reducing the concerns among health care workers. In addition, reliable logging systems track the number of uses, permitting removal from service at the specified life time.

COMFORT

Comfort of gown users must be compared for gowns of the same rating (i.e., level 3). Data on comfort measurements are not widely available.[33] However, heat barrier and moisture transmission ("breathability") are quantifiable comfort-related measurements.[21] Other comfort factors such as improper fit, stiffness, noise, and roughness are largely not measured. It is reasonable to assume that these other comfort or appearance factors can be designed into the gown or drape and thus be indistinguishable for disposables and reusables at the same level of protection. Lewis and Brown,[21] using thermal manikins and standard comfort thermophysiologic models,[34,35] showed that 2 reusable and disposable gowns achieved the comfort range for operations exceeding 3 hours, typical for the use of level 4 gowns. All 7 of the reusable and disposable gowns tested were in the core temperature range of comfortable for operations less than 1 hour, now a common occurrence.

Mittermayer et al.[2] examined 16 reusable and 11 disposable gowns. He found for reusables (11 gowns) that 1-, 2-, and 3-ply woven gowns with laminates were in the acceptable to very good comfort range, based on a moisture vapor transmission rate <8 m^2 Pa/W. Seven disposable gowns of 1- and 2-ply nonwovens with film laminates were in the same comfort range (moisture vapor transmission rate <8 m^2 Pa/W). These quantitative measurements of comfort were comparable for disposable and reusable products.

Conrady et al.[36] used a more rigorous, user-comparative effectiveness study of reusable and disposable gowns worn by surgeons and surgical technicians. The surgical teams conducted 119 surgical procedures in 2 hospitals and compared both types of gowns by wearing each type in various procedures. This is the only direct evidence-based study of gown comfort currently reported. The gowns were generally level 2 and 3 gowns, based on whether it was minor or major surgery, respectively. Surgeons and technicians rated the reusable gowns as more comfortable.

For gown comfort, the available field data and anecdotal discussions with manufacturers and users suggest that current reusable gowns, at level 2 and 3 as typical of short procedures, are more comfortable than disposable gowns. At level 4 or in long procedures, reusable gowns with breathable laminates are more comfortable than disposable gowns.

ECONOMICS

Economic comparisons of perioperative reusable and disposable textiles often include unspecified factors, making quantitative comparison difficult.[1,3,4,7,37,38] Also, laundry and sterilization at many large hospital facilities are now provided by an external vendor, rather than performed in-house. Approximately 1% of the hospitals with reusable perioperative textiles process these in-house (personal communication, J. Hamilton, SRI Surgical, 2010). This might make economic comparison easier because purchase and contracts are distinct costs, but that has not been evident in published studies.

A major difference between reusables and disposables has been the purchasing systems for these products. Reimbursements to hospitals for volume of purchases (of which gowns and drapes are not a large percentage) are characteristic of the disposable market. These cash flows are often not transparent, nor do these necessarily accrue to the departments needing the gowns and drapes. Reusables are more often provided on an annual or multiyear service contract. Thus, a comprehensive multiyear evaluation of disposables versus reusables has not been performed, and is unlikely to occur.

There are only 3 published economic studies of contemporary surgical gowns, all non-United States (US). In conducting a comprehensive purchasing study in Turkey, Baykasoglu et al.[38] found that the cost of reusable gowns ($8 per surgical package) was approximately 25% of the cost of disposable gown costs ($33 per surgical package). Lizzi et al.,[39] conducting a study in an Argentinean hospital, found that reusables cost $16 per surgical package, whereas disposables cost $9 per surgical package. Martec Corporation, a Canadian engineering firm, studied the use of gowns at the National Health Service in the United Kingdom.[40] They found disposables were 4% lower in cost than reusables, which was within the margin of error of the study. No detailed multihospital economic study is available. The lack of clear data in either direction suggests that reusable and disposable surgical gowns and drapes are probably similar in costs with most variations attributable to local contract negotiations.

Cost differences between reusables and disposables may be overshadowed by personnel preferences. This would explain the higher reusable use percentages in Europe (50%) versus the US (10%),[41] rather than any fundamental cost differences. Neither disposable nor reusable systems have eliminated the other product type. This suggests similar costs because significant cost differences would have driven the market to essentially zero for the expensive option.

Many hospitals undertake economic analyses before product purchase. Unfortunately, there is no independent access to these data. One can only look at the market and conclude that because both reusable and disposable surgical gowns and drapes remain on the market, these costs must remain competitive. Lastly, the ideal mix may not be exclusively reusable versus disposable textile. Laufman et al.[1] anticipated the evolution of hybrid surgical packages, which are now in the market, in which specific reusable and disposable items are selected based on economic and environmental factors, creating a more sustainable surgical package.

ENVIRONMENTAL LIFE CYCLE ANALYSIS

Life cycle inventory is the quantitative measurement of energy and emissions (known as a life cycle inventory) that occurs in the manufacture, use, and disposal of surgical gowns and drapes. This encompasses all aspects from oil and ore to the finished gown or drape, the cleaning and sterilizing of reusable products, and the final end-of-life stage for reusables and disposables. Life cycle impact assessment is the quantification of each environmental impact, such as carbon footprint, human toxicity, and stream eutrophication, based on the life cycle inventory results.

During the use and at the end-of-life stage, surgical wastes (blood, tissue, fluid) are produced for both disposable and reusable gowns and drapes. The surgical waste and disposable gowns are either sent to landfills, where only the surgical waste degrades (modern gowns are essentially inert), or incinerated, where the majority of carbon is converted to carbon dioxide. Currently, landfill is the dominant route for disposables and is analyzed in these life cycle studies. Reusable gowns are washed to produce laundry wastes that are treated to achieve receiving water standards. Reusable gowns at end-of-life are typically transferred to other uses (less developed countries or alternative applications) and thus only the treatment of the surgical waste (blood, tissue, fluid) is included.

In 1998, the CDC hypothesized that there were no differences in life cycle impacts between reusable and disposable gowns.[29] Since 1993, there have been 5 life cycle studies of protective surgical gowns and 1 study of worker coveralls in nuclear power plants.[11,42–46] These studies do not support the CDC hypothesis conclusion. These life cycle studies typically compare a fixed number of disposable gowns (typically 50–75) with a single reusable gown used 50 to 75 times. As a result, these studies compare the manufacturing, sterilization, and transport of disposables to the manufacture, laundry, sterilization, and transport cycles for reusables. These studies show that the environmental impact of transport for reusables is modest. For example, in the Environmental Clarity report,[46] transport

accounts for <2.2% of overall gown life cycle energy at 1000 miles per laundry cycle.

Analysis of life cycle data is often limited by the amount of transparent information in the reports. This does not suggest that the conclusions are flawed, but simply that most published studies lack the quality of life cycle data reporting required for quantitative analysis of perioperative textiles.

Table 2 provides a comparison of the disposable and reusable systems covered by each of the 6 life cycles, whereas Table 3 shows the results of these studies. Table 4 documents the life cycle factors missing from each study. All 6 life cycle studies found that the reusable system provided substantially better environmental profiles than single-use systems. Selecting disposables instead of comparable reusables increased energy use and carbon footprint by 200% to 300%, increased the water footprint by 250% to 330%, and increased solid waste from 38 kg to 320 kg per 1000 gown uses (a 750% increase).

THE MCDOWELL STUDY

The oldest life cycle study is the comparison by McDowell[11] of a woven polyethylene terephthalate (PET) reusable gown and lap drape used over 75 cycles and a single-use disposable spunlace PET (50%)/wood pulp (50%) nonwoven gown and lap drape. This 15-page report was published in 1993, but the detailed data remain unavailable. The study basis was 1 surgical procedure in which 3.7 gowns and 1.2 lap drapes were used. The report does not state the protection desired by the gown user, but the gowns appear to be a level 2. The gowns predate the AAMI standards for liquid protection and the advent of modern gowns meeting these standards. The weight of these gowns and drapes was not provided and so other comparative calculations were not possible. The report does not provide data on the supply chain and manufacturing processes of the disposable and reusable gowns.

Despite these limitations, the report by McDowell is frequently cited to support the claim that the manufacturing of the reusable gown produces higher volatile organic chemical (VOC) emissions (a part of the photochemical ozone impact category) from dyeing and finishing compared with disposables. Because both the disposable and reusable systems use PET, it is unclear why the dyeing and finishing for a given color (such as pink or blue) should be substantially different. Because the reusable is dyed only once per 75 uses, whereas the disposables are dyed 75 times for the same 75 uses, the VOC emission difference is even less clear. Two later studies evaluated VOC emissions and found that manufacturing of disposable gowns produced 4 to 5 times larger VOC emissions than the manufacturing of reusable gowns.[43,44] It would seem that citing the McDowell life cycle study as having greater VOC for reusable gowns and drapes is inconsistent with the mutual use of dyeing PET and the entire supply chain aggregation of VOC measured as a photochemical ozone impact category.

McDowell reports the reusable perioperative textile water use as 3.9 gallons per gown and 10.7 gallons per lap drape, far more than the 0.14 gallons per gown and 0.93 gallons per lap drape required for disposables. The report does not distinguish water required in manufacturing from water required for laundry and sterilization, precluding comparison with other life cycle studies. As shown in Table 3, subsequent comparisons of water use in the manufacturing of disposable gowns by the Royal Melbourne Institute of Technology (RMIT), the European Textile Service Association (ETSA), and Environmental Clarity suggest that McDowell underestimated the water use by a factor of 13 to 800. Therefore, McDowell's water estimates are likely incorrect. Any of the corrected factors for water would indicate more water use by disposables than reusables. Gown sterilization is discussed as a health risk factor by McDowell, but does not appear to be in the environmental life cycle. The report showed that higher energy was needed for the disposable system (20 megajoule [MJ]/gown and 42.5 MJ/lap drape) than the reusable system (5.8 MJ/gown and 11 MJ/lap drape).

THE ETSA STUDY

The ETSA conducted a life cycle study published in 2000.[42] The functional unit of comparison was 1 reusable gown (woven PET and Gore laminate) with disposable primary packaging versus 1 disposable gown (nonwoven 50 wt% PET and 50 wt% wood pulp) and a low-density polyethylene barrier film plus disposable primary packaging, as shown in Table 2. No gown protection standard was cited, but from the general description, the reusable gown was probably level 3 and the disposable gown between levels 2 and 3. The reusable gown was laundered for 75 cycles. Transport for the reusables and disposables was specified. This report had a moderate amount of transparency, but was often unclear in units (e.g., kg reusable gowns was used, but in some instances appeared to be soiled gown and other places clean gown, a significant difference in weight). Few data on manufacturing and process are shown. An older reusable gown with cotton and PET was also studied, but because it is not currently meeting AAMI level 2, 3, and 4 standards, this gown was not included in this review.

The ETSA report was the first to identify that greater water use occurs in the manufacture of disposable gowns compared with the water used in laundry and sterilization of a reusable gown, as shown in Table 3. The purpose of the water use in the supply chain of either gown was not given. The energy for the supply chain, manufacture, use, and end-of-life of the reusable gown system (75 cycles) was lower (11–15 MJ/gown) than that of the disposable gown (75 gowns) (29–35 MJ/gown). The reusable gowns required 42% less energy and 32% less water than disposable gowns, as shown in Table 3.

THE RMIT STUDY

The RMIT University conducted a life cycle inventory study published in 2008.[43] They used the surgical package as a functional unit, although it was only the most basic package (gown and towel). The reusable gown was between a level 2 and level 3, whereas the disposable was probably a level 3. The reusable gown and towel were assumed to be usable for 127 cycles. This is significantly higher than the 50 to 75 cycles found in current practices where testing for AAMI compliance standards is used. Their sensitivity analysis showed that their overall energy differences were still present at 50 cycles, but the 127 cycles

Table 2. Descriptions of Life Cycle Inventory Studies of Reusable and Disposable Textiles

	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2010)
Reusables	1 surgery, 3.7 gowns, and 1.2 lap drapes, washed 75 cycles	1 large gown, woven level 3 or 4, washed 75 cycles	1 surgical package, washed 127 cycles	1 gown washed 50 cycles	1 gown for nuclear power plant radiological protection, 100 cycles	1000 level 3 gown uses, washed 75 cycles
	1 large gown, woven PET, likely level 2	546 g = 389 g PET and 157 g Gore material modeled as polyurethane	1 gown, woven (94% PET/6% cotton) (between a level 2 and level 3), 287 g	1 large gown, woven PET with polyethylene laminate, 407 g, level 3	Woven nylon, weight not given	Critical areas, Gore fabric; noncritical areas, woven PET: 1 gown 0.49 kg
	1 lap drape, woven PET		Cotton towel, 73.5 g			
			Disposable paper autoclave indicator tape, 5 g			
Primary disposable packaging	Not defined		Polypropylene nonwoven CSR wrap, 12.8 g	Not defined	Not defined	Paper CSR wrap and insert, 22.3 kg
		Disposable paper and LDPE, 58 g	Outer bag, half paper half HDPE, 14.9 g			EMAC outer bag, 12.5 kg
Secondary disposable packaging						LDPE bag, 0.33 kg
Tertiary disposable packaging						LDPE film, 0.0033 kg
	Not given	Total 604 g (1.33 lb.)	Total 393.7 g (0.87 lb.)	Total 407 g (0.9 lb.)	411 (0.91 lb.)	Total 490 kg (1100 lb.)
Disposables	1 large gown, spunlace 50% PET, 50% wood pulp	1 large gown, nonwoven level 3 or 4	1 surgical package	1 large gown, polypropylene nonwoven, 137 g, level 3	1 gown for nuclear power plant radiological protection, single-use	1000 level 3 gowns
		230 g = 104 g paper pulp, 104 g PET, 22 g LDPE film	1 gown (approximately level 3), nonwoven polypropylene, 222 g		Nonwoven polyvinyl alcohol	critical areas, polypropylene film; noncritical areas, SMS PET: 1 gown 0.243 kg
			Paper towel, 13.9 g			
Primary disposable packaging	Not defined	Not defined	Nonwoven polypropylene CSR wrap, 12.8 g	Not defined	Not defined	SSMS PP CSR wrap, 22.1 kg
						Inset paper, 3.1 kg
		Paper and LDPE, 58 g	Outer bag, half paper and half HDPE, 21.9 g			LDPE outer bag, 13.9 kg
Secondary disposable packaging						LDPE bag, 3 kg; boxboard 35 kg
Tertiary disposable packaging						LDPE film, 0.33 kg
	Not given	Total 288 g (0.63 lb.)	Total 271 g (0.60 lb.)	Total 137 g (0.3 lb.)	266 g (0.59 lb.)	Total 243 kg (535 lb.)
Allocation	Not defined	Mass in most places, system expansion for recycle of disposables	Mass allocation inferred from the databases cited	Mass allocation inferred from the databases cited	Literature values, so mass allocation is assumed	Mass allocation
Transport loop						
Reusable	Not defined	Ship to Europe (20, 000 km), truck to hospital (3000 km), truck to laundry (200 km)	Truck in China (100 km), ship to Melbourne (9617 km), truck to manufacturer (30 km), truck to laundry (30 km)	Truck from manufacture to hospital (2000 km)	Not defined	Fabric movement in US (3320 km) to Mexico and return (959 km) to distribution in US (2800 km), all truck

(*Continued*)

Table 2. (Continued)

	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2010)
Disposable	Not defined	Not defined	Ship NY to Honduras (3165 km), ship to Melbourne (18, 757 km), truck to distribution warehouse (30 km), truck to hospital (50 km)	Truck from manufacturer to port (800 km), ship to port (11, 670 km), rail to hospital (2870 km)	Not defined	Truck in China (800 km), ship to US (11, 700 km), distribution in US (2200 km)
End-of-life						
Reusables	Incineration with energy recovery	Landfill	Packaging landfill	Incineration	Not defined	Reuse as gown outside US; wastewater treatment of surgical wastes
Disposables	Incineration with energy recovery	Landfill	Packaging and gown landfill	Incineration	Dissolution, Fig. 2	Landfill of gown and surgical waste, gas capture
Other items included in life cycle						
Reusables						Water for laundry/sterilization and manufacturing
Disposables						Water for manufacturing; ethylene oxide for sterilization; lost instruments from surgery

PET = polyethylene terephthalate; ETSA = European Textile Service Association; RMIT = Royal Melbourne Institute of Technology; MnTAP = Minnesota Technical Assistance Program; CSR = central sterile room; LDPE = low-density polyethylene; HDPE = high-density polyethylene; EMAC = ethyl methacrylate copolymer; SMS = spun bond-melt blown-spun bond; SSMS PP = spun bond-spunbond-melt blown-spun bond polypropylene; NY = New York; US = United States.

are used in this review because most of their results are for this functional unit, as shown in Table 3. The RMIT report had greater transparency than the previous 2 studies, but it is limited to the discussion of the laundry and sterilization of reusable gowns. The surgical package with 2 items was not separated to provide the reader with specific gown and towel data. This is a particular problem because the gown and towel (for both disposable and reusable) are made from different materials. Most data are in percent of total energy, but the actual total is never given. In addition, detailed information on laundry and sterilization are given per kilogram fabric, but the units of the summary are per surgical package and it is unclear how these transformations of data were done.

The RMIT study found that reusable textiles, after 127 cycles, required less water (2.9 gallons per gown and towel) than disposable textiles (3.7 gallons per gown and towel), giving similar results as ETSA, as shown in Table 3. Using their sensitivity analysis, the water use of the reusable and disposables was approximately equal at 75 to 85 cycles, the more typical reuse range for such systems, although the details of the water use for the disposable supply chain were not presented. The energy use could only be quantified by back-calculating from the CO_2 (global warming) emissions, a clear example of low transparency. The reusable surgical package had lower energy requirements (8.5 MJ/gown and towel) than the disposable system (16.6 MJ/gown and towel), as shown in Table 3. RMIT determined the cumulative VOC emissions for these 2 surgical packages, when expressed as photochemical oxidation impact normalized as ethylene. The disposable surgical package was 0.46 g photochemical oxidation per surgical package, whereas the reusable was 0.16 g photochemical oxidation per surgical package, a substantially different result from the early McDowell life cycle study. The soiled gown weight compared with the clean gown was estimated by the authors and was given as 2.6 kg soiled gown/kg clean gown. This is approximately 100% larger than recent direct measurements.[46]

THE MINNESOTA TECHNOLOGY ASSISTANCE PROGRAM STUDY

Van den Berghe et al.[44] at the Minnesota Technology Assistance Program reported a life cycle study in 2010. The comparative systems were a reusable woven PET gown with low-density polyethylene laminate and a nonwoven polypropylene gown, both level 3, as shown in Table 2. The reusable gown was cycled 50 times. This study is not readily available as a report and so only slides from presentations are available for use. Results are expressed in CO_{2eq} emissions, thus these were back-calculated to estimate energy in MJ. As a result, this study currently has low transparency and very limited detailed results.

The study by the Minnesota Technology Assistance Program cataloged energy for these 2 gowns. The reusable gown was noticeably lower in life cycle energy (4 MJ/gown) than the disposable gown (13 MJ/gown). No water evaluations were included. VOC emissions were 5 times higher with disposable gowns than reusable gowns. This supports the RMIT life cycle results and does not support the McDowell life cycle results.

Table 3. Comparative Results of Life Cycle Inventory Studies of Reusable and Disposable Textiles

	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2011)
Reusables	Package, 3.7 PET gowns; 1.2 PET lap drapes, 75 cycles (no masses given); likely level 2	Gown: PET/PU (0.546 kg) 75 cycles; between level 3 and 4	Package: PET/cotton gown (0.287 kg), cotton towel (0.074 kg), 127 cycles; between level 2 and 3	Gown: PET with PE film (0.41 kg), 50 cycles; level 3	Gown for nuclear power plant radiological protection, woven nylon (0.41 kg), 100 cycles	Gown: critical areas Gore fabric, noncritical areas woven PET, 75 cycles; level 3 (0.49 kg)
		Process energy values	Process energy values			Process energy values, all based on gown use
Washer		3.2 MJ natural gas/kg clean gown, 80°C, Table 4 and Fig. 10	5.4 MJ natural gas/kg clean linen, 80°C Table 4-6			Energy improvement laundry, 1.5 MJ natural gas/kg clean gown: conventional laundry, 5 MJ natural gas/kg clean gown
		0.3 MJ electricity/kg clean gown (based on 1.55-lb. soiled linen/lb. clean linen), Table 4	0.18 MJ electricity/kg clean linen			Energy improvement laundry, 0.6 MJ electricity/kg clean gown: conventional laundry, 0.6 MJ electricity/kg clean gown
Washer water use		17.3 kg/clean gown = 2.5 gal./lb. soiled linen (based on 1.55-lb. soiled linen/lb. clean linen), Table 8	1.6 gal./lb. soiled linen based on 40% recycle of 2.7 gal./lb. soiled linen, Table 4-6		3.4 gal./lb. clean gown	2.36 gal./lb. soiled laundry = 3.6 gal./lb. clean gown
Dryer		6.6 MJ/clean gown = 12.0 MJ natural gas/kg clean gown, Table 5	3.1 MJ natural gas/kg clean linen, Table 4-8			Energy improvement laundry, 10 MJ natural gas/kg clean gown: conventional laundry, 10 MJ natural gas/kg clean gown
		0.36 MJ electricity/gown, 0.66 MJ electricity/kg clean gown	0.18 MJ electricity/kg clean linen			Energy improvement laundry, 0.4 MJ electricity/kg clean gown: conventional laundry, 0.4 MJ electricity/kg clean gown
Total laundry		15 MJ natural gas/kg clean gowns, based on 1.55-kg soiled/kg clean gown	8.5 MJ natural gas/kg clean linen, summation		3–4 MJ/kg gown	Energy improvement laundry, 12.6 MJ natural gas/kg clean gown: conventional laundry, 15 MJ natural gas/kg clean gown
		0.85 MJ electricity/kg clean linen	0.36 MJ electricity/kg clean linen			Energy improvement laundry, 1 MJ electricity/kg clean gown: conventional laundry, 1 MJ electricity/kg clean gown
Steam sterilization		0.54–4.8 MJ natural gas/kg clean linen	1.8 MJ natural gas/kg clean linen, Table 4-10		Not needed	0.44 MJ natural gas/kg clean gown
			0.09 MJ electricity/kg clean linen, Table 4-10			0.063 MJ electricity/kg clean gown
Steam sterilization water use			1.9 gal. water/lb. clean linen, Table 4-10			0.02 gal. water/kg clean linen
Wastewater treatment			0.072 MJ electricity/kg soiled linen (0.032 MJ/lb. soiled linen), Table 5-15			1.2 MJ electricity/kg soiled linen

(*Continued*)

Table 3. (*Continued*)

	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2011)
End-of-life of surgical pack or gown	Incineration with energy recovery	Incineration	Landfill	Incineration	Not included	Reused
Results		Natural resource energy[a]	Natural resource energy[a]	Natural resource energy[a]	Natural resource energy[a]	Natural resource energy[a]
Manufacture, new gown		180 MJ/kg gown, Fig. 10	1.45 MJ/gown plus towel 127 cycles = 180 MJ/surgical gown plus towel = 410 MJ/kg surgical gown plus towel, from Table 0-1 and % from Fig. 6-1	78 MJ/gown = 190 MJ/kg gown	86 MJ/gown = 209 MJ/kg gown	240 MJ/kg gown
Wash			2.3 MJ/surgical pack = 5.8 MJ/kg surgical pack		Table 2	
Dry			1.35 MJ/surgical pack = 3.4 MJ/kg surgical pack			
Sterilize			1.35 MJ/surgical pack = 3.4 MJ/kg surgical pack			
Total laundry/sterilization		23.5 MJ/kg gown	12.6 MJ/kg surgical pack	5.6 MJ/kg gown (no sterilization)		Energy improvement, 17.7 MJ/kg clean gown: conventional, 21.9 MJ/kg clean gown
Polypropylene CSR wrap manufacture			0.78 MJ/surgical pack = 2 MJ/kg surgical pack			0.67 MJ/clean gown = 1.4 MJ paper CSR/kg clean gown
Outer bag, half paper, half HDPE			0.5 MJ/surgical pack = 1.3 MJ/kg surgical pack			0.56 MJ/clean gown = 1.1 MJ EMAC outer wrap/kg clean linen
Transportation, new gown	Not included	1.9 MJ/kg gown	Incomplete	13.9 MJ/kg gown		14 MJ/kg clean gown
Energy for functional unit	5.8 MJ/gown, 16 MJ/drape	11.4–14.9 MJ/gown, 21–27 MJ/kg gown, Table 1	8.5 MJ/surgical pack = 22 MJ/kg surgical pack, summation	4 MJ/gown, 9.8 MJ/kg gown	220 MJ/gown	11.9 MJ/clean gown = 24 MJ/kg clean gown
Water		11–17 kg/gown = 2.9–4.5 gal./gown = 2.2–3.4 gal./lb. gown, Table 14	11 kg/gown and towel = 2.9 gal./gown and towel = 3.3 gal./lb. gown and towel			0.38 kg/clean gown = 0.2 gal./kg clean gown
Disposables	Package, 3.7 50% pulp, 50% spunlace PET gown, 1.2 50% pulp, 50% spunlace PET lap drape	Gown: PET/pulp (0.23 kg)	Package: PP (0.222 kg)/paper towel (0.014 kg)	Gown: polypropylene nonwoven (0.14 kg); level 3	Gown for nuclear power plant radiological protection, polyvinyl alcohol nonwoven (0.27 kg)	Gown: critical areas polypropylene film, noncritical areas SMS PET; level 3 (0.24 kg)
Results		Natural resource energy	Natural resource energy	Natural resource energy	Natural resource energy	Natural resource energy
Manufacture		120–130 MJ/kg gown	15.2 MJ/surgical pack = 56 MJ/kg surgical pack, from Table 0-1 and % on Fig. 6-5		57.5 MJ/gown = 430 MJ/kg gown	19.5 MJ/gown = 80 MJ/kg clean gown

(*Continued*)

Table 3. (*Continued*)

	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2011)
CSR wrap			Polypropylene, 0.9 MJ/surgical pack = 3.3 MJ/kg surgical pack			PP SMS, 1.5 MJ/clean gown = 6 MJ/kg clean gown
Outer bag			Half paper and half HDPE, 0.52 MJ/surgical pack = 1.4 MJ/kg surgical pack			LDPE, 0.47 MJ/clean gown = 1.9 MJ/kg clean gown
Transportation	Not included	2.6 MJ/kg gown	Incomplete	6.8 MJ/kg clean gown	Not included	20 MJ/kg clean gown
End-of-life of surgical package or gown		Incineration	Landfill	Incineration	Dissolution and wastewater treatment	Landfill
Energy for functional unit	20 MJ/gown, 42.5 MJ/drape	28–35 MJ/gown, 120–150 MJ/kg gown, Table 1	16.6 MJ/surgical pack = 61 MJ/kg surgical pack	13 MJ/gown, 95 MJ/kg gown	6050 MJ/gown	22.5 MJ/gown = 92.5 MJ/kg clean gown
Water		43 kg/gown = 11.5 gal./gown = 18 gal./lb. gown	14 kg/gown and towel = 3.7 gal./gown and towel = 6.2 gal./lb. gown and towel, Table 5-1		49 gal./lb. clean gown	0.8 kg/gown = 3.3 kg/kg clean gown = 0.4 gal./lb. gown
Environmental reduction when selecting functional unit of reusable system, expressed as % of functional unit of disposable system (based on values per gown or functional unit)	29% gown and 38% lap drape	42% nre; 32% water	51% nre, 78% water	31% nre	3.6% nre, 7% water	53% nre; 48% water

PET = polyethylene terephthalate; PE = polyethylene; ETSA = European Textile Service Association; RMIT = Royal Melbourne Institute of Technology; MnTAP = Minnesota Technical Assistance Program; MJ = megajoule; HDPE = high-density polyethylene; CSR = central sterile room; EMAC = ethyl methacrylate copolymer; PP SMS = polypropylene spun bond-melt blown-spun bond; LDPE = low-density polyethylene.

[a] nre = natural resource energy; process energy is converted to nre using factor for delivering fuel to point of use and factor for energy generated per MJ fuel, natural gas factor 1.15, electricity factor 3.44.

Table 4. Listing of Factors that Appear Missing in Life Cycle Studies of Reusable and Disposable Medical Textiles

Missing elements	McDowell[11] (1993)	ETSA[42] (2000)	RMIT[43] (2008)	MnTAP[44] (2010)	UniTech[45] (2010)	Environmental Clarity[46] (2011)
Manufacture of fabric life cycle	X			X		
Cut-sew-trim assembly	X	X		X		
Transport	X	X (unclear transport in supply chain of disposables)				
Sterilization	X	X (disposables)	X	X (disposables)		
End-of-life	X	X (reusable)			X (reusable)	
Capital equipment	X	X	X		X (reusable)	X
Packaging	X (primary and secondary)	X (secondary and tertiary)			X (primary and secondary)	
Wastewater treatment	X	X		X	X	
Dyeing and finishing		X	X	X		

ETSA = European Textile Service Association; RMIT = Royal Melbourne Institute of Technology; MnTAP = Minnesota Technical Assistance Program.

THE UNITECH CORPORATION STUDY

A fifth life cycle study was completed in 2010 by UniTech.[45] This study examined worker coveralls in nuclear power plants. These gowns do not require water permeation protection, and are thus more like medical contact precaution garments. The reusable gown is made of woven nylon, whereas the disposable gown is of polyvinyl alcohol, 2 very different fabrics from surgical gowns. The reusable gown was evaluated for 100 uses. The disposable gown is dissolved at end-of-life and managed as a liquid. In addition, no sterilization is required.

The energy life cycle comparison they completed showed 6050 MJ/gown for the disposable and 220 MJ/gown for the reusables. The water use for the reusables was 3.4 gallons/gown whereas the disposables was 49 gallons/gown. The details of water use in the supply chain were not provided.

THE ENVIRONMENTAL CLARITY STUDY

Environmental Clarity completed a life cycle study in 2011.[46] The functional unit was 1000 uses of level 3 gowns, which means 13.3 gowns were manufactured and laundered/steam sterilized 75 cycles to give a total of 1000 reusable gown uses. For the disposable system, 1000 gowns were manufactured and sterilized using ethylene oxide. The manufacturing of the reusable gown had in the critical zones of the gown a trilaminate of woven or knitted PET with a center layer of a breathable barrier film modeled after a breathable barrier film involving a 3-layer laminate with an expanded polytetrafluoroethylene film. In the noncritical zone, a woven PET fabric was used. For the disposable level 3 gown, the critical zone was spun blown-melt bond-spun blown PET with a polypropylene film barrier. This same material, without the polypropylene film barrier, was used in noncritical zones.

A separate laundry and sterilization system was analyzed for the reusable gown. Data were used for an energy-improved laundry/sterilization system and for a conventional laundry/sterilization because this is the largest contributor to the reusable gown system. For the disposable system, each gown was sterilized with ethylene oxide and the supply chain for ethylene oxide was also included.

The surgical waste (fluid, tissue, blood) was measured in the field. For the reusable gowns, the life cycle inventory includes this organic load (chemical oxygen demand) as treated in the aerobic municipal wastewater treatment plant. This life cycle inventory block included the energy and waste to return the nonevaporated water part (97.75%) of the laundry/sterilization water to regulatory-permitted condition and thus was not counted as water consumed. The reusable gown, after 75 cycles, was routinely transferred to developing countries and used as a surgical gown.

The same mass of surgical waste per gown or drape was used in the disposable system and transferred to an anaerobic landfill, where it undergoes degradation to create methane and carbon dioxide. A general US profile of gas capture and no gas capture at landfills was used to assess the impact of the degradation of the surgical waste in this life cycle inventory. The disposable gown is essentially nondegradable polymer and so only the energy of landfilling a unit weight of gown plus decomposition of surgical waste were included.

Medical instruments are routinely lost in the OR after the patient leaves. These were measured in the field. In the case of reusables, these were returned to the health care facilities. However, in the disposables life cycle inventory study, these instruments were manufactured as replacements for the instruments that were lost to the landfill. The life cycle inventory of these instruments was added to the disposables case.

The study also included the transportation of all the chemicals in the supply chain as well as the fabric going to cut, sew, and trim during manufacturing and then to the hospitals as separate items for both reusable and disposable life cycle inventory.

The energy of the full cradle-to-end-of-life analysis of the 1000 disposable gown uses (1000 gowns) was 22,500 MJ, whereas for the 1000 reusable gown uses (13.3 gowns laundered 75 times) of the reusable system, the energy was 11,900 MJ. Similarly, the water use (not returned to surface water, known in the water footprint literature as blue water) for the 1000 gown uses was 800 kg for the disposable gowns and 385 kg for the reusable gowns.

Direct life cycle measurement of the manufacture for radiofrequency identification (RFID) devices to track the

number of reusable cycles was not made, but a published literature source for a 32-MB DRAM chip was found.[47] The life cycle for the microchip was 40 MJ/chip, which for 1 RFID per gown is 40 MJ/reusable gown/drape. Using the transparent Environmental Clarity life cycle analysis, the basis of 1000 gown uses is 12,530 MJ with RFID (before accounting for chip recycle) versus 22,500 MJ/1000 disposable gown uses. Without the life cycle of the RFID chip, the respective energy values are 11,900 MJ and 22,500 MJ, thus indicating that the tracking feature does not substantially change the life cycle results. In addition, the RFID tracking chips are virtually 100% recycled into new gowns and drapes (no observable loss in RFID function over 2 decades). Therefore, the greenhouse gas effect of these RFIDs on the gown or drape carbon footprint or other environmental impacts is essentially zero.

For the environmental life cycle, the 6 studies on reusable versus single-use gowns and drapes present a consistent set of results. There is a significant life cycle difference between these alternatives. First, when comparing reusables with disposables, the energy requirement for reusable perioperative textiles is approximately 30% to 50% of the energy (expressed as natural resource energy, which is the sum of all fuel energy needed to deliver energy to the point of use, convert the fuel into usable energy, and consume the energy in the manufacturing or other processes). Said differently, the disposables are 200% to 300% higher in energy usage. When water use needed in manufacturing is added to water required for laundry and sterilization, disposable textiles consume 250% to 330% more water than comparable reusable textiles. Only the earliest life cycle inventory study deviates from these findings,[11] but that study is compromised by numerous errors that are corrected by the evidence of the other independent life cycle inventory results. Specifically, the volatile organic carbon emissions and water consumption are in fact lower with reusable systems than reported by McDowell[11] for the 1993 study. The transparent database of the Environmental Clarity study[46] has improved life cycle analyses of single-use and reusable surgical textiles, and will help identify hybrid (reusable and disposables combined) surgical packages to provide the health care market with the best alternatives.

JOBS

An interesting comparison of reusable and disposables has been the relation to jobs and employment.[2,38,48] However, no comprehensive study of jobs for reusable and disposable alternatives was found at this time. Those studies that included local jobs as a factor in comparing reusable and disposables identified that reusable laundry, assembly, and transport steps provided more jobs than the disposable alternatives. Mittermayer[2] even classified the jobs as local and hence an attribute to differentiate the gown and drape alternatives. At this time, because there are no comprehensive labor studies, this current review only identifies jobs as a potential dimension for comparisons of reusables and disposables.

CONCLUSION

Reusable and disposable gowns and drapes meet new standards for medical workers and patient protection, use synthetic lightweight fabrics, and are competitive in price. Reusable surgical textiles offer substantial sustainability benefits over the same disposable product in energy (200%–300%), water (250%–330%), carbon footprint (200%–300%), volatile organics, solid wastes (750%), and instrument recovery. This has now been verified in all 6 available life cycle studies. Other factors including cost, protection, and comfort are reasonably similar. The large environmental sustainability benefits of reusables allow nurses, physicians, and hospitals to make substantial improvements for this industry. It is no longer valid to indicate that reusables are better in some environmental impacts and disposables are better in other environmental impacts. The uniformity of life cycle results from multiple studies over the past decade may reduce the need for future studies of perioperative textiles and shift interest to other reusable OR medical products, such as laryngeal mask airways and suction canisters.

DISCLOSURES

Name: Michael Overcash, PhD.
Contribution: This author designed the study, conducted the study, analyzed the data, and wrote the manuscript.
Attestation: Michael Overcash approved the final manuscript.
This manuscript was handled by: Steve L. Shafer, MD.

ACKNOWLEDGMENTS

This study was designed with input from a team of firms responsible for surgical disposables and reusables (Lac-Mac, Medline, W. L. Gore & Associates, and SRI Surgical). Funding was from W. L. Gore & Associates and SRI Surgical. This review was substantially improved by inputs from the Association of the Nonwoven Fabrics Industry (INDA), Textile Rental Services Association of America (TRSA), and the American Reusable Textiles Association (ARTA). The perspective of both the single-use and the reusable communities has been committed to scientific, transparent results.

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IMPLEMENTATION MODULE:

Moving (Back) to Reusables in the OR

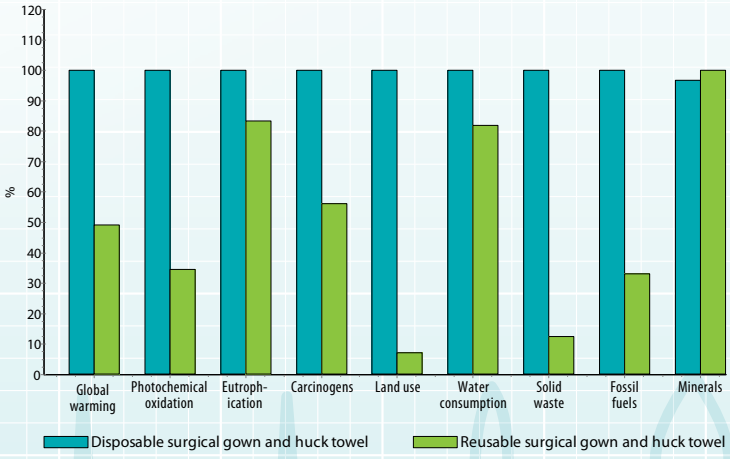
Revisiting Reusables

When considering how to reduce the environmental footprint of the operating room, it makes sense to first revisit the old adage of Reduce-Reuse-Recycle. This common sense approach relies on the concept of avoiding use of materials or supplies that are not needed to protect or ensure patient or worker safety (reduce), using a reusable, preprocessed or reposable option where a product must be used, and where no reusable option is available ensure the product is recyclable. The most environmentally unfriendly option is a single-use, disposable product that cannot be recycled at the end of use. When undertaking a comparative analysis, surgical services managers need to consider the lifecycle costs of disposable items beyond first cost.[1,2]

Much of the waste generated in the operating room (OR) is due to the myriad of disposable products and packaging used for surgery. Perioperative professionals today primarily use disposable basins, towels, surgical drapes, table covers and gowns,[3] in addition to a variety of other single-use, disposable medical supplies—many or all of which inevitably end up in the waste stream. Though surgical linens and basins were historically reused and reprocessed or laundered onsite, concerns about quality and appropriate levels of barrier protection largely transitioned the market to disposable textiles and basins. Surgical gowns and textiles can be classified as either single-use (disposable) or multi-use (reusable) and are classified as medical devices by the US FDA.[4,5] Surgical gowns, drapes, sheets, table covers and mayo stand covers can be classified by the Association for the Advancement of Medical Instrumentation's (AAMI) liquid barrier performance standard (AAMI PB 70)[6] for protective apparel and drapes into four levels of barrier performance. Both reusable and disposable product manufacturers can utilize this standard for classifying the level of performance for their products and both offer products which meet all levels. A variety of factors are now leading hospitals to reconsider the use of reusable surgical gowns, surgical textiles and basins.

Disposable surgical gowns, towels, back table and mayo stand covers are routinely disposed of as regulated medical waste after a single surgical procedure as opposed to reusable textiles which create very limited packaging waste and are typically reused 75 times or more.[7] One study found that when these disposables were replaced with reusable products, there was an average of 64.5% reduction in surgical waste generated.[8] An Australian life cycle assessment from November 2008 demonstrated the environmentally intensive footprint of disposable versus reusable textiles (see Figure 1).

Figure 1: Comparison of life cycle factors of disposable textiles compared with reusable textiles.[9]



Beyond their environmental impact, disposable gowns and drapes often get negative feedback from surgeons and surgical technologists for thermal comfort issues, tearing—as in the case of the back table cover where surgical techs often use an extra drape to prevent tearing on the back table,[10] and size—disposables are often smaller than reusable products which can lead to additional draping to weigh down the edges.[11] When surgeons were asked in a 2010 study to rate gown comfort, ease of use and protective properties of reusables versus disposables, they found surgeons clearly preferred the reusables:

Figure 2: Surgeons' Preference for Disposable and Reusable OR Supplies[13]

	Superior	Good	Fair	Poor
Gown Comfort				
Disposable	6%	38%	23%	33%
Reusable	86%	10%	4%	0%
Ease of Towel/Gown Use				
Disposable	33%	47%	19%	1%
Reusable	87%	11%	2%	0%
Protective Properties of Gowns				
Disposable	30%	45%	20%	5%
Reusable	96%	6%	2%	0%

The same study found that the process to order and deliver sterile disposable products actually had six additional handling steps as opposed to using a service provider to deliver reusable products.[14] While reusable textiles typically have a higher first cost than disposables, perioperative services should be evaluating all of the steps in the supply chain as well as waste disposal costs in order to look at a one-to-one comparison. When you consider all the data, the cost-benefit for reusables becomes clearer.

For perioperative professionals that have been in the business for awhile, talking about reusable surgical gowns may conjure up images of the once-tried and true cotton and poly-cotton gowns laundered onsite. But today's reusable textiles are not those of twenty years ago—they are technologically advanced textiles that have been tested to meet barrier performance standards and refined to provide optimal clinician comfort and ease of use. How then does a facility make the case to transition back to reusables utilizing a service provider, and operationalize the change? There are several finite steps an organization can follow to make a move to reusable surgical gowns, towels, sheets, back table and mayo stand covers and basins.

Reusables: In-House or Vendor?

There are some significant differences between choosing to utilize a vendor to provide reusable textiles, and choosing to go back to laundering and sterilizing reusable textiles in-house. The environmental impact of laundry operations can be significant. If a hospital is not able to upgrade aging infrastructure for its laundry operations to take advantage of water and energy efficiencies, as well as transitioning to more environmentally friendly laundry chemicals, the environmental impacts of the laundry operation can sometimes challenge the environmental preferability of reusable surgical textiles. Pair this with the fact that hospitals then become responsible for ensuring that surgical textiles are all classified correctly, sterilized appropriately, and repaired or replaced in a timely manner and the business case can be complicated. When paired with an environmentally progressive laundry operation and top-notch SPD staff, reusable surgical textiles processed in-house can make sense but one definitely needs to take additional factors into consideration. This implementation module focuses specifically on making the business case for the use of reusable surgical textiles and basins via a vendor rather than processing reusables in-house--with additional research to come on identifying the right mix of factors to champion onsite processing of reusable surgical textiles.

Step 1. Identify your Allies: Infection Prevention

Changing practices sometimes means changing minds. Before you work on rolling out reusable surgical gowns, towels, sheets, back table and mayo stand covers and basins, think about what the arguments against a transition to reusables might be. Reach out to your Infection Preventionist (IP). Share the literature available demonstrating that reusable surgical linens meet the AAMI liquid barrier performance standards for protective apparel and drapes. Understand any concerns your organization's IP may have and address them one at a time, gathering data from Practice Greenhealth, reusable textile vendors, the American Reusable Textile Association or others. IPs can be your greatest ally in this transition as patient safety concerns trump just about any other issue. Reach out to OR leadership and let them know you are trying to learn more about the benefits of reusable textiles and ask if they will support you in gathering additional information for consideration.

Step 2. Develop a Baseline for Use of Disposables

Before being able to make the case for a transition to reusables, it is important to be able to quantify how disposables are impacting the OR and the environment. You're going to want to understand:

- **What is the volume of custom packs that the OR uses each month?** Materials Management or OR management should be able to provide you with data on the number and kinds of custom OR packs being utilized by the department.
- **What disposable textile products are part of each kind of custom pack used by the OR?** You may have to audit different packs in order to correctly identify disposable textile components in each packs. You'll want to quantify disposable surgical gowns (by performance level), towels, back table and mayo stand covers, sheets and basins in each kind of pack.
- **How much do the disposable textiles and basins found in each pack weigh?** Once you have itemized the contents of each kind of pack, gather a sample set of disposable textile supplies and basins and gather using the different combinations just gathered for the different custom packs, weigh the number of disposable textile and basin items in each pack. Multiply these weights times the number of that kind of pack utilized each month by the OR. This data should provide you with a fairly accurate assessment of the volume of disposable textiles (in pounds) leaving the hospital each month.
- **How are disposable textiles currently being disposed of?** Also relevant to this baseline is determining whether all disposable textiles and basins are currently being disposed of as regulated medical waste—as is often common practice. If your organization has a strong RMW segregation program and is segregating disposable textiles and basins as solid rather than medical waste, it will impact your baseline cost assessment. Reach out to Environmental Services and determine what the hospital is spending per pound to dispose of RMW and/or solid waste. Multiply your total weight of disposable textiles and basins each month by the cost per pound to dispose of it to get a total waste management cost of disposable textiles for the OR. This is the money the organization will avoid spending on waste disposal if it moved to reusable surgical textiles and basins.
- **What are the line item costs for disposable textiles in custom packs—if available?** In order to do a comparison, you need to have a sense of how much the disposable textiles and basins are costing your organization. Because there are other disposable products in the custom packs that won't be eliminated by a transition to reusable textiles and basins, it is important to try and identify pricing for just the disposable textiles and basin items rather than estimate the total cost of the custom pack. Be sure to capture any handling, packaging or sterilization costs that may be added following the line item pricing. Multiply the cost for disposable textiles in each pack by the number of packs of that type utilized by the OR each month to get a total supply cost for disposable textiles in the OR. Also be sure to understand if there are common practices that would add to that supply cost, e.g. staff double drape the back table for each procedure or are lining the back table with towels to prevent holes, and have ordered extra back table covers or towels separately for this purpose. These additional supply costs should be figured in to the total.
- **Are there any other factors to consider about current use of disposable textiles?** Inquire with staff whether they have any ongoing concerns about the use of disposable textiles in custom packs. Do the gowns make them too hot—requiring additional cooling for the OR? Too cold—requiring reheat for the OR? Are they uncomfortable? Reach out to Central Supply or Sterile Processing to determine how many steps your organization currently has in place to order, receive, handle and deliver sterile disposable supplies to the OR.
- **Determine total costs for use of disposable textiles in the OR each month.** Add the total waste management costs for disposable textiles to the total supply costs for disposable textiles to get the total current baseline cost for the use of disposable textiles in the OR. Make a note of other intangible drawbacks or benefits to the use of disposable textiles in custom packs and keep supply handling steps for disposable textiles for comparative purposes.

Step 2. Reach out to Reusable Surgical Supply Vendors/Reprocessors

The next step is to understand what alternatives are available to replace the use of disposable textiles and basins in custom packs. Get a sense of what different vendors are offering. Understand if they provide their reusable textiles as a stand-alone offering or if they partner with a disposable kit manufacturer to also provide custom packs. Some reusables vendors/reprocessors have unique partnerships with disposable custom kit manufacturers where reusable textiles are provided as part of a disposable custom kits.[15] Are they able to deliver the sterile reusable surgical textiles to your OR each day? Determine the steps that would need to be taken by the Sterile Processing Department or Central Supply to order, receive, handle and deliver sterile reusable supplies to the OR. If providing just-in-time inventory, what is the back-up plan were a truck to be delayed or diverted? Get pricing estimates for similar volumes of reusable textiles to replace the disposable textiles currently being used. Ensure any additional hauling or fuel surcharges are captured in the total price point.

Step 3. Compare Disposable vs. Reusable Textile Costs and Process

Line up the baseline supply costs for disposables against the projected costs for the replacement reusables. Factor in waste disposal costs for disposables. While the costs for disposing of disposable textiles does not usually show up in the budget of the OR (as waste management costs are typically charged centrally to Environmental Services), it is a cost to the bottom line of the organization. See sample cost comparison below.

Disposable Surgical Textiles and Supplies	**Reusable Surgical Textiles and Supplies**
Total Supply Cost for Disposable Surgical Textiles and Supplies in existing OR custom packs monthly	Potential Supply Costs for Reusable Surgical Textiles and Supplies to replace Disposables
Any additional supply costs for a la carte disposable textiles, basins, pitchers for OR monthly	Any additional supply costs for a la carte reusable textiles and supplies for the OR monthly
Total pounds of waste generated by disposable surgical textiles and supplies from OR monthly	Savings from recovered instruments—estimated for a typical hospital at upwards of $20,000 per year.
Total costs for managing disposables as RMW or solid waste each month	$0
Total Costs of Using Disposable Surgical Textiles and Supplies	**Potential Costs of Using Reusable Surgical Textiles and Supplies**

You should now be able to lay out the case for why a transition to reusable surgical gowns and textiles makes sense financially and environmentally. The next step involves getting feedback from staff on the comfort, ease of use and protective qualities of disposable versus reusable textiles in the OR. Note: the cost-benefit analysis might be so compelling at this point that OR leadership might be willing to consider a transition. If you have a sense that there may be clinician resistance to a transition, include Step 4.

Step 4. Pilot Reusable Surgical Textiles

To allay any concerns about transition to a new product in the OR, it makes sense to pilot new products before moving forward with a full-scale roll-out. Pull together a small team to work on running the pilot project and get approval from surgical services leadership before proceeding. Based on initial cost-comparison numbers, they will likely agree to support a pilot. Determine a reasonable pilot period—one to three days midweek would likely hit many of the surgeons on staff as well as other clinical staff.

Perioperative staff utilizing reusable surgical gowns to perform surgery.

Work with a reusables vendor to provide product for pilot period. Determine questions you will be asking OR staff after the using the reusable products and document in a simple questionnaire. Work with a small team to set up exact pilot procedure. A 2010 study highlighted in the AORN Journal[16] provides a good working model to start from. Pilot steps include:

1. Announce the pilot project and let surgical staff know they are being asked to participate and provide feedback.
2. From baseline development in Step 2, you should already have weights for disposables in each custom kit. This will be the amount of waste avoided when reusables are used.
3. Replace all disposable textiles and previously agreed upon disposable supplies (e.g. basins) with reusable versions.
4. After surgery, ensure reusable textiles and supplies are captured for reuse.
5. Provide each surgical team with review questions. (Referenced study asked surgeons to rate gown comfort, gown and towel ease of use and gown protective properties. Simultaneously, they were asked to rate the disposable products they typically work with).
6. Allow space for other kinds of feedback and commentary about pros or cons of reusables versus disposables.
7. Tally results and write up for management review.

If your results are similar to other studies, you should see increased clinician satisfaction and positive feedback. This, in addition to the cost-benefit analysis, should be the linchpin in moving the organization to reusable surgical textiles and supplies. Be sure to utilize other factors in your case for reusables including improved surgical supply inventory process and lost instrument return—the latter a huge cost-savings for the organization.

Step 5. Coordinate Chain of Custody for Reusables

Once the transition to reusables has been approved by OR leadership and a vendor has been selected, it is critical to work with the vendor/reprocessor, materials management, central supply and/or the sterile processing department to determine the appropriate chain of custody for the reusable textiles and supplies. Sterile reusables packs configured per the hospital's requirements should arrive in SPD each day. SPD personnel pull packs for case carts which then make their way down to the ORs. Unlike disposables, these products do not leave the OR in waste receptacles. Instead, the vendor should supply liquid-proof, color-coded bags or totes in which used reusable items should be placed after surgery. The bags or totes of used reusable surgical products are then moved to a predetermined designated pick-up point for vendor to transport to reprocessing plant. Because these steps have not previously been utilized with the disposable products, it is important to ensure that all of the details are addressed and a plan is in place for handling the soiled products before training the OR and SPD staff.

Step 6. Train OR Staff on Use and Collection of Reusables

Once the supply handling and collection procedure has been finalized, it is time to educate perioperative staff on appropriate practices for using reusables. Education should be provided on the differences between the levels of protection for the different reusable products, and which products should be used for which procedures. Surgical set-up should remain consistent, but breakdown after the surgery will require some practice changes. Hold In-Services to educate staff about the new reusable products being rolled-out. Ensure they understand the collection procedure for these reusable items and the need to sort reusable items from the disposable items. Help staff understand that throwing out reusable products will not be considered acceptable as this runs counter to the idea of reducing waste and adds to the overall cost. Hold a more in-depth training and troubleshooting session with a volunteer from each shift to ensure each knows collection procedure inside and out and can guide other members of the surgical team on the correct procedure if need be. Partner with the vendor to provide the most comprehensive and useful training. Vendor training capacity and support should be written into the sales contract where possible.

Step 7. Collect Post-Implementation Evaluation and Address Concerns

It may be meaningful to consider doing an evaluation about a month or two after implementation of the reusable textiles and supplies. This could be as informal as asking around or as formal as a short written feedback request asking again about comfort, ease of use, protective properties and any other benefits and/or concerns. Be sure to check in with SPD as well as OR staff. Carefully review concerns. Expect that there will be some negative feedback—as is typical in any major product transition. Do your best to determine whether these are isolated complaints or a consistent theme that needs to be addressed. Troubleshooting is part of any product replacement.

Step 8. Track Savings and Environmental Benefits and Celebrate Success

Tracking cost-savings and waste avoidance provides a way to demonstrate the benefits of the transition back to the organization. Some vendors will actually track avoided costs of disposables and waste generation for you. They can compare the volume of products you are currently using to the weight and costs of the disposable alternatives and provide you with accurate benefit figures. In other cases, you may need to collect some of this data yourself. Reach out to EVS and see if they have a way to track RMW reductions in the OR. Use purchasing records to determine supply costs. Be sure to share positive data with staff. You can also use this as an opportunity to share positive feedback from the post-implementation survey. Make sure the organization's sustainability leader or green team (if applicable) knows about the success the OR is having, and includes it in any award applications or recognition opportunities. It is important to let staff know that they are making a difference—not only in the financial viability of the organization, but also by better protecting the environment—which is intrinsically connected to human health. Success in one arena can often build momentum to tackle the next—seemingly more difficult—challenge.

For More Information: Go to www.GreeningTheOR.org for a list of key resources that can assist you in this program area. Because this list is updated often, we keep it online, so as not to date this implementation module. Also available are case studies on replacing disposables with reusables in the OR. Learn from your peers!

Endnotes

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Reducing Medical Waste

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ABSTRACT

Medical waste is a necessary by-product of any hospital environment; however, the majority of regulated medical waste is produced in the OR from the use of disposable surgical supplies (eg, drapes, gowns, basins, gloves, sponges). We conducted a concept comparison project in the ORs of two large medical centers in Bethesda, Maryland, and Washington, DC, to evaluate the effects of using reusable surgical basins, gowns, and table and Mayo stand covers in place of disposable products. Survey results indicated that surgeons and surgical technologists found the reusable products to be preferable to the disposable products currently in use. In addition, using reusable products provided a means to decrease regulated medical waste generated in the OR by an average of 65% as well as reduce the cost of waste disposal. AORN recommends evaluating the environmental effects of using reusable, reposable, and disposable products; our findings provide evidence that may be useful to surgical facilities that seek to adopt a "green" approach. *AORN J* 91 (June 2010) 711-721. © AORN, Inc, 2010. doi: 10.1016/j.aorn.2009.12.029

Key words: *medical waste, regulated medical waste, waste management, reusable supplies, disposable supplies, gowning and draping material, surgical supply management, greening the environment.*

Medical waste is a necessary by-product of any hospital environment. According to Health Care Without Harm, 4 million tons of general waste are produced by health care facilities in the United States each year.[1,2] Disposing of this waste accounts for approximately 20% of a hospital's environmental services budget.[3]

The recommended standard for the percentage of regulated medical waste in health care facilities is 15% or less of overall waste[4]; however, researchers have found that many facilities dispose of up to 70% of waste as regulated medical waste.[4,5] A major source of the waste produced in the OR is disposable surgical supplies.[6] These supplies include surgical drapes, gowns, basins, gloves, and surgical sponges. In an effort to reduce the waste stream, AORN recommends evaluating the "environmental impact of reusable, reposable, and disposable products."[7(p534)] Perioperative personnel today primarily use disposable basins, towels, surgical drapes, table covers, and gowns packaged in custom packs and as individually packaged supplies. The majority of these supplies become regulated medical waste. Waste generation is directly related to the purchase and supply practices in each surgical treatment location. Surgical facilities that seek to adopt a green approach should meticulously examine purchasing practices, inventory delivery, and handling and

doi: 10.1016/j.aorn.2009.12.029

space requirements, as well as the weight and volume of normal and regulated medical waste that leaves the OR.[5]

In an ever-changing surgical environment, perioperative leaders are charged with making sound decisions to establish a safe and fiscally responsible environment for patients and employees. AORN recommends that perioperative nurses actively promote and participate in resource conservation.[2,7] We conducted a project to evaluate whether reusable supplies would meet the same high standards as disposable supplies and reduce the regulated waste stream in two ORs.

THE ORIGIN OF THE WASTE STREAM

Waste issues begin in the purchasing department where materials are purchased that eventually become waste that requires disposal.[5,6] Reducing the amount of normal waste and regulated medical waste in an OR can appear to be an insurmountable task; however, there are numerous ways to reduce waste (eg, reducing, reusing, recycling). One option to consider for reducing regulated medical waste is to reduce the purchase of disposable surgical materials. Perioperative supply management includes considering the "impact of the item on the waste stream when purchasing supplies and equipment."[2(p713)] This is crucial to the reduction of regular and regulated medical waste and is one way in which AORN recommends conserving and managing supplies.

Practice Greenhealth, an organization that supplies information about environmental practices in health care, recommends adding the purchase price of an item to the cost of its waste disposal, occupational health costs, environmental impact, and warehousing costs to determine the ultimate cost of purchasing the disposable medical item.[8] In addition to proper segregation of waste materials, which can reduce costs, a method that aids in decreasing regulated medical waste is the use of reusable products, such as surgical gowns, linens, and basins.

SURGICAL DRAPES AND GOWNS

Surgical draping refers to practices used to create a sterile field during surgical procedures. Draping is based on aseptic principles[9] and includes the use of sterile drapes placed on the patient as well as surgical scrub gowns, back table covers, and Mayo stand covers. The proper selection of draping materials is an important aspect of surgical draping. The collective use of these materials creates a sterile barrier between the surgical field and possible sources of contamination, and protects the surgical team from exposure to bloodborne pathogens.[9] The choice of surgical gowning and draping materials should be grounded in the physical attributes of the materials; however, other factors must also be considered, including the environmental effects of disposable versus reusable products. AORN provides guidance on environmental responsibility[2,7] and recommended practices for the selection and use of surgical gowns and drapes[10] to help with this process.

Surgical drapes and gowns are manufactured as single use (ie, disposable) or multi-use (ie, reusable) products and are classified as medical devices by the US Food and Drug Administration (FDA).[11] As such, all surgical drapes and gowns chosen should be appropriate for the anticipated use and must meet strict FDA regulations and criteria to be used as surgical barriers. AORN's "Recommended practices for the selection and use of surgical gowns and drapes," states that "Surgical gowns should be selected for use according to the barrier quality of the item and the wearers' anticipated exposure to blood and body fluids."[10(p127)] The Association for the Advancement of Medical Instrumentation's (AAMI) liquid barrier performance standard for protective apparel and drapes[12] and technical information report on selecting and using protective apparel and drapes[13] are excellent tools to help perioperative personnel determine the level of protection required. The AAMI outlines four categories of barrier materials for surgical materials:

- Level 1 – liquid resistant (ie, inhibits penetration of liquid), used for simple procedures when blood loss is expected to be at a minimum;
- Level 2 – liquid barrier (ie, prevents visible penetration of liquid), used for procedures when fluids may present a problem;
- Level 3 – microbial barrier (ie, prevents penetration of microbes), used for procedures when bacterial contamination is expected; and
- Level 4 – liquid proof (ie, prevents penetration of liquids and microbes), used for procedures during which the surgeon's hands will be in a body cavity.[12,14]

These categories have proven useful in determining the barrier effectiveness of surgical draping and gowning materials. Two tests described by ASTM International (formerly the American Society for Testing and Materials) in standards ASTM F1670 and ASTM F1671 were developed to evaluate surgical linens for viral and liquid penetration, and are used to determine whether materials perform to Level 4 standards.[12,14] The tests are used to detect the penetration of synthetic blood and viruses, respectively.[12,14] The results of these tests are considered by both the AAMI and the FDA to be the only acceptable measurement for determining Level 4 barrier performance.[13]

Further guidance has been provided by the Occupational Safety and Health Administration's *Bloodborne Pathogen Final Rule* to reduce exposure through the use of barrier materials that do not allow penetration of blood or fluids.[15] By using these criteria, for our project we chose reusable products that could substitute for disposable products already in use, to determine whether we could reduce the amount of regulated medical waste.

CONCEPT COMPARISON PROJECT

We (ie, a group of one faculty member and three perioperative graduate students) conducted an exercise in two major medical centers in Bethesda, Maryland, and Washington, DC, to examine the effects of substituting reusable products for the disposable surgical gowns, back table covers, towels, Mayo stand covers and basins, bowls, and pitchers provided in the custom packs used at both facilities. We compared the amount of waste generated when disposable items were used with the waste generated when similar reusable items were used. We also compared the number of process steps required in the supply chain for disposable items with an alternative practice of using nondisposable supplies. In addition, we looked at the acceptability of alternative, nondisposable, sterile products to surgeons and surgical technologists who work at these two facilities. This exercise was an independent academic project and was not sponsored or endorsed by manufacturers of either disposable or nondisposable products.

Concept Comparison Questions

We asked the following questions:

- Could personnel efficiencies be improved through an alternative purchase practice for surgical packs that included nondisposable gowns, towels, Mayo stand covers, back table covers, and surgical basins?
- How would surgeons and surgical technologists rate alternative sterile, nondisposable products compared with the disposable products currently in use?

We measured the regulated medical waste from 12 surgical services at two hospitals. The surgical services that participated in the evaluation were cardiovascular, dental, general surgery, gynecology, ophthalmology, orthopedics, otolaryngology, pediatrics, plastic surgery, podiatry, urology, and vascular surgery.

Project Strategy

We used a convenience sample for the selection of the surgical procedures based on the daily schedules at the two hospitals. Fifty-nine surgical

TABLE 1. Participating Surgical Specialties

Surgical service	Number of procedures	
	Facility A	Facility B
Cardiovascular	0	1
Dental	1	0
General surgery	12	16
Gynecology	8	11
Ophthalmology	8	8
Orthopedics	10	13
Otolaryngology	1	4
Pediatrics	1	2
Plastic Surgery	3	3
Podiatry	5	0
Urology	5	1
Vascular	5	1
Total procedures	**59**	**60**

procedures were completed at Facility A and 60 surgical procedures were completed at Facility B, for a total of 119 procedures (Table 1). We measured the regulated medical waste from each surgical procedure.

We obtained consent from the surgical administrative staff at the two facilities before the comparative information collection phase. A local FDA-regulated facility that provided the nondisposable surgical products partnered with the student team to supply 120 sterile reusable packs for the purposes of the project. They provided daily pick up and delivery of the reusable products. We provided a precomparison opportunity for staff members to see and feel the gowning and covering materials at both surgical facilities. This provided an introduction to the reusable product and an opportunity for the students to explain the concepts of the data collection for the comparison. A representative from the nondisposable product facility was present and available to answer questions that pertained to the products and the sterilization validation process and to confirm that the products met the FDA requirements for sterilization at each facility.

The practice at both facilities was to use additional draping material over the disposable back table cover. When we asked staff members to describe the rationale for adding the additional disposable half-sheet on the back table, staff members stated that this practice was to prevent inadvertent puncture of the disposable back table drape. We asked staff members to change their current practice for purposes of this exercise and refrain from placing a second drape on the back table and Mayo stand. The reusable back table drape was impermeable and did not require additional draping material to prevent drape punctures.

During the precomparison procedures, we

- preweighed all disposable surgical custom packs before the start of each surgical procedure at each facility;
- preweighed single-use items, which included the back table cover, gowns, Mayo stand cover, a pack of hand towels, a disposable plastic emesis basin, a large basin, and a pitcher, to accurately reflect the added weight when these items were added to the sterile field during a procedure;
- assembled the contents of two nondisposable comparison packs and sterilized them at the FDA-approved facility;
- ensured that minor procedure packs (eg, for hernia repairs; minor ear, nose, and throat procedures) contained
  - Level 2 gowns,
  - towels,
  - a Level 4 back table cover,
  - a Level 4 Mayo stand cover,
  - a metal emesis basin, and
  - a metal pitcher; and
- ensured that major procedure packs (eg, for mastectomies, arthroscopic procedures) contained
  - Level 3 gowns,
  - a Level 4 back table cover,
  - a Level 4 Mayo stand cover,

Figure 1. Example of an open sterile nondisposable pack used for the concept comparison tests. *Photograph courtesy of Col George Nussbaum.*

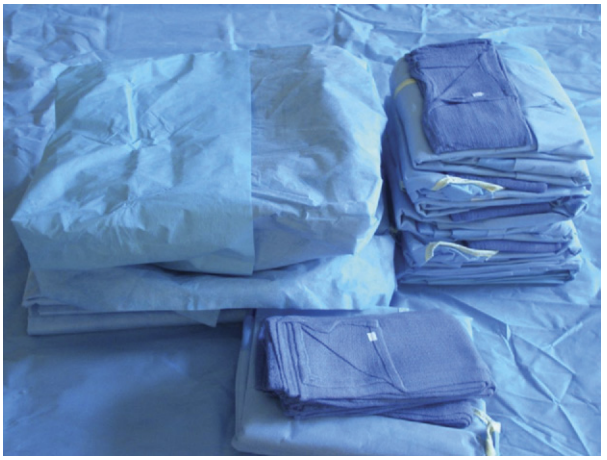

Figure 2. Example of an open sterile disposable pack used at the facilities. *Photograph courtesy of Col George Nussbaum.*

- towels,
- a metal emesis basin,
- a metal pitcher, and
- a large metal basin.

During the concept comparison exercise, we

- opened a sterile, reusable (ie, nondisposable) pack on to the back table (Figure 1) and opened a facility-specific custom pack of disposable products (Figure 2);
- asked the surgical technologist to transfer items that were needed for the surgical procedure from the disposable custom pack to the surgical back table in a sterile manner (Figure 3); and
- removed and weighed all remaining disposable gowns, towels, basin ware, and back table covers items (Figure 4).

We were present for all 119 comparative procedures and were available to provide direction in opening of the reusable products, clean up, and proper removal of the reusable products from the OR at the end of the procedures. We recorded all data at the end of each day to account for the amount of medical waste from each procedure.

After the comparative exercise, we administered a questionnaire to the surgeons and surgical technologists, which asked them to compare the current disposable products to those used during the exercise with regard to satisfaction with comfort, ease of use, and protective properties. The project team collected data from all participants and recorded all responses for each facility. On a scale of 1 to 5 in which 5 = superior, 4 = good, 3 = fair, 2 = poor, and 1 = unacceptable, surgeons were asked to rate the disposable surgical gowns for comfort, ease of use, and protective properties and to rate the comparison (ie, nondisposable) surgical gowns for comfort, ease of use, and protective properties. Surgical technologists were

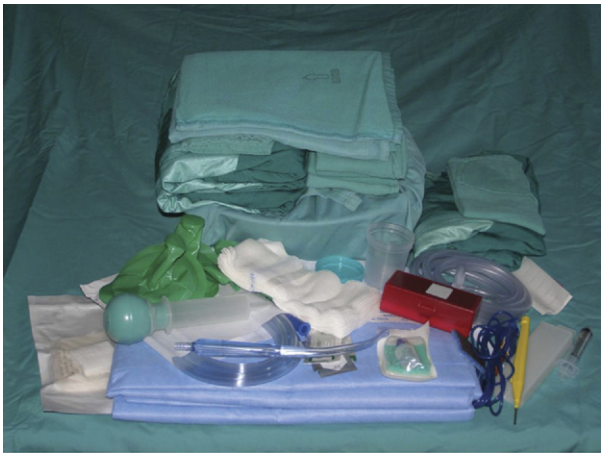

Figure 3. Required disposable items transported to the back table with nondisposable items. *Photograph courtesy of Col George Nussbaum.*

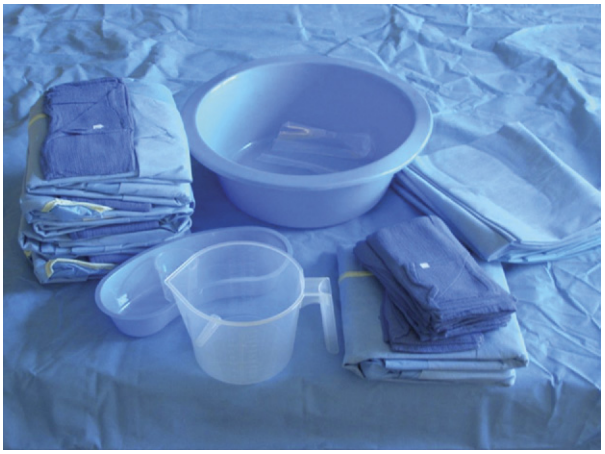

Figure 4. Disposable items replaced by reusable products. This represents the items that normally enter the surgical waste stream. *Photograph courtesy of Col George Nussbaum.*

also asked to rate the disposable and reusable gowns for comfort, ease of use, and protective properties, and, in addition, they were asked to rate disposable versus reusable back table covers, Mayo stand covers, and basins.

CONCEPT COMPARISON RESULTS

We weighed and recorded the surgical waste generated by both facilities. For the purposes of this concept comparison, we intentionally did not include liquid waste because it did not factor into the use of disposable or nondisposable gowning and draping materials. We calculated the weight that would have entered the waste stream for any additional disposable surgical item that was added to the procedure or substituted for a nondisposable product during each procedure performed, thus each procedure served as its own control.

Surgical Supply Inventory Process

We explored current practices in the surgical supply purchase and inventory process. The steps required at both facilities to obtain surgical products before surgical procedures were similar, with variances only in the names of the departments that ordered and provided supplies (eg, surgical processing department versus central supply). For the hospitals' current practice, we identified a total of 10 steps from the time of supply ordering to supply arrival in the OR for the surgical procedure (Figure 5). In contrast, there were only four steps required to order surgical supplies when using the alternative practice (Figure 6).

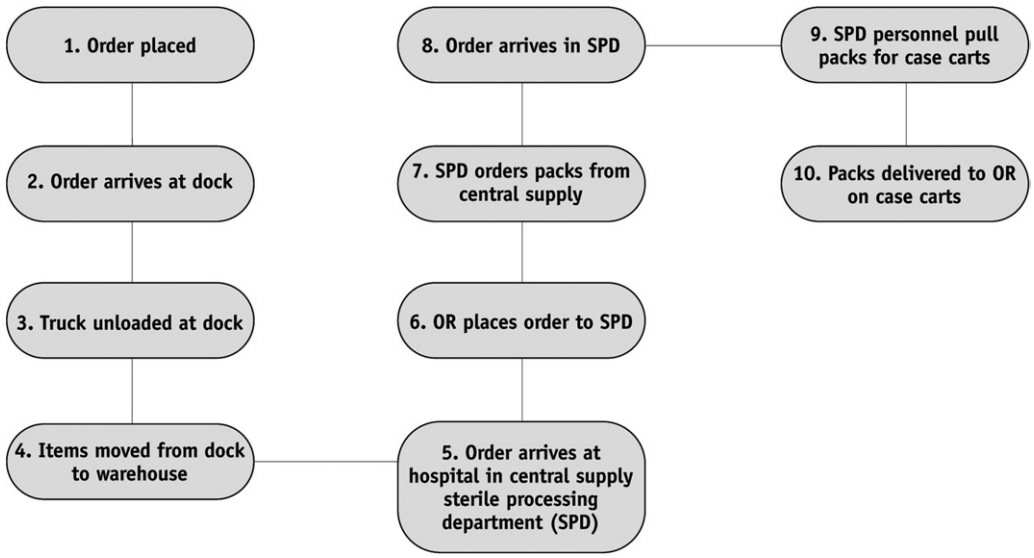

Figure 5. Ten steps required to order and deliver sterile disposable supplies to the OR when using the current practice.

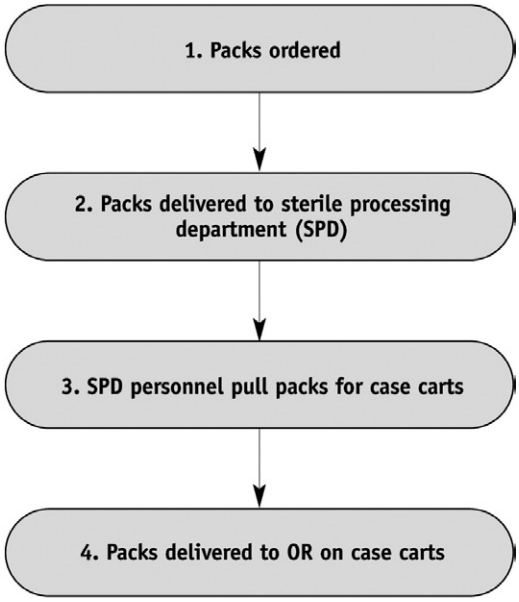

Figure 6. Four steps required to order and deliver sterile reusable supplies to the OR when using the alternative practice.

Acceptability Ratings of Products

One hundred eight surgeons and 64 surgical technologists participated in the comparative exercise (Table 2). We asked the surgeons to rate only the acceptability of the towels and surgical gowns.

- For comfort, 6% of surgeons rated the qualities of the surgical gowns currently in use as superior, 38% as good, 23% as fair, and 33% as poor. The surgeon's comfort rating for the nondisposable product was 86% superior, 10% good, 4% fair, and 0% poor.
- For ease of use, surgeons rated the qualities of the towels and surgical gowns currently in use as 33% superior, 47% as good, 19% as fair, and 1% as poor. The surgeon's ease of use rating for the comparative nondisposable products were 87% superior, 11% good, 2% fair, and 0% poor.
- For protective properties, surgeons rated the qualities of the surgical gowns currently in use as 30% superior, 45% as good, 20% as fair, and 5% as poor. The surgeon's ease of use rating for the comparative product (ie, nondisposable gowns) was 92% superior, 6% good, 2% fair, and 0% poor.

In addition to evaluating the surgical towels and gowns, we asked surgical technologists to evaluate basin ware and back table and Mayo stand covers. They evaluated both the current disposable products in use and the sterile, nondisposable products.

- For comfort, surgical technologists rated the qualities of the surgical gowns currently in use as 23% superior, 38% good, 30% fair, and 9% poor. The surgical technologists' comfort rating for the nondisposable product gowns was 83% superior, 9% good, 8% fair, and 0% poor.
- For ease of use, surgical technologists rated the qualities of the towels, surgical gowns, basin ware, and back table and Mayo stand covers currently in use as 53% superior, 20% good, 24% fair, and 3% poor. The surgical technologists' ease of use rating for the nondisposable towels, surgical gowns, basin ware, and back table and Mayo stand covers was 86% superior, 6% good, 8% fair, and 0% poor.
- For protective properties, surgical technologists rated the qualities of the towels, surgical gowns, basin ware, and back table and Mayo stand covers currently in use as 23% superior, 41% good, 33% fair, and 3% poor. The surgical technologists' protective properties rating for the nondisposable towels and surgical gowns, basin ware, and back table and Mayo stand covers was 94% superior, 3% good, 3% fair, and 0% poor.

Subjective written comments made by the participants included:

- "I loved the gowns, I wish we had these for all cases."
- "The back table and Mayo covers are very durable."
- "I did not need to double drape the back table."

TABLE 2. Gown Comfort and Ease of Use of Disposable and Reusable OR Supplies (Surgeons, n = 108; Surgical technologists, n = 64)

	Superior	Good	Fair	Poor	Unacceptable
Gown comfort					
Surgeons disposable	6%	38%	23%	33%	0%
Surgeons reusable	86%	10%	4%	0%	0%
Surgical technologists disposable	23%	38%	30%	9%	0%
Surgical technologists reusable	83%	9%	8%	0%	0%
Ease of towel/gown use					
Surgeons disposable	33%	47%	19%	1%	0%
Surgeons reusable	87%	11%	2%	0%	0%
Ease of towel, gowns, basin ware, and back table and Mayo stand cover use					
Surgical technologists disposable	53%	20%	24%	3%	0%
Surgical technologists reusable	86%	6%	8%	0%	0%
Protective properties of gowns					
Surgeons disposable	30%	45%	20%	5%	0%
Surgeons reusable	92%	6%	2%	0%	0%
Protective properties of towels, gowns, and basin ware and back table and Mayo coverings					
Surgical technologists disposable	23%	41%	33%	3%	0%
Surgical technologists reusable	94%	3%	3%	0%	0%

- "I love going green for the environment."
- "The gown moves better, much more comfortable."
- "I like the strength of the back table cover."
- "The gown is cooler."
- "I was pleasantly surprised, I had my doubts but I really like the gown, it breathes."
- "Of all the products trialed at this facility, I actually like this one."
- "Happy to see we are trying to save the environment."
- "I am for switching to these gowns."
- "Really liked the back table cover and happy we are saving the environment."
- "Do I have to give it back?"

Waste Reduction Outcome

The combined weight of the 59 total custom packs used at Facility A was 446.41 lb. The weight of the disposable gowns, towels, back table cover, and Mayo covers for the 59 custom packs replaced by the reusable gowns, towels, back table covers, and Mayo stand covers from the FDA-regulated facility was 311.05 lb. The use of reusable products demonstrated a 70% reduction in surgical waste. Facility B had a combined weight of 461.35 lb for the 60 total custom packs opened. The weight of the disposable items replaced by reusable items from the local FDA-regulated facility was 268.56 lb. In this instance, there was a 59% reduction in surgical waste with use of reusable products (Table 3).

DISCUSSION

During the course of the data collection, we noted several "incidental findings." The contents of custom packs at Facility A had not been updated to reflect the actual usage or needs of the surgeons or procedures. We discovered that several items in the custom packs were routinely unused and disposed of, often before the procedure started. The custom

TABLE 3. Surgical Waste Reduction

Facility	Total weight of disposable custom packs	Total weight of disposable items replaced by reusable products	Net change from use of reusable products
A	446.41 lb	311.05 lb	70% reduction in material entering the waste stream
B	461.35 lb	268.56 lb	59% reduction in material entering the waste stream

packs at Facility B were updated more frequently and were a more accurate reflection of the needs of the surgeon and the procedures; although Facility B required more single-wrapped items added to the sterile field than Facility A, the waste of unused items was minimal.

The segregation of regulated medical waste at both facilities was indiscriminate and varied from staff member to staff member, including surgeons and anesthesia personnel. When queried about the justification for separating regulated medical waste, staff members were not able to verbalize what is considered to be regulated medical waste and what is not. Staff members also stated that it did not really matter which bag the trash went into because "it all went out as trash anyway."

The average cost nationwide for the disposal of regulated medical waste is $0.28 per pound.[5] Facility A performs approximately 10,000 surgical procedures per year, and an average of 5 lb of waste was diverted per case during this comparative exercise. Facility B also performs approximately 10,000 surgical procedures per year, and an average of 4.5 lb of waste was diverted per procedure. At this rate, annual waste generation would equal 50,000 lb per year for Facility A and 45,000 lb per year for Facility B, which would result in a potential cost savings of $14,000 per year for Facility A and $12,600 per year for Facility B by converting to a purchase practice of using nondisposable surgical towels, gowns, Mayo stand covers, back table covers, and stainless steel basins (Table 4).

SUMMARY

This concept comparison supports AORN's recommendation to evaluate reusable, reposable, and disposable products.[7] The findings from this exercise illustrate the amount of waste entering the waste stream from the use of completely disposable custom surgical gown and drape packs versus a nondisposable pack that contains back table cover, towels, gowns, Mayo stand cover, and basins. The average weight reduction in medical waste per procedure was 5 lb from the use of the nondisposable items. The need to determine whether gowns, drapes, or towels are saturated sufficiently to warrant being considered regulated

TABLE 4. Potential Cost Savings

Facility	Number of annual procedures	Average waste decrease per procedure	Annual weight decrease	Cost savings at $0.28/lb
A	10,000	5.0lb	50,000 lb, 25 tons (US), 22,679.618 kg	$14,000
B	10,000	4.5lb	45,000 lb, 22.5 tons (US), 20,411.656 kg	$12,600

medical waste is eliminated because they are returned for reprocessing rather than leaving the facility as waste. This represents a 70% reduction in the waste that ultimately reaches a landfill or commercial incinerator. Cost savings will vary for each surgery center based on the habits of separating normal waste from regulated medical waste; the costs per pound for differing categories of waste; federal, state, and local regulations; and the potential fines for Occupational Safety and Health Administration violations.

Our project also illustrated the decrease in nonvalue-added process steps in the supply chain from the point of purchasing surgical packs to the use of the materials in the OR. A 10-step process of handling and moving surgical packs could be reduced to four steps if supplies were delivered to the sterile processing department daily, or a two-step process if supplies were delivered directly to the OR.

Our survey demonstrated the rapid acceptance and eagerness of surgeons and surgical technologists to convert to the use nondisposable products. Laustsen[16] proposed that the greening process in perioperative areas should occur in small steps and that acceptance by staff members will occur when changes take place gradually. This concept comparison exercise demonstrated a different perspective, in that the surgical staff members were eager to convert to a "greener" method in a very short period.

In a letter to the editor of the *AORN Journal,* Belkin wrote, "The amount of red bag medical waste can be reduced by judicious use of reusable items. Perhaps a mix of reusable and disposable products will prove to be the optimal choice."[17(p16)] In December 2008, a major supplier of disposable surgical products announced a partnership with a national FDA-approved company that provides reprocessing and sterilization of nondisposable surgical gowns, towels, table covers, drapes, and basin ware.[18] Collectively, this copartnership creates hybrid packs that supply both nondisposable and disposable products as one unit (Figure 7). In this bold effort to encourage truly "going green," industry leaders are advancing strategies that will help surgery centers reduce their purchase of medical waste and are leading the way in becoming more responsible for the environment. AORN

Figure 7. A hybrid pack, showing a mix of reusable and disposable sterile supplies. *Photograph courtesy of SRI Surgical, Tampa, FL.*

Editor's note: *The views expressed are those of the authors and do not reflect the official policy or position of the Uniformed Services University of the Health Sciences, the Department of Defense, or the United States government. Publication of this article does not imply AORN endorsement of specific products.*

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PRACTICE Greenhealth™

GREENING THE O.R.™

The Business Case for Greening the OR™

WHY FOCUS ON THE OPERATING ROOM?

The operating room is critical to a hospital's success, and to its business model—bringing in between 40-60% of the organization's revenue[1,2] and up to 60% of its operating margin in some instances.[3] The OR is also a significant cost center. It is the leader in medical supply usage for the entire hospital,[4] estimated to account for approximately 33 percent of all hospital supply costs,[5] and has large cost requirements relative to energy use and waste management.

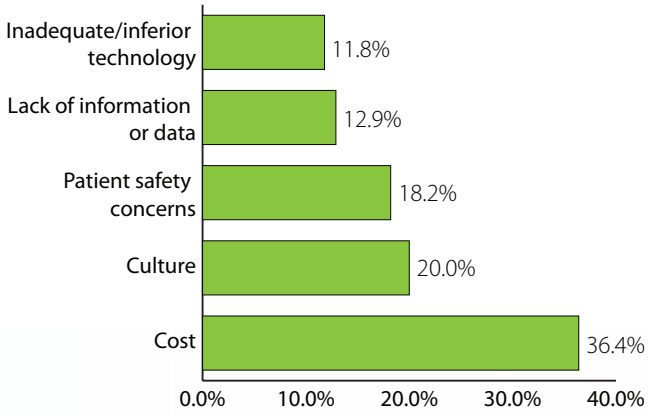
But hospitals across the country are demonstrating that there are ways to cut costs in the OR while reducing the environmental footprint of the department.

- MetroWest Medical Center saved an estimated $29,843 and was able to reduce its waste stream by 5,606 lbs of disposable blue wrap in 2010 as a result of transitioning 66% of its surgical instrumentation to reusable rigid sterilization containers in the OR.
- Bon Secours Good Samaritan Hospital, a 377-bed facility in Suffern, NY, installed a system for fluid management in the operating room avoiding the creation of 261,999 lbs. of waste and saving $86,460 in 2010.
- Hospital Corporation of America (HCA) and its 163 member hospitals realized $17.6 million in savings in 2010 by reprocessing medical devices and avoided placing 298 tons of waste into landfills.

Greening the OR™ is a new initiative—led by Practice Greenhealth—to coalesce and build the body of knowledge around environmental best practices in the OR that can also improve patient safety, worker health and the bottom line. A number of hospitals have made significant advancements in identifying green best practices in the OR, but until now, no one has stepped in to make those best practices accessible in one place, nor facilitate the kinds of dialogue needed to drive green innovation in the OR forward.

Practice Greenhealth asked hospitals the following question:

Overall, what are the biggest challenges to implementing 'green' interventions in your organization's ORs?



The resulting data demonstrates the need to frame this issue for the sector and increase the published literature substantiating green best practices in the OR. While some green practices do require capital investments, many do not and can generate significant cost-savings. Tackling OR culture, while difficult, is possible when you have strong data to base decisions upon, peer hospitals who can model best practices, and leadership from within the OR. Patient safety must and will remain paramount in any discussion of alternate practices or products. This business case will lay out the rationale for the integration of green, sustainable best practices in the OR, and will demonstrate how OR departments at leading hospitals are beginning a new dialogue with sustainability leaders, the supply chain and service providers about how to create collaborative solutions to today's sustainability challenges that can not only save critical healthcare dollars that can be rediverted into patient care, but can also improve patient and worker safety while being a better community steward.

Practice Greenhealth is using a dynamic, collaborative approach that brings together a variety of stakeholders to define a set of data-driven, science-based, best practices in the OR that reduce environmental impact, reduce cost, increase efficiency, and improve worker and patient safety—or some combination of these. The Initiative is focused on engaging key stakeholder groups relevant to the OR to ensure that best practices are being discussed and vetted through the appropriate channels and driven by all available data.

Deliver quality patient care utilizing practices and products that are safe for patients, workers and the environment while minimizing costs.

The Initiative has the potential to significantly impact the supply chain—hospitals, health systems and group purchasing organizations are working with Practice Greenhealth to leverage the purchasing power of the healthcare sector to drive product and process innovation. The healthcare supply chain is also a critical partner in the exploration of new and innovative ways to address old and unsustainable practices, products and services. Companies today are increasingly recognizing that green products make good business sense—for the long term, and are engaged and interested in strategic thinking and dialogue with healthcare customers about creating better solutions. Indeed, many of these companies have demonstrated their willingness to try innovative approaches to identifying synergies and even collaborations across company lines to meet the needs to hospital customers.

Those responsible for designing and constructing the hospitals of the future are also a key element in this conversation—as the green operating room of the future goes beyond product selection to think about integrated design teams, engineering, safer materials selection and technology integration.

Greening the OR™ is a sector-wide initiative that will provide administrators and OR managers with the tools necessary to reduce environmental impact while driving down costs.

Perceptions persist that green programs and products cost more despite comprehensive evidence to the contrary. Learn more about how environmental best practices in the OR are a mechanism to reduce cost while also engaging staff in a new dialogue about how to increase efficiencies at the organization.

BEST PRACTICE #1:

RMW Segregation in the OR

Leading hospitals have demonstrated that an early focus on waste segregation in the OR can demonstrate significant reduction of the infectious waste stream while also generating big dollar savings relative to the hospital's waste budget. Specific implementation strategies vary but emphasis is placed on diverting clean, sterile packaging and non-infectious waste (per state definition) into either solid waste or recycling containers.

- "Inova Fairfax Hospital, an 833-bed hospital in Northern Virginia, decreased the regulated medical waste being generated by its ORs by 18.6% over just a 6-month period, saving the hospital more than $15,000 and promising far greater savings long-term."

  Seema Wadhwa LEED AP, Sustainability Engineer, Inova Health System/Sustainability Director, Urban Ltd, Fairfax, VA

- "In 2010, our Waste Management Team achieved a 47% reduction in regulated medical waste, reducing 28,795 pounds of waste by initiating a targeted focus on RMW reduction in our ORs and Labor & Delivery. Cost savings due to red bag waste reduction were in excess of $89,000."

  Judith Focareta, Coordinator, Environmental Health Initiatives, Magee-Womens Hospital of UPMC, Pittsburgh, PA

BEST PRACTICE #2:

Divert and Purchase Reprocessed Medical Devices

Hospitals are finding that partnering with a third party reprocessor to reprocess medical devices are an important element in responsible stewardship of the organization's financial resources. Programs to collect certain FDA-eligible medical devices in the OR for reprocessing and then purchase back the reprocessed devices are generating huge cost-savings and significant waste reductions for a variety of organizations. More than 70% of hospitals nationwide now reprocess some or all of their FDA-eligible medical devices.[6]

- "The University of Washington Hospitals in Seattle, WA diverted 5.8 tons of waste and saved the organization $496,123 in 2008 by reprocessing more than 100 different single-use medical devices."

  Sheila Jobe-Lockwood, Compliance Outreach Coordinator, Environmental Health & Safety, University of Washington Medicine, Seattle, WA

- "Through reprocessing of medical devices, Advocate Christ Medical Center was able to save $400,000 and avoided sending almost 5 tons of waste to the incinerator or landfills in 2010."

  Mary Larsen MS, Environmental Stewardship Manager, Advocate Health Care, Chicago, IL

BEST PRACTICE #3:

Fluid Management Systems in the OR

Hospitals are eliminating staff exposure to bloodborne pathogens and minimizing regulated medical waste (RMW) disposal costs by moving to fluid management systems in the OR. Fluid management systems automate the process of flushing blood and body fluids to the sanitary sewer, reducing the need for staff to manually empty suction canisters or use expensive solidifiers to dispose of suction canisters to RMW. Many also utilize a reusable or integrated canister that is cleaned and reused, lowering ongoing supply costs.

- "Bronson Methodist Hospital implemented a fluid management system in 2003. In 2010, this technology allowed Bronson to save approximately 8 tons of regulated medical waste and plastic suction canisters at a savings of $7,200."

  Lisa Hardesty, EOC and Sustainability Manager, Bronson Methodist Hospital, Kalamazoo, MI

- "In 2007, St. Mary's Hospital Medical Center (an affiliate of Hospital Sisters Health System) instituted a fluid management system that reduces its regulated medical waste by 5,400 lbs each year at an annual cost savings of over $10,000 dollars."

  Ronald VanSchyndel, EVS 1st Line Supervisor, St. Mary's Hospital Medical Center, Green Bay, WI

Perioperative staff at MetroWest highlight the rigid sterilization containers used in the OR and Sterile Processing.

BEST PRACTICE #4:

Medical Plastics Recycling in the OR

The OR might be the last place you'd expect to find a recycling container, but hospitals are increasingly partnering with their waste haulers to identify appropriate medical plastics for diversion to recycling markets. While a large portion of OR supplies are disposable and packaging is ubiquitous, facilities are surprised to find the vast majority of medical plastics generated in the OR are recyclable with the right hauling partner. As several of the country's largest waste haulers develop integrated waste solutions focused on servicing all of a hospital's waste streams, access to medical plastics recycling in the OR is growing rapidly. Partnered with a focus on better segregation of infectious waste, this program can derive real financial savings.

- "Fletcher Allen Medical Center achieved a 38% recycling rate in 2010. The nursing staff in the OR have been initiators of Fletcher's OR recycling program which collects approximately 50 tons of recycling annually at a savings of approximately $6000."

  Louis Dinneen, Director, Facilities Management, Fletcher Allen Medical Center, Burlington, VT

- "Spectrum Health in Grand Rapids, MI initiated a medical plastics recycling program in its 45 ORs in 2007. In 2010, the OR recycled 42,500 lbs of Blue Wrap, saving $1,300 in avoided waste costs. The blue wrap program is part of Spectrum Health's larger hospital recycling initiative that since 2007 has saved nearly $200,000 and reduced waste bound for the landfill by 2,943 tons."

  Josh Miller, Sustainability Coordinator, Spectrum Health, Grand Rapids, MI

BEST PRACTICE #5:

Reusable Gowns, Textiles and Basins in the OR

The culture of waste in the OR is driven in large part by the increasing volume of disposable medical supplies on the market today. Many hospitals—after jumping on the disposables bandwagon—are beginning to rethink the use of reusable textiles and supplies in the OR. Reusable surgical textiles are demonstrating increased clinician satisfaction while also providing comparable barrier protection. And reusable table and mayo stand covers, surgical towels and basins are common sense switches that drive down costs by reducing the volume of waste generated.

- The University of Maryland Medical Center moved to reusable textiles in the OR more than 15 years ago, and utilizes a vendor to provide clean, sterilized surgical textiles. In 2010, UMMC avoided the creation of 138,748 pounds of waste as a result of using reusable textiles in the OR, demonstrating an estimated cost-savings of $38,849[7] in avoided waste disposal costs, and an estimated $39,000 in returned instruments.

  Victoria Stewart, MBA, Business Director, Perioperative, Endoscopy and Rehab Services, University of Maryland Medical Center, Baltimore, MD

- "Kaiser Permanente's use of reusable surgical gown and basin sets reduced the organization's regulated medical waste by 30 tons, at a savings of 3.8% in 2010."

  Andrew Knight, Senior Sourcing Director, Kaiser Permanente, San Diego, CA

BEST PRACTICE #6:

Reusable Hard Cases for Surgical Instrumentation

Hospitals purchase large volumes of blue sterile wrap for sterilization of kits in preparation for the OR. Blue wrap is not reusable and immediately becomes waste in the OR during procedure set up. While recycling of blue wrap is available in some areas, the supply costs relative to replacing used material continue. Innovative hospitals have begun a transition from disposable blue wrap to the use of reusable rigid sterilization containers for surgical instrumentation. The cases can be reused continually, driving down the purchase of blue wrap and the associated waste disposal costs while still protecting sterility and function of the instrumentation.

- Mills-Peninsula Medical Center, a 413-bed hospital in Burlingame, CA purchased rigid sterilization containers for the organization in 2006 at a cost of $34,987. They were able to avoid blue wrap purchases of $25,173 and save $26,000 in rewrapping costs for torn blue wrap sets, making the payback 8.2 months with an additional cost-savings of $16,186 in one year without even tallying waste avoidance costs into the equation.

  Gail Lee, past Director, Environmental Health & Safety, Mills-Peninsula Medical Center, Burlingame, CA

- Boulder Community Hospital purchased $150,000 of rigid sterilization containers for the OR in 2003 and over two years, reduced blue wrap purchase from $250,000 to $60,000 annually—less than a two year payback. BCH has saved over $1 million in avoided supply costs since 2003 as a result of the program.

  Kai Abelkis, Sustainability Coordinator, Boulder Community Hospital, Boulder, CO

BEST PRACTICE #7:

OR Kit Reformulation

ORs routinely dispose of items included in OR kits that are never used during the procedure. OR staff in leading hospitals are working with physicians to review preference cards—and in some cases, audit surgeries—to determine where unneeded or excess items may be making their way into the kits and routinely are disposed of as waste rather than utilized during the procedure. Streamlining custom kits, reviewing preference cards, and standardizing both the number and type of items included (as much as possible) can result in decreased inventory, reduced supply costs and avoided waste disposal fees. While this best practice tackles entrenched behavior and OR culture head on, it is very feasible to implement with cooperation from surgical staff.

- "The University of Minnesota Medical Center-Fairview, saved an estimated five tons of waste and $116,000 dollars in 2010 through its surgical pack reformulation efforts."

  Crystal Saric, Coordinator of Waste Services and Waste Reduction, Fairview Health Services, Minneapolis, MN

- "In collaboration with its vendor, Mayo Clinic Surgery in Rochester, MN reviewed and reformulated its custom packs in the OR in an effort to reduce both waste and cost, saving nearly $125,000 in avoided supply costs with the new kits since April of 2009."

  Kevin T. Hovde, C.P.M., Supply Chain Mgmt Performance Consulting Lead Senior Analyst – Surgery, Mayo Clinic, Rochester, MN

  Thomas J. Louks, Hospital Surgical Services Finance Specialist, Mayo Clinic, Rochester, MN

BEST PRACTICE #8:

OR Setback Programs for HVAC for Unoccupied ORs

ORs have the highest requirements for air changes per hour, require strict temperature parameters and use energy-intensive (and often heat- generating) surgical lighting systems. Often these systems run all night --even when the OR is unoccupied. Forward-thinking hospitals are evaluating OR setback mechanisms to decrease air changes and/or turn out the lights during these unoccupied hours as a means of reducing both energy and cost. Other hospitals have replaced heat-generating halogen lighting with LEDs or have adjusted temperature fluctuation to a setpoint to increase efficiency.

- "By moving to HVAC occupancy sensors in two of its new digitally controlled ORs, Providence St. Peter Hospital in Olympia, WA reduced its energy use by 25,000 kWh and 2,460 Therms and is saving $4,000 dollars per year."

  Keith Edgerton, Sustainability Coordinator, St. Peter Hospital and Providence Southwest Washington Service Area

- "By increasing the temperature in Advocate Illinois Masonic Hospital's operating rooms from an average of 64 degrees, to an average of 70 degrees, we saved $72,000 per year in patient warming devices. Eliminating the need to pre-cool the operating rooms yielded a significant energy savings as well."

  York Chan, Administrator, Facilities Services Advocate Health Care, Chicago, IL

BEST PRACTICE #9:

Reusable Sharps Container Systems

Instead of buying disposable sharps containers that go into the infectious waste stream and drive up waste costs while also requiring ongoing replacement, hospitals are moving to reusable sharps container systems. The full containers are typically collected by a service provider who mechanically empties them (reducing exposure for workers at the same time), cleans and disinfects them and returns them to the hospital for reuse. Containers are often used hundreds of times, driving down both waste and replacement supply costs—a win-win.

- "Borgess Medical Center, a 450-bed hospital in Kalamazoo, MI made the switch to reusable sharps containers in 2007. The transition has enabled Borgess to reduce its regulated medical waste by 10.5 tons at savings of $11,000 dollars annually."

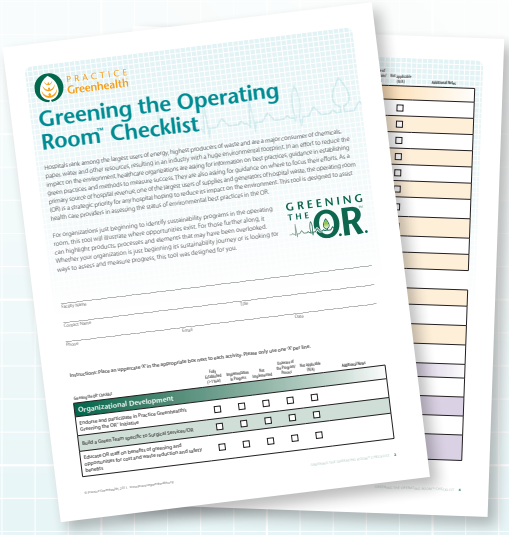
  Eric Buzzell, Executive Director, General Services & Property Management, Borgess Medical Center, Kalamazoo, MI

- "The reusable sharps container program at Illinois Masonic Hospital (an affiliate of Advocate Health) reduced its regulated medical waste by 10 tons and saved the organization $13,000 dollars in 2010."

  Steve Verzi, Safety Coordinator, Advocate Illinois Masonic Hospital, Chicago, IL

How Can the Greening the OR™ Initiative Assist Your Facility?

The Greening the Operating Room™ Initiative is designed to let healthcare organizations play at the level they feel comfortable. Participation is free and there are a myriad of resources—evolving every day—that can assist your facility in learning more about different best practices. The initiative is a dynamic learning community where you can hear about other hospitals' successes, strategize around barriers to implementation and engage the supplier community to create new solutions to today's issues. Learn a bit more about some of the educational opportunities offered by the initiative.



Checklist

Want to get a sense of how far along your facility is in greening its operating rooms? Use this checklist to do a self-audit. You may be surprised by how many best practices you already have in place or may encounter all kinds of new best practices to explore.

Sharing Calls

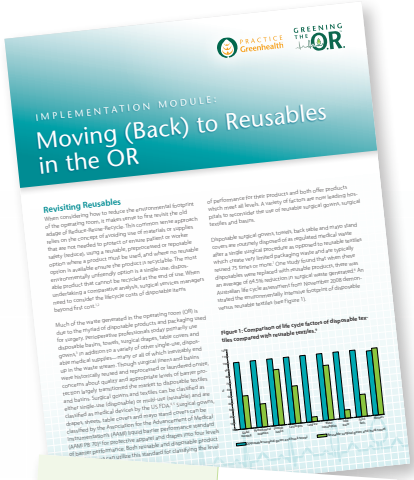
Want to learn more about a new program but don't see it on the webinar calendar or have a more immediate need for additional information? Hospitals formally participating in the initiative (and all Practice Greenhealth members) can request a sharing call. Staff will put out a call request inviting other hospitals to come and share their experience with that particular program. Calls are facilitated by Practice Greenhealth but are largely informal opportunities for sharing advice, resources and strategies.

Webinars

Practice Greenhealth began a Greening the OR™ webinar series in 2011. Webinars are free to all facilities formally participating in the initiative and to all Practice Greenhealth members. Each month, the series focuses on a different best practice and shares real-time case studies from participating hospitals. Webinar calendar available at: www.GreeningTheOR.org.

Implementation Modules

Practice Greenhealth is rolling out a series of implementation modules as part of the Greening the OR™ Initiative. These multi-step resource guides walk interested hospitals through the steps necessary to explore, build and implement different sustainable best practices in the OR. For a complete list of current modules, go to: www.GreeningTheOR.org



Case Studies

Practice Greenhealth is writing a series of case studies featuring organizations participating in the Greening the OR™ Initiative. Practice Greenhealth realizes the value of data-driven case studies that share the experiences and successes of other healthcare organizations in implementing sustainable best practices. Learn how other hospitals have organized their implementation efforts or overcome key barriers. Practice Greenhealth also makes case studies from other sources available on its website to give participants the widest range of resources possible. For a recent list of case studies on different sustainable best practices in the OR, go to: www.GreeningTheOR.org

Greening the OR™ Calculators

Making the business case for a specific sustainable practice can be challenging if you don't know how to frame the data and make the cost-benefit analysis. Practice Greenhealth is working with hospitals and the healthcare supply chain to provide a series of calculators that will allow healthcare organizations to accurately estimate the kinds of financial savings and environmental benefits they can expect to realize. Learn more at www.GreeningTheOR.org.

Council for Environmentally Responsible Surgery (CERS)

Practice Greenhealth recognizes the critical role that physicians in the operating room can play in determining the success (or failure) of new best practices. The Council is a new initiative aimed at engaging surgeons, other physicians who perform surgery and anesthesiologists to explore the needs of this community relative to substantiating and driving best practices.

COUNCIL FOR ENVIRONMENTALLY RESPONSIBLE SURGERY

How to Participate

The Greening the OR™ Initiative is bringing together a cross-section of the healthcare sector to explore and demonstrate that ORs are identifying strategies to reduce their environmental impact while searching for ways to do it safely and cost-effectively. Learn how you can join the community.

Endorse the Initiative.

Healthcare facilities and ambulatory surgery centers can participate in the initiative by filling out a simple commitment form. ***There is no fee to participate***. The commitment form provides a menu of options—offering facilities different ways to participate in the initiative. From sharing calls with other hospitals to the Greening the OR™ Webinar Series to opportunities to highlight your organization's successes at conferences and to the media—Practice Greenhealth is committed to building a vibrant learning community. Learn more at: www.GreeningTheOR.org

Sponsor the Initiative.

This initiative is about reaching across company lines and innovating sustainable strategies to address today's OR challenges. Is your company ready to be part of the solution? Learn how you can get involved in Greening the OR™ activities by contacting:

Robert Jarboe
Executive Vice President, Business Development
bjarboe@practicegreenhealth.org • 502.727.8658

Endnotes

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GREENING THE O.R.™
The Greening the OR™ Initiative is defining best practices in the OR to reduce environmental impact, reduce cost, increase efficiency, and improve worker and patient safety. Practice Greenhealth is grateful for the support of a number of sponsors of the Greening the OR™ Initiative. For a complete list, please visit: **www.GreeningTheOR.org**

MINNESOTA TECHNICAL ASSISTANCE PROGRAM

Case Study

UNIVERSITY OF MINNESOTA

Reducing waste from the operating room

A surgeon at the University of Minnesota Medical Center-Fairview recently reduced the amount of waste generated during one of his procedures and is saving the facility $2,000 and 80 lbs of waste annually.

The University of Minnesota Medical Center-Fairview (UMMC) is a highly-respected educational institution located on the University's Minneapolis campus. The hospital has nearly 2,000 beds and performs over 20,000 surgeries each year. Fairview's mission is to improve the health of the communities it serves.

One surgeon has linked community health to the health of the environment and has made it his mission to reduce as much waste from his procedures as possible. Dr. Rafael Andrade was concerned about the waste and pollution generated during surgical procedures and has been working to reduce that waste by minimizing unnecessary disposable items, using more reusable equipment, and minimizing toxic chemicals. For one common procedure, Dr. Andrade realized waste could be reduced with a few simple, but safe substitutions and item deletions.

Need for Change

The first procedure Dr. Andrade evaluated for waste reduction is the vascular access port placement. This procedure is done to provide easy venous access in patients receiving chemotherapy. The ports allow easy access to a vein for medication, blood draws, and CT scan contrast injections. The ports also minimize needle sticks and help maintain vein integrity. Many surgeons at UMMC perform this procedure; it is performed over 200 times annually in UMMC's operating rooms. Dr. Andrade alone performs this surgery approximately 40 times each year.

Each set of instruments and equipment for a specific procedure, often called a pick, is prepared according to the doctor's specification. Dr. Andrade realized that following the port placement, the pick had a number of unnecessary items and redundancies. Therefore, he worked with operating room nurses and staff members to determine what items in the pick were vital to the success of the surgery (Table 1).

Waste-Reduction Opportunities

From examining his pick and determining what items were extraneous, Dr. Andrade was able to reduce the amount of items and reduce the waste from the procedure.

The new pick contains 27 items, as opposed to 44 in the old pick. The new pick also includes reusable gowns and linens and reduces the number of syringes, sutures, drapes, and dressings discarded. Dr. Andrade's pick eliminates one pound of waste and saves $50 in supply costs per case.

Additional Waste Reducing Changes

Additional changes that Dr. Andrade has implemented include minimizing surgical prep waste, using reusable gowns, and choosing only the necessary amount of sterile saline solutions. Additionally, a recommendation has been made for the facility to start moving toward using lead-free indicator tape.

Surgical prep waste

3M's Duraprep™, a patient skin prepping solution in a self-contained applicator, is used to provide

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asepsis to the area where the port is being inserted into the patient. Any leftover Duraprep™, because it contains alcohol, must be disposed of as an ignitable hazardous waste. Also, solvents such as alcohol are used to clean the iodine residue left from the Duraprep™ off of the patient's skin, which adds to the time required for the procedure and increases costs and waste. Alternatives, such as Hibiclens™, are non-hazardous and do not need to be removed from patient's skin, which reduces the use of additional materials and time.

Duraprep™ is sold in both 10 and 26 ml sizes. Often the 26 ml is included in surgical picks; however, it is possible that 10 ml size would suffice. For cases that do not require a large field of asepsis, a 10 ml size of Duraprep™ could be used, which can potentially eliminate the hazardous waste leftover from the procedure.

Reusable gowns

Reusable gowns that are washed and reprocessed through UMMC's sterile processing department cost Fairview $1.08 each to process. Each gown can be reprocessed approximately 50 times before disposal. Disposable gowns for the procedure cost the hospital $2.39 and generate 0.5 lbs of waste each. Overall, Dr. Andrade's choice of reusable gowns costs Fairview $170 annually and generates no solid waste. However, using disposable gowns would cost $287 and generate 60 lbs of waste annually.

Sterile saline solutions

Picks often have 1 liter containers of sterile saline; however, the port placement procedure uses less than 500 ml. Substituting 500 ml sterile saline for the 1 liter bottles would reduce over 20 lbs of waste save $16 annually.

Lead-free indicator tape

Reusable gowns, as well as surgical instruments, must be wrapped and sterilized. The wrapping fabric, often called "blue wrap" is secured using indicator tape which changes color once the package has been sterilized. UMMC currently uses lead-based indicator tape. Therefore, the tape and any blue wrap that is in contact with the tape may be considered hazardous waste. To lessen the amount of hazardous waste generated by sterilization, UMMC can either move to hard cases or use copper-based indicator tape.

Impact

Currently, the new pick that Dr. Andrade has begun using reduces the waste by one pound and saves $50 for each procedure. Changing to 500 ml bottles of saline reduces waste by an additional pound per procedure. Assuming Dr. Andrade performs 40 procedures per year, he alone saves UMMC at least $2,000 in material costs, eliminates at least 80 lbs of waste, and reduces greenhouse gas emissions by 64 lbs.

Table 1. Picks Used for Port Placement Procedure

New Pick		Old Pick		
Pitcher sterile 1000mL		Pitcher sterile 1000mL		
Linen towel 5-pack		Linen towel 5-Pack		
Linen gown pack (3 reusable gowns)		Gown Xlg disp (disposable gown)		
Pack Minor: Bag, bedside Blade, #15 Cover, back table Cover, Mayo stand Cautery w/blade, holder Cautery, tip cleaner	Needle counter, 40 ct Needle, 25 g 1 ½ Sponge, 4 x 8 Syringe control, 10cc Light handles, 2 4 x 4 dressing, 2	**Pack Angio Minor:** 7 qt basin 0.67 oz Benzoin tincture Cover, back table 2 C-arm snap, large Fluid containment cup w/lid 2 oz med cup 5 oz specimen cup w/lid Drape, split	Dressing, Tegaderm 4 x 4 ¾ Guide wire 0.035 x 145 cm Med cup, 2 oz Needle, 18 g x 7cm Seldinger Needle, 25 g x 2″ injection Scalpel, #11 IV Dressing split Dressing, Tegaderm 2 3/8 x 2 3/4	Sponge, 2 x 2 gauze 30-Sponge, 4 x 4 2 ply 2-Steri Strips ½ x 4″ Stopcock, 1 way 2-Syringe 10 cc LL Syringe 10 cc control LL w/shield 2- Syringe 10 cc LS w/shield 2-Syringe, 30 cc LL
Prep Duraprep 26mL	Radiation cover probe	Prep Chlorhexidine 4% 4oz	Suture Ethilon 3-0 PS-1 18″	Syringe ear bulb 3oz
Drape U split 74 x 120″	Suture Vicryl 3-0 SH 27″	Light Handle X1	Suture Vicryl 3-0 SH 27″	Label medication system
Drape Ioban incise 13 x 13″	Suture Prolene 3-0 SHDA 36″	Decanter Vial	Suture Vicryl 4-0 PS-2 18″ UND	Blade clipper
ESU ground pad universal w/o cord	Suture Vicryl 4-0 PS-2 18″ UND	Pad Chux underpad 30X30″	Suture PDS II 3-0 SH 27″	Sol NaCl 0.9% 10mL vial
Syringe 10mL LL w/o needle	Solution, water, 1000 mL bottle	Catheter SQP 08fr SL	Sponge Ray-Tec 4X8″	Sol NaCl 0.9% 1000mL bottle
Blade clipper	Solution, NaCl 0.9%, 1000 mL bottle	Syringe 10mL LL w/o needle	Catheter VA intr 10fr 16cm kit	

#142CS 01/09

For More Information

MnTAP has a variety of technical assistance services available to help Minnesota businesses implement industry-tailored solutions that maximize resource efficiency, prevent pollution, increase energy efficiency, and reduce costs. Our information resources are available online at <mntap.umn.edu>. Please call MnTAP at 612.624.1300 or 800.247.0015 for personal assistance or more information about MnTAP's services.

Media contact: Nancy Jenkins 913/432-6177

April 29, 2009

Healthcare Purchasing News

Response to an April 2009 Article
"Softer, stronger fabrics enhance gowns and drapes"

To the Editors:

Having read the report entitled, **"Softer, stronger fabrics enhance gowns and drapes"** in your April, 2009 issue, I wish to comment on a number of points in the section of the article entitled, **Reusable vs. Disposable**.

Claims that it takes,"one and a half gallons of water to launder one surgical gown and as much as four gallons of water to launder a reusable drape," are misleading.

The report does not take into account that with today's modern tunnel washing systems, which have built in water reuse capabilities, we can launder surgical textiles and achieve maximum quality while using 0.5 – 0.7 gallons of water per pound of textile.

A large majority of reusable surgical gowns weigh under a pound. Accordingly, the amount of water used to launder one gown, requires less than 0.5 gallons of water.

With regard to surgical drapes and wraps, they vary in size from about 18" x 18" to some as large as 60" x 90". These may range in weight from a few ounces to nearly 30 ounces, with the majority weighing somewhere between these figures.

Smaller drapes, at 36" x 36", or less, would also require under 0.5 gallons of water to launder. The very largest drapes and wraps would be expected to use about one gallon of water to launder. The claim that drapes require four gallons of water to wash is significantly exaggerated.

The report goes on to state that disposable products actually have a lower environmental burden on the environment. The following points should be considered which are contrary to this premise:

- One should consider that the **Clean Air Act** identifies six recognized forms of pollution. These are sulfur and nitrous oxide, carbon monoxide, volatile organic compounds, particulate matter and lead.

- Single-use, disposable products need to be incinerated in medical waste incinerators (MWIs) or taken to waste landfills. Both methods of disposal have been identified as producing numerous factors adversely impacting on the environment.

- The U.S. EPA has found that MWIs produce negative consequences for air quality. They reported that MWIs result in emissions containing furans, carbon monoxide, heavy metal and dioxin. Further, the EPA has identified MWIs as the largest known source of dioxin emissions in the U.S. (Dioxins, says EPA findings, can result in cancerous and noncancerous human health effects.)

- The alternate procedure for disposing of hospital waste is through the use of landfills. Waste landfill sites have been found to yield many environmental difficulties. Included in these are the proliferation of leachate which can impact negatively on ground water, aquifers and entire ecosystems.

- In addition to the preceding, solid waste landfill sites are known to generate large quantities of methane and other gases containing volatile organic compounds (VOCs).

- Multiple studies reported in *Environmental Health Perspectives, Archives of Environmental Health* and *Environmental Research* disclose that in populations living adjacent to landfill sites, there are significantly higher levels of many health problems ranging from birth defects to many forms of cancer.

Comment was made in the April report that reusable gowns and wrappers also eventually find their way to landfill sites. While this point is true, reusable products, more often than not, are downgraded and recycled when they no longer meet the performance requirements of the surgical suite. Frequently, such products continue in use for the cover-up needs of housekeeping, food service, maintenance and engineering departments. Downgraded wraps and drapes are also utilized as excellent equipment and dust covers and tarpaulins, as needed.

One should also not forget the EPA/AHA Memorandum of Understanding, known as Hospitals for a Healthy Environment (H2E), continuing to call for a 50% reduction in hospital waste by 2010.

In addition, it should also be noted that the European Textile Services Association, (E.T.S.A.) commissioned dk TEKNIK ENERGY & ENVIRONMENT, a Life Cycle Assessment organization headquartered in Denmark, to evaluate the environmental impact of reusable and disposable surgical gowns. A number of environmental impact categories were evaluated, including energy consumption, global warming, acidification (of water and soil), eutrophication (nutrient discharged to the water environment), and post- consumer waste. Directed by an independent Critical Review Panel, the Life Cycle Assessment was carried out in an objective manner and based on ISO standards. Several categories of reusable and disposable gowns were studied. It was concluded that, in the overall comparison, reusable surgical gowns have the lowest negative impact on the environment.

While neither reusable nor disposable products will meet every single requirement of healthcare's critical needs in the 21st Century, all of the preceding demonstrates a preponderance of details that favor reusable healthcare materials as the most Green and environmentally advantageous choice for our society. Certainly a 90%, usage rate of disposable surgical products, as claimed in the report referred to with this narrative, is not a practical plan to sustain our future environment.

Respectfully submitted,

Howard M. Zins

Howard M. Zins is the principal of Howard M. Zins Associates, a consulting firm specializing in the area of material technology related to institutional textiles. Formerly Director, Textile Development, with Angelica Uniform Group, he serves on the board of the American Reusable Textile Association, (ARTA). ***www.arta1.com***

HIGH-TECH SURGICAL GOWNS AND DRAPES - SAFETY, COMFORT, SUSTAINABILITY AND COST-EFFECTIVENESS

E.T.S.A.

OVERALL COMPARISON BETWEEN REUSABLES AND DISPOSABLES

	High-tech reusable	Cotton reusable	Disposable
Barrier effect	+	–	+
Cleanliness	+	+	?
Particle emission	+	–	–
Strength	+	+	–
Thermal management	+	–	–
Comfort/breathability	+	+	–
Environmental impact	+	+/–	–
Functionality	+	–	+
Cost effectiveness	+/–	+/–	+/–
Value for money	+	–	+/–
Balance	**9**	**3**	**2**

E.T.S.A.

SURGICAL GOWNS AND DRAPES ARE MEDICAL DEVICES, REGULATED BY STANDARDS TO PROTECT PATIENTS AND HOSPITAL STAFF

- Surgical textiles, such as surgical gowns, surgical drapes and clean air suits, are used to protect patients and hospital staff from infections
- Surgical textiles are regulated by EN 13795 series of standards
- EN 13795 specifies requirements and excludes non-conforming products from the market – e.g. fabrics without sufficient barrier function, whether disposables or reusables (cotton)
- Modern reusable products (like micro fibres or laminates) provide not only safety but also more comfort, sustainability and cost-effective solutions compared with disposables

E.T.S.A.

SURGICAL GOWNS AND DRAPES ARE MEDICAL DEVICES

- Surgical gowns and drapes serve
  - + to reduce post-operative wound infections, thereby **protecting hospital staff** and
  - + **protect patients** against hospital-acquired infections (HAIs)

- Surgical gowns and drapes are medical devices which are subject to legal requirements in terms of infection control

E.T.S.A.

LEGAL REQUIREMENTS FOR SURGICAL TEXTILES ARE SPECIFIED IN EN 13795 SERIES

- Due to their intended use surgical textiles are usually considered to be medical devices and have to meet given essential requirements
- Essential requirements in the Medical Device Directive are specified by the EN 13795 series of European Standards
- EN 13795 brings together current infection control knowledge
- EN 13795 sets minimum requirements for barrier performance, cleanliness and strength

"STATE OF THE ART„ IN SCIENCE AND TECHNOLOGY BECOMES APPLICABLE LAW

- Scientific publications show the correlation between hospital-acquired infections (HAIs) on the one hand and between transmission of infective agents and the barrier effect of surgical textiles on the other hand
- New state-of-the-art knowledge for determining clinical action
- The latest developments in know-how are becoming legally binding requirements under the legislation governing medical devices

E.T.S.A.

EUROPEAN DIRECTIVES BECOMING NATIONAL LAW

- The basic health and safety requirements for medical devices are stipulated in Directive 93/42/EEC governing medical devices
- Implementation into national law makes the provisions of the Directive legally binding at national level
- The Directive's provisions are detailed in technical standards

E.T.S.A.

COMPLIANCE WITH STANDARDS IS RECOMMENDED FOR TWO REASONS

- Standards document latest developments in science and technology – if problems occur, not complying with standards means having acted contrary to better knowledge (also see product liability)
- Compliance with harmonised standards automatically gives a presumption of conformity with the basic health and safety requirements in the European Directive

E.T.S.A.

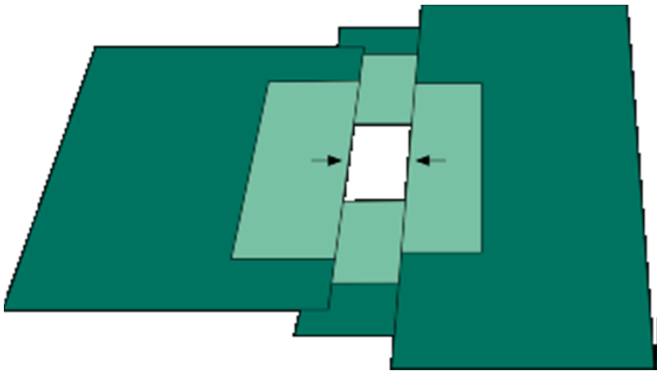
WHAT IF A MEDICAL PRODUCT IS NOT STRICTLY "PLACED ON THE MARKET"?

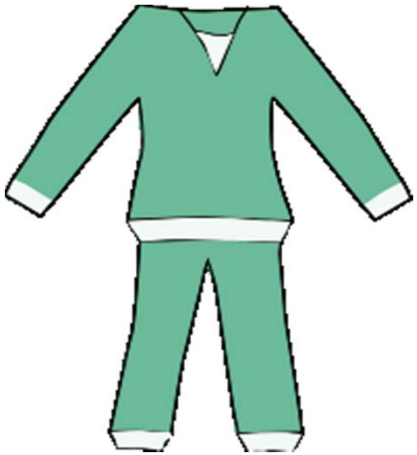
- Although the Directive on medical devices only address at those "placed on the market" …
  - National regulations and good manufacturing practices also govern the *putting into service* of medical devices
  - In 1999, the European Court of Justice upheld a patients claim, rejecting a Danish hospital's argument that device which caused the damage had not been "placed on the market" – and was limited to in-house processing and did not go beyond the hospital.

E.T.S.A.

REQUIREMENTS OF SURGICAL GOWNS AND DRAPES SPECIFIED IN EN 13795

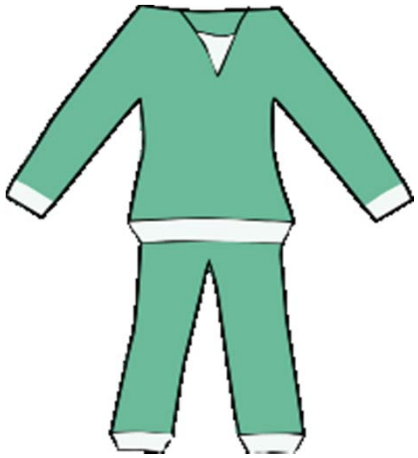
- Surgical drapes, surgical gowns and “clean air suits” are covered





WHAT ARE “CLEAN AIR SUITS”?

- Clean air suits describe a special form of OR clothing which *can be demonstrated* to reduce the particles emitted by the wearer
- This is achieved through materials (with filter effect) and design (e.g. neck/sleeve bands)
- Clean air suits are worn instead of normal working clothes, i.e. also under the OP gown where applicable



E.T.S.A.

REQUIREMENTS FOR THE USE OF REUSABLE AND DISPOSABLE PRODUCTS

- The EN 13795 set of standards specifies performance *requirements for ready-for-use products*
- applying to *reusable and disposable products* and
- which have to be complied with by reusable products *during their "life cycle"* (i.e. not merely when they are new)
- objective: whatever is used in the OR has to meet the requirements

E.T.S.A.

THREE-PART STRUCTURE ENABLES SIMPLE NAVIGATION THROUGH THE STANDARD

- EN 13795 – Surgical drapes, gowns and clean air suits, used as medical devices, for patients, clinical staff and equipment
- Part 1: General requirements for manufacturers, processors and products
- Part 2: Test methods
- Part 3: Performance requirements and performance levels

E.T.S.A.

EN 13795 COMPLETED

- EN 13795 parts 1 and 2 were approved respectively in November 2002 and November 2004 and are now in force
- EN 13795 part 3 was approved in March 2006 and is now also in force

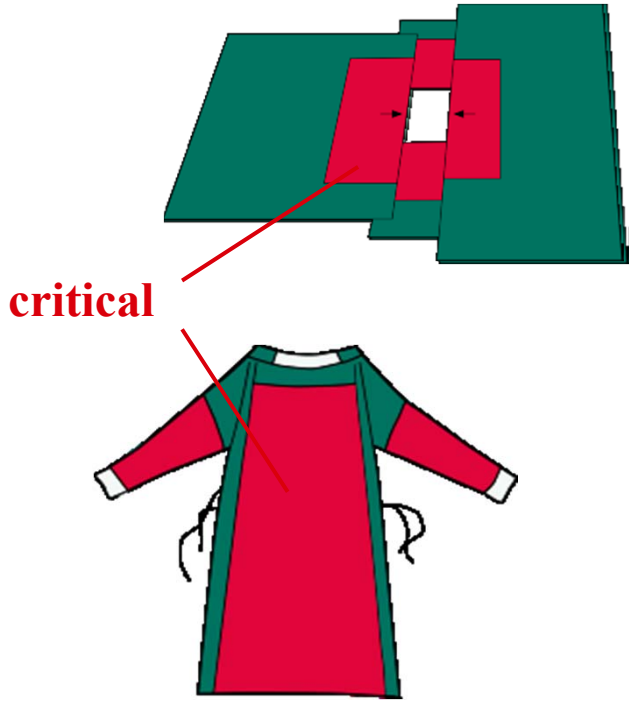
WHAT EN 13795 ACHIEVES

- EN 13795 Part 1
  - + Specifies manufacturing and processing requirements
  - + Specifies the relevant characteristics to be evaluated
  - + Defines information to be supplied by manufacturers/processors about their products (instructions on how operators/users are to handle the products; critical and less critical product areas; test results) and
- thus enables meaningful comparison of products

E.T.S.A.

2 PERFORMANCE LEVELS
2 PRODUCT AREAS

- In recognition of different practical requirements (e.g. dry and wet surgical procedures) EN 13795 distinguishes between two performance levels : “standard” and “high”
- The manufacturer shall also define “critical” and “less critical” product areas



E.T.S.A.

RELEVANT PROPERTIES

Charateristics to be evaluated for		Surgical drapes	Surgical gowns	Clean air suits
Resistance to microbial penetration - dry		X	X	X
Resistance to microbial penetration - wet		X	X	–
Cleanliness – Microbial		X	X	X
Cleanliness - Particulate matter		X	X	X
Linting		X	X	X
Resistance to liquid penetration		X	X	–
Liquid control		(X)*	–	–
Bursting strength	- dry	X	X	X
	- wet	X	X	–
Resistance to tearing	- dry	X	X	X
	- wet	X	X	–
Adhesion for fixation for the purpose of wound isolation		Info. annex	–	–
Comfort		Info. annex	Info. annex	Info. annex

E.T.S.A.

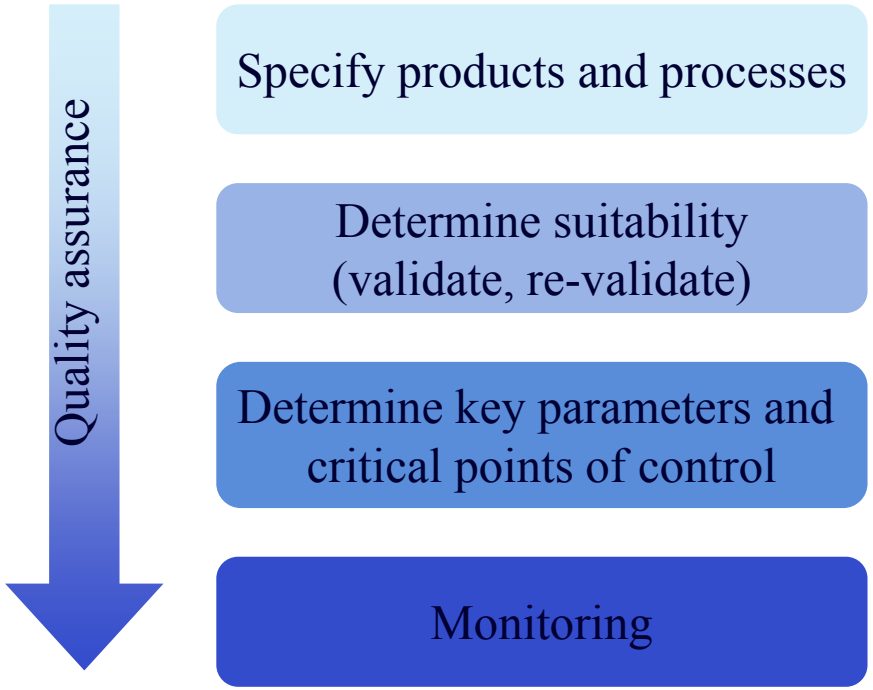
BETTER REUSABLE QUALITY AND QUALITY ASSURANCE

- EN 13795 requires validated processes for manufacturing and processing to ensure compliance of surgical textiles
- Reusables offer additional performance on top of a guaranteed performance
- Studies revealed inconsistency of disposable products and hence the superior quality (= lower variations) of reusables

E.T.S.A.

QUALITY ASSURANCE REQUIRED BY EN 13795

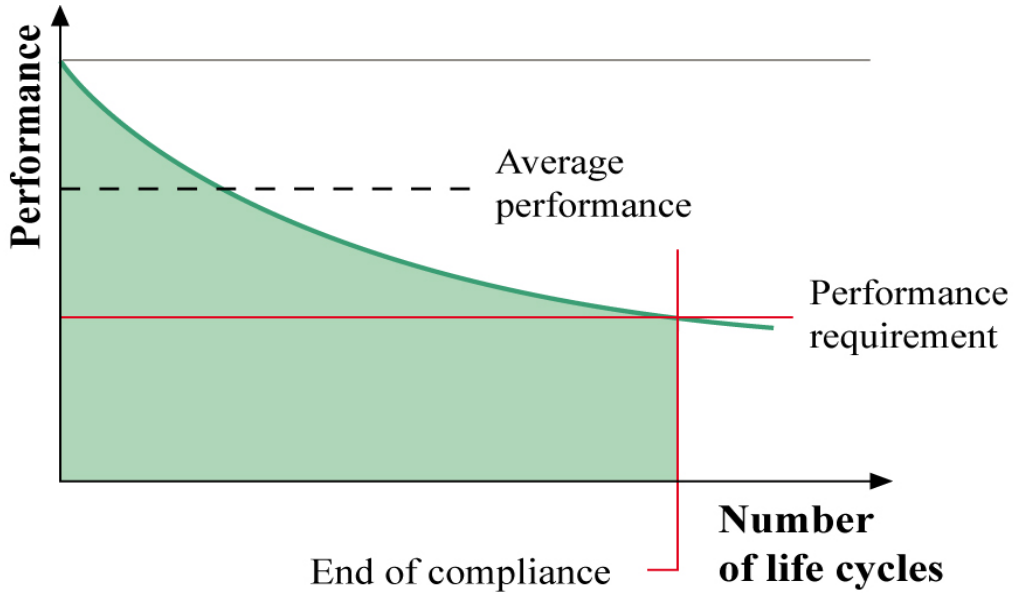
- The standard requires validated procedures for manufacturing and processing as well as a quality assurance system and routine monitoring



E.T.S.A.

REUSABLES OFFER AVERAGE PERFORMANCE BEYOND THE ASSURED PERFORMANCE

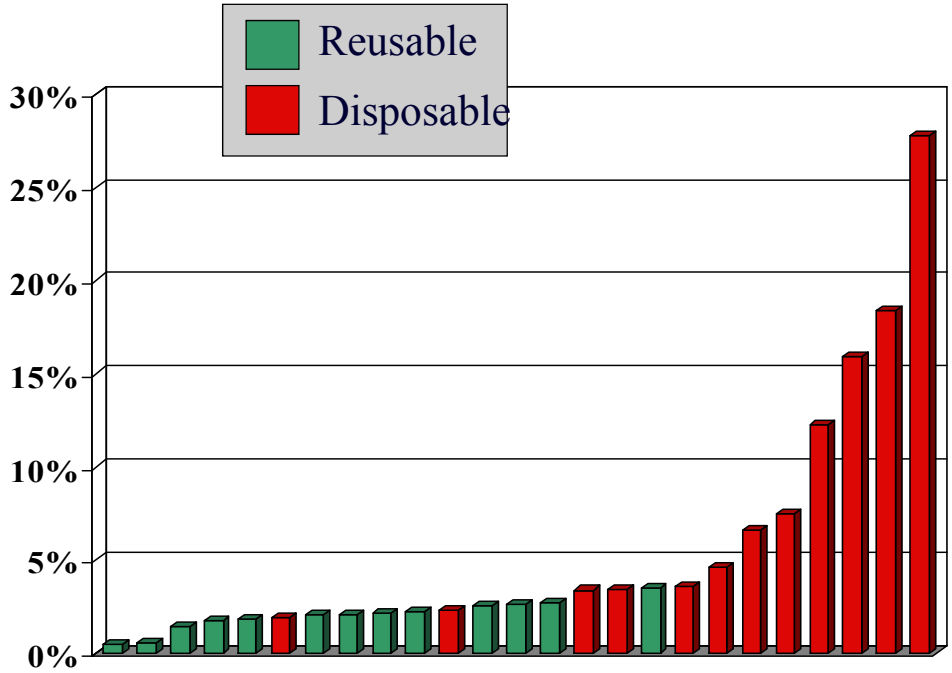
- Validation of reusable products includes service life tests for each property
- Withdrawn from circulation if only one property falls below its limit value
- The average performance of reusables is inevitably much higher than the assured performance



E.T.S.A.

REUSABLE OR TEXTILES PROVIDE MORE CONSISTENT QUALITY

- Measurements of the liquid barrier (according EN 20811) show that reusables vary considerably less (lower coefficient of variation) - their quality is more consistent!



E.T.S.A.

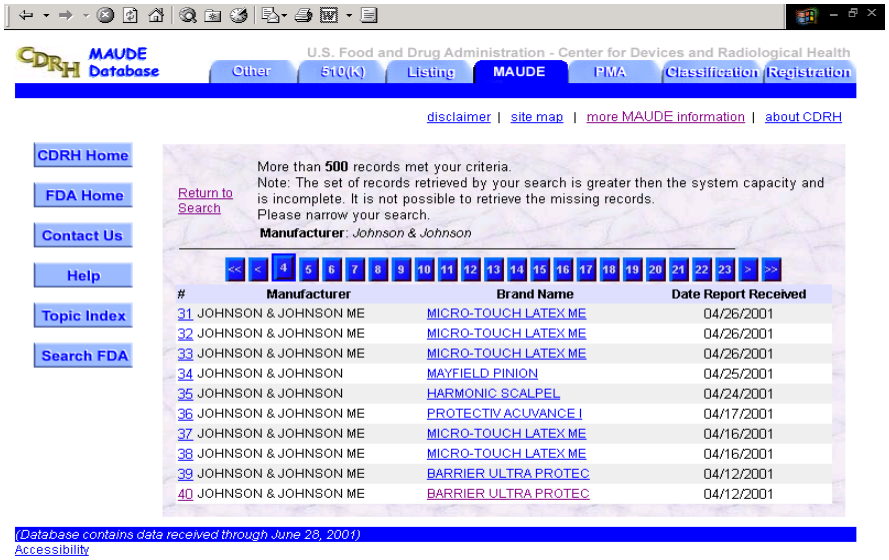
EXPERTS GIVE A CRITICAL ASSESSMENT OF THE QUALITY OF DISPOSABLE PRODUCTS

- "The results indicate that the resistance to liquid penetration performance – sometimes even within the same product – strongly varies, which leads us to expect equally varying degrees of performance in other legally required tests, such as the resistance in the wet microbial penetration test."
- "As a consequence, the widely held opinion that single-use materials are of homogenous quality and inherently "safe" may no longer be sustained."

E.T.S.A.

ERRORS AND INCIDENTS IN DISPOSABLES

- A database search at the FDA (US Food and Drug Administration) produced the following results:
- In 10 years (1992-2001), more than 1000 incidents involving drapes.
- More than 1000 incidents involving gowns.



MAUDE Database

U.S. Food and Drug Administration - Center for Devices and Radiological Health

Other | 510(K) | Listing | MAUDE | PMA | Classification | Registration

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Return to Search

More than **500** records met your criteria.
Note: The set of records retrieved by your search is greater then the system capacity and is incomplete. It is not possible to retrieve the missing records.
Please narrow your search.
Manufacturer: *Johnson & Johnson*

<< < 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 > >>

#	Manufacturer	Brand Name	Date Report Received
31	JOHNSON & JOHNSON ME	MICRO-TOUCH LATEX ME	04/26/2001
32	JOHNSON & JOHNSON ME	MICRO-TOUCH LATEX ME	04/26/2001
33	JOHNSON & JOHNSON ME	MICRO-TOUCH LATEX ME	04/26/2001
34	JOHNSON & JOHNSON	MAYFIELD PINION	04/25/2001
35	JOHNSON & JOHNSON	HARMONIC SCALPEL	04/24/2001
36	JOHNSON & JOHNSON ME	PROTECTIV ACUVANCE I	04/17/2001
37	JOHNSON & JOHNSON ME	MICRO-TOUCH LATEX ME	04/16/2001
38	JOHNSON & JOHNSON ME	MICRO-TOUCH LATEX ME	04/16/2001
39	JOHNSON & JOHNSON ME	BARRIER ULTRA PROTEC	04/12/2001
40	JOHNSON & JOHNSON ME	BARRIER ULTRA PROTEC	04/12/2001

(Database contains data received through June 28, 2001)
Accessibility

E.T.S.A.

E.g. FLUID PENETRATION …

- Product description: Barrier Ultra Protec. Gown
- Supplier: Johnson & Johnson Medical, Inc.
- Report type: Initial
- Account: The surgeon reported penetration of this gown in the area of the sleeves and front during a “bloody” operation. No account of germs contained in the blood or other negative influences.
  The inside of the gown displayed two large blood stains in the hip area, with further traces on the inside of the right sleeve.

E.T.S.A.

SCIENTIFIC STUDIES REVEAL STRENGTHS AND WEAKNESSES OF SURGICAL TEXTILES

- Surgical textiles available on the market were tested for characteristics using test methods listed in EN 13795 (already during its development)
- No single study was able to give a representative picture of surgical textiles available on the market
- Reusable surgical textiles showed impressive performance
- Disposables showed unexpected weaknesses - The myth of disposables was uncovered

E.T.S.A.

INFORMATIVE STUDIES ON THE QUALITY OF SURGICAL TEXTILES

- In addition to a large number of individual reports, three wider-ranging studies provide information concerning the quality of OP textiles available on the market
  - 1996 HygCen for Johnson & Johnson (D)
  - 1999/2000 HygCen for Safec (A, CH, D, I, NL, UK)
  - 2001 HygCen for EDANA (F, UK)
- These studies have in common that they do not claim to be representative in terms of sample size and/or procedure

E.T.S.A.

SCOPE OF THE STUDIES IS DIFFERENT

- While the 1996 and 2001 studies are limited both in regional terms and in their scope, the 1999 study shows a good cross-section throughout Europe.

Study	Reusable			Disposable		
	Manufacturer	Sets	Items	Manufacturer	Sets	Items
1996 (J & J)	7	67		5	14	
1999 (Safec)	19	264	1.191	12	101	359
2001 (EDANA)		68	199		50	125

E.T.S.A.

DIFFERING OBJECTIVES ALLOW LIMITED CONCLUSIONS

- As the random sampling was arranged by the commissioning party in all cases, the studies can hardly be expected to be representative, regardless of the numbers of samples
- Only the SAFEC study gives a relevant overview
- The results already give some facts about the respective quality placed on the market
- The studies show how good or bad reusable and disposable products *can be*

E.T.S.A.

SCIENTIFICALLY DEMONSTRATED PERFORMANCE OF SURGICAL TEXTILES IN MAIN PERFORMANCE CATEGORIES

- Barrier effect (resistance to microbial and liquid penetration)
- Cleanliness
- Linting
- Strength
- Comfort
- Environmental
- Functionality
- Cost efficiency

E.T.S.A.

BARRIER EFFECT

- The barrier effect is a central function of OR textiles. This is tested in three ways:
  - + microbial barrier in a dry state
  - + microbial barrier in a wet state
  - + liquid barrier
- Reusable and disposable products are more or less comparable in this respect. The quality does not therefore depend on whether a product is simply reusable or disposable.

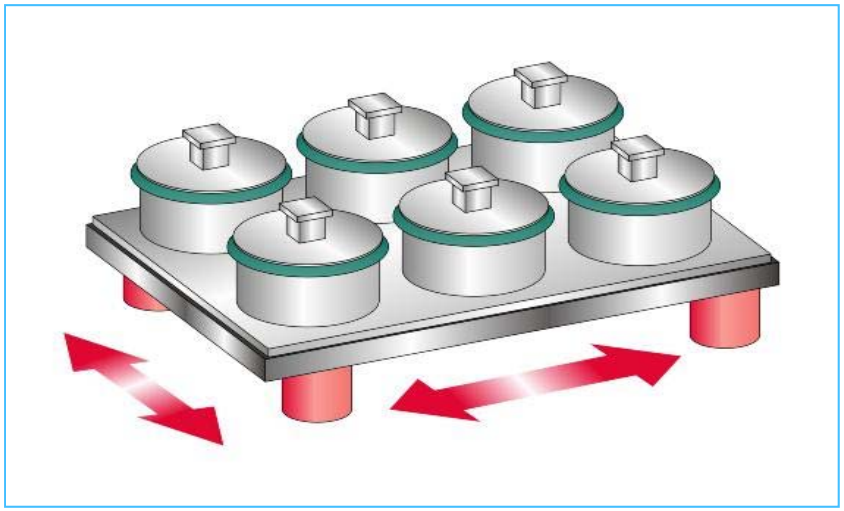
E.T.S.A.

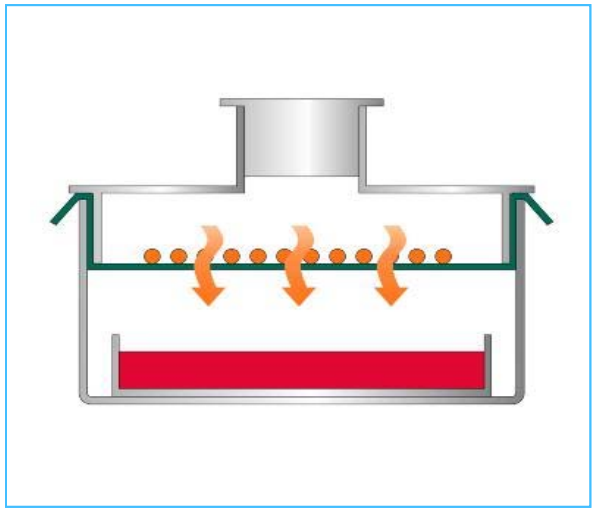
MICROBIAL BARRIER IN DRY STATE

- Test procedure standardised as per EN ISO 22612
- Development on the basis of EDANA 190
- Identifies the dry filter effect to a certain extent (which is not otherwise tested)
- Costly, destructive test method, not suitable for monitoring
- No substantial results available as yet (not considered in published studies)

E.T.S.A.

EDANA 190 / EN ISO 22612



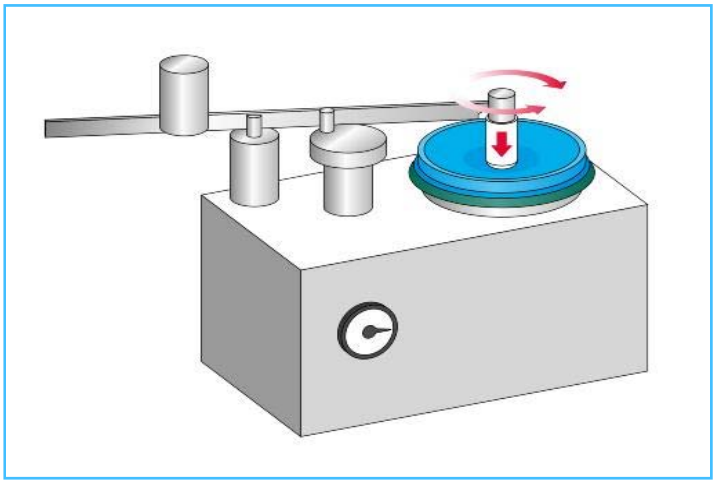


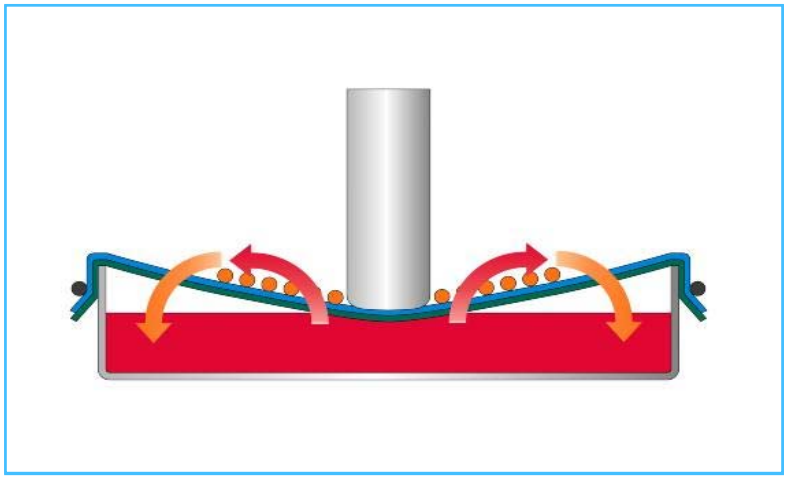
MICROBIAL BARRIER IN WET STATE

- Test procedure standardised as per EN ISO 22610:2005
- Development on the basis of Swedish Standard SS 8760019
- Practical method, takes account of wet conditions, mechanical action and time
- Destructive method, not suitable for monitoring
- Problems with comparing results over different years
- Test method could still be improved – immediate revision likely

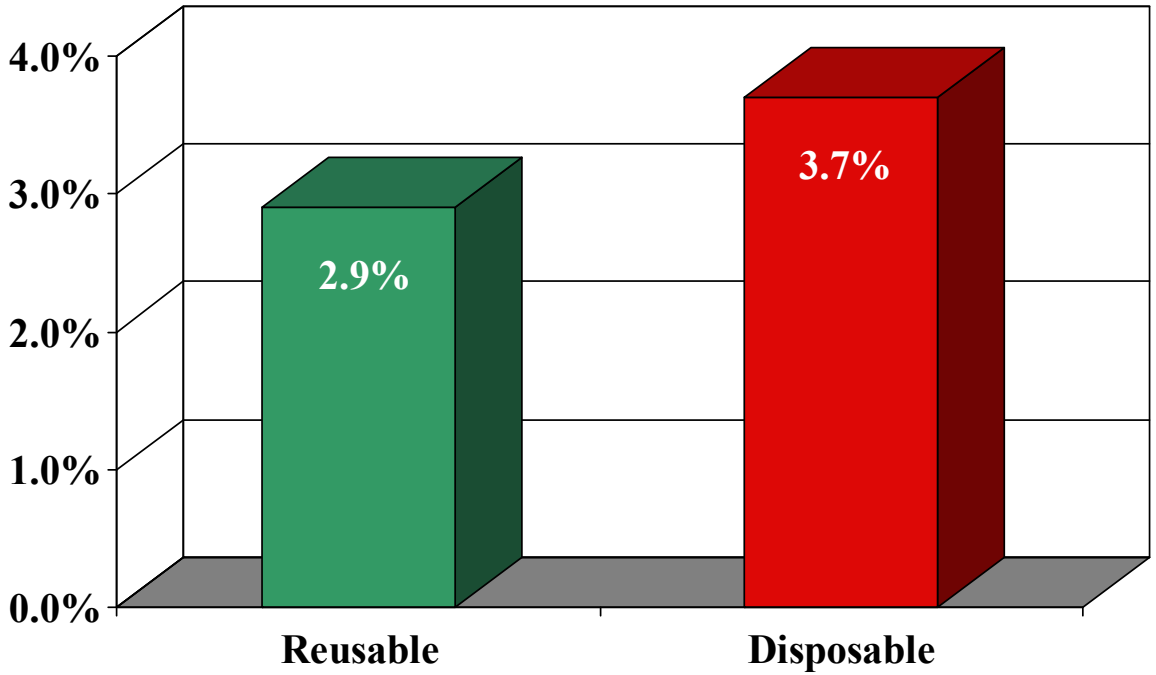
SS 8760019 / EN ISO 22610

- The method simulates bacterial penetration in practice: agar and bacteria are on different sides of the material





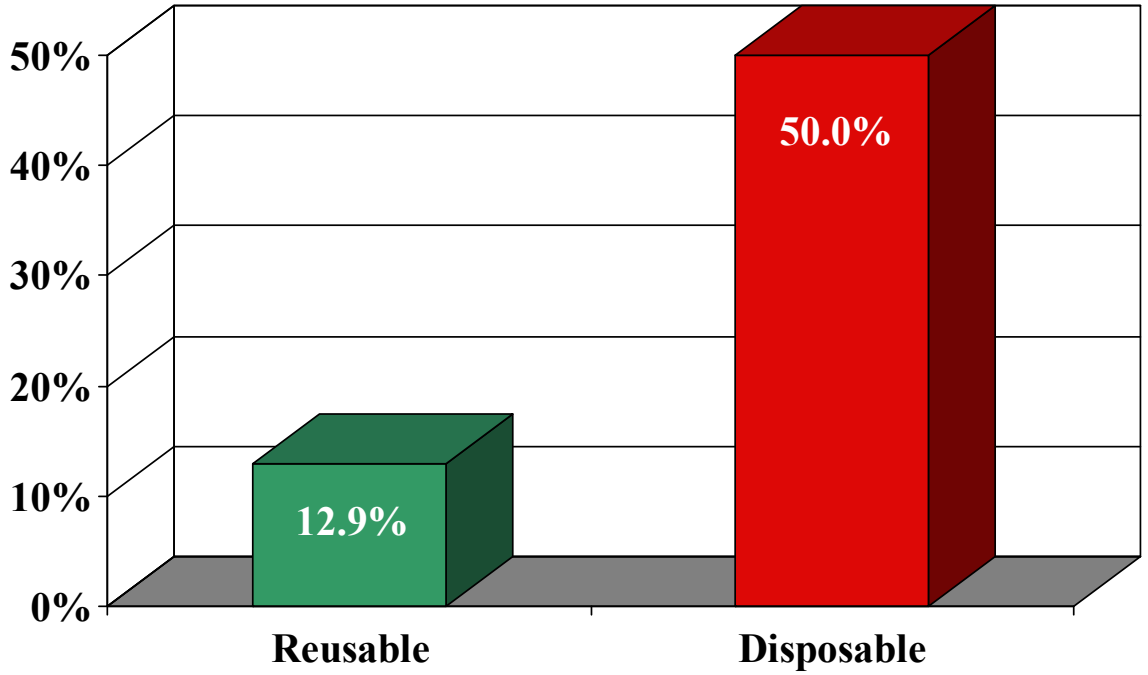
REUSABLE ITEMS BETTER FOR OR DRAPES



Percentage of surgical drapes with bacterial penetrations in the area close to the wound: reusable items display less penetration

E.T.S.A.

REUSABLE ITEMS FAR BETTER FOR OR GOWNS



Percentage of "high" performance surgical gowns (front and sleeves) with bacterial penetration: reusable items show considerably less penetration

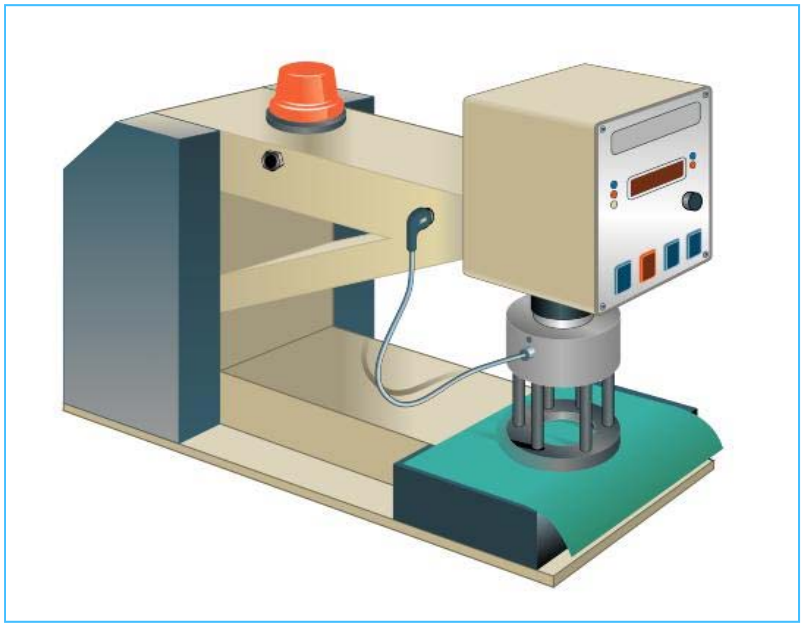
E.T.S.A.

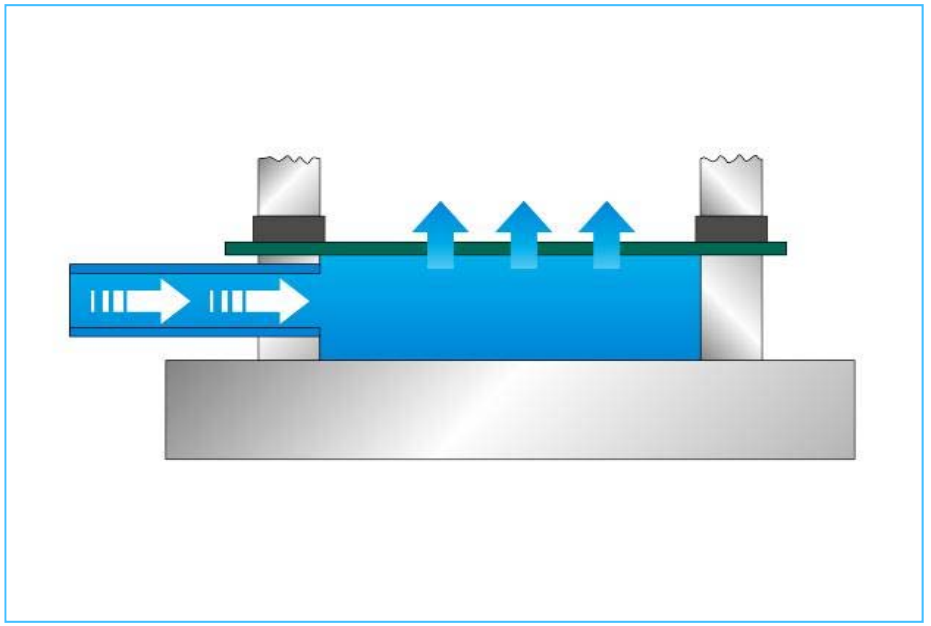
LIQUID BARRIER

- EN 20811 – Resistance to water penetration
- Also known as hydrostatic head test
- Proven test method with high level of reproducibility and comparability with “old” results
- The method is non-destructive and easy to manage: ideal test procedure for monitoring

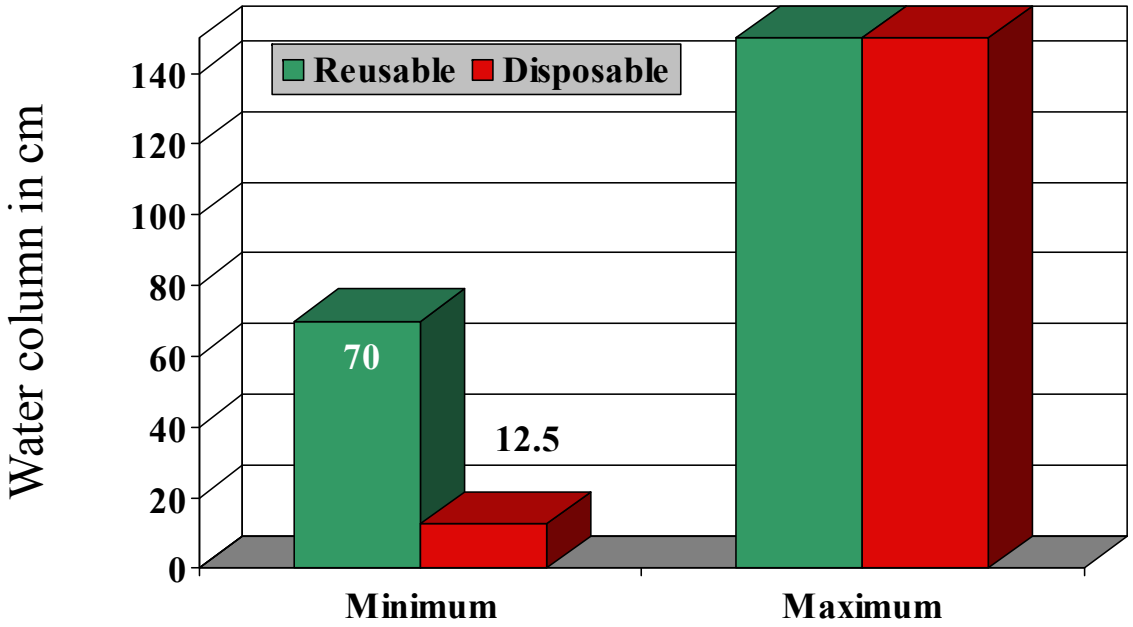
E.T.S.A.

EN 20811 - LIQUID BARRIER





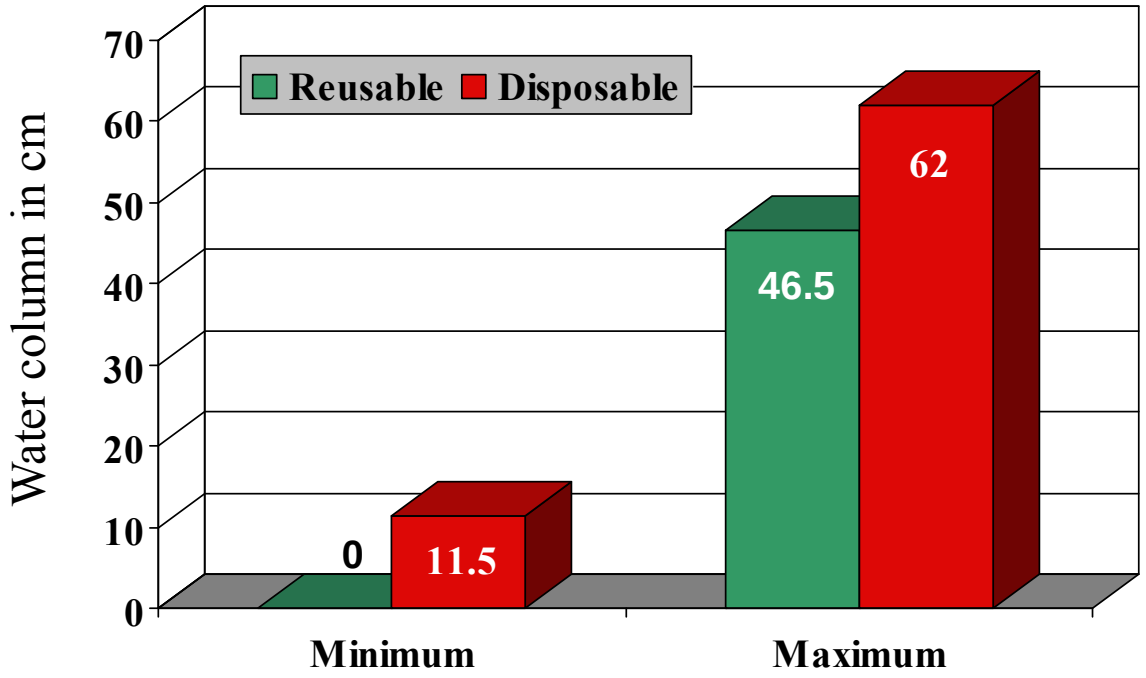
REUSABLE ITEMS BETTER IN THE CRITICAL AREA OF SURGICAL DRAPES



Significantly higher minimum level for the liquid barrier measured on reusable surgical drapes in the critical area (close to the wound)

E.T.S.A.

REUSABLE ITEMS WEAKER IN AREA OF SURGICAL DRAPES FAR FROM THE WOUND



Lower minimum and maximum level for reusables for the liquid barrier, measured on surgical drapes in the less critical area (far from the wound), including the seam with the area close to the wound

E.T.S.A.

MICROBIAL CLEANLINESS (BIOBURDEN)

- "Bioburden" is the microbial cleanliness (population of micro-organisms) of a product *before sterilisation*
- This test must be carried out in association with the validation of sterilisation
- Bioburden is an indicator of cleanliness and decontamination in manufacturing and reprocessing
- Testing is conducted in accordance with EN 1174 (Part 2, clause 5.2.4.2)

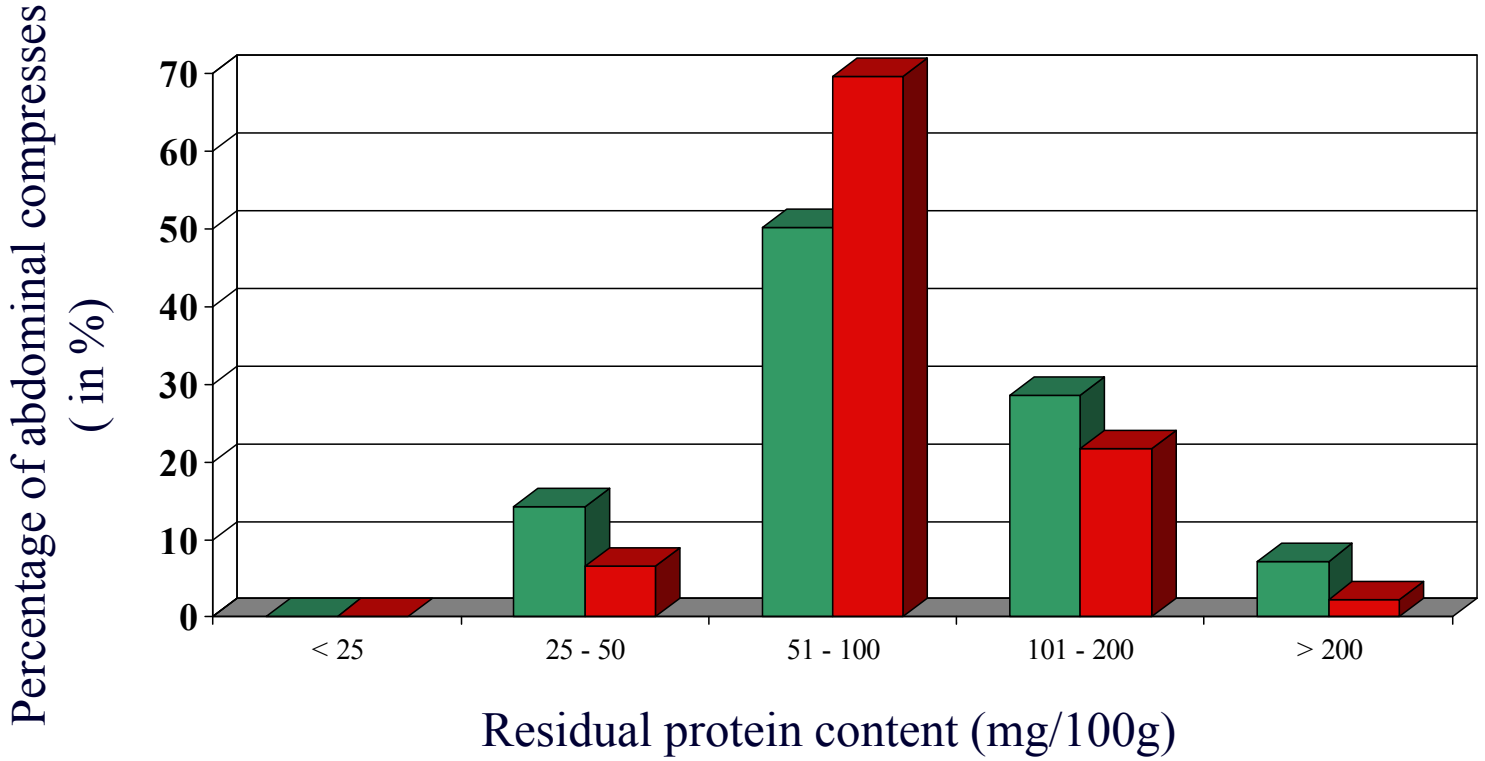
E.T.S.A.

COMPARATIVE TEST RESULTS NOT PUBLISHED SO FAR

- Clause 5.2.4.2 specifies a stomachal procedure, contact plating is not permissible...
- EN 1174 does not stipulate any specific parameters for the test method, rather only basic principles (measuring principle and validation)
- The procedure can be applied non-destructively and is therefore also suitable for monitoring
- There is no published data available for single-use products

E.T.S.A.

COMPARABLE LEVELS OF RESIDUAL PROTEIN FOR REUSABLE AND DISPOSABLE ABDOMINAL SWABS



E.T.S.A.

NO MAJOR RISK THROUGH REUSABLE ITEMS IN RELATION TO CJD

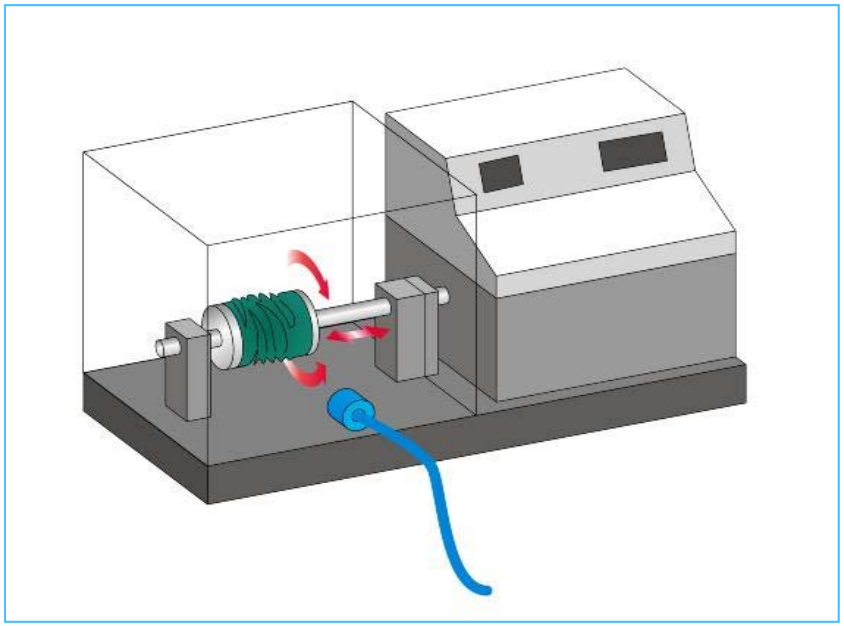
- Experts consider it practically impossible in clinically unrecognisable suspected cases of CJD (Creutzfeld-Jacob Disease) for the disease to be transmitted via reusable OR textiles
- “The use of reusable laundry in the operating theatre is not associated with any danger of the transmission of CJD”
- The prerequisite for this is reprocessing using standardised cleaning and sterilisation methods

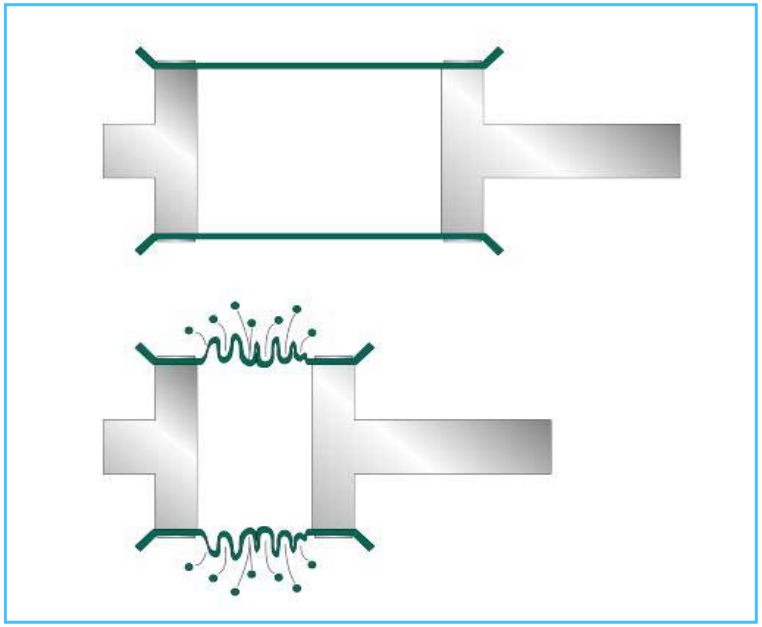
E.T.S.A.

PARTICLE EMISSION

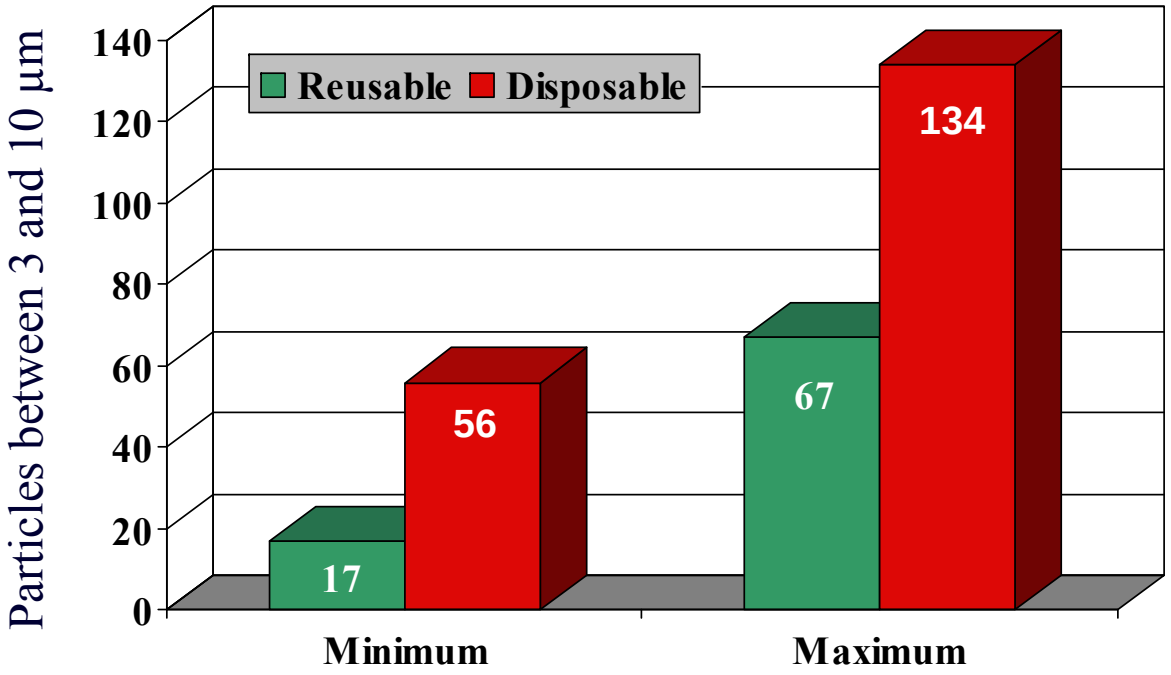
- Distinction is made between fabric (“linting”) and foreign particles (“particulate matter”)
- Both types of particle emission are considered to be equal with regard to their medical relevance, i.e. as potential carriers of micro-organisms and causes of foreign-body reactions
- Particulate matter is calculated from the particle counts during the first 90 seconds

EDANA 220 / ISO 9073-10





REUSABLE ITEMS EMIT FEWER PARTICLES



Reusable items emit substantially lower minimum and maximum levels of particles

E.T.S.A.

STRENGTH

- The strength of surgical textiles is especially important because they are subjected to high mechanical stress levels when used
- Even the best possible barrier properties are of little use if the material tears or bursts during use
- In the standard, strength is measured in two ways :
  - + bursting strength
  - + tensile strength
- Reusable products perform better in both categories

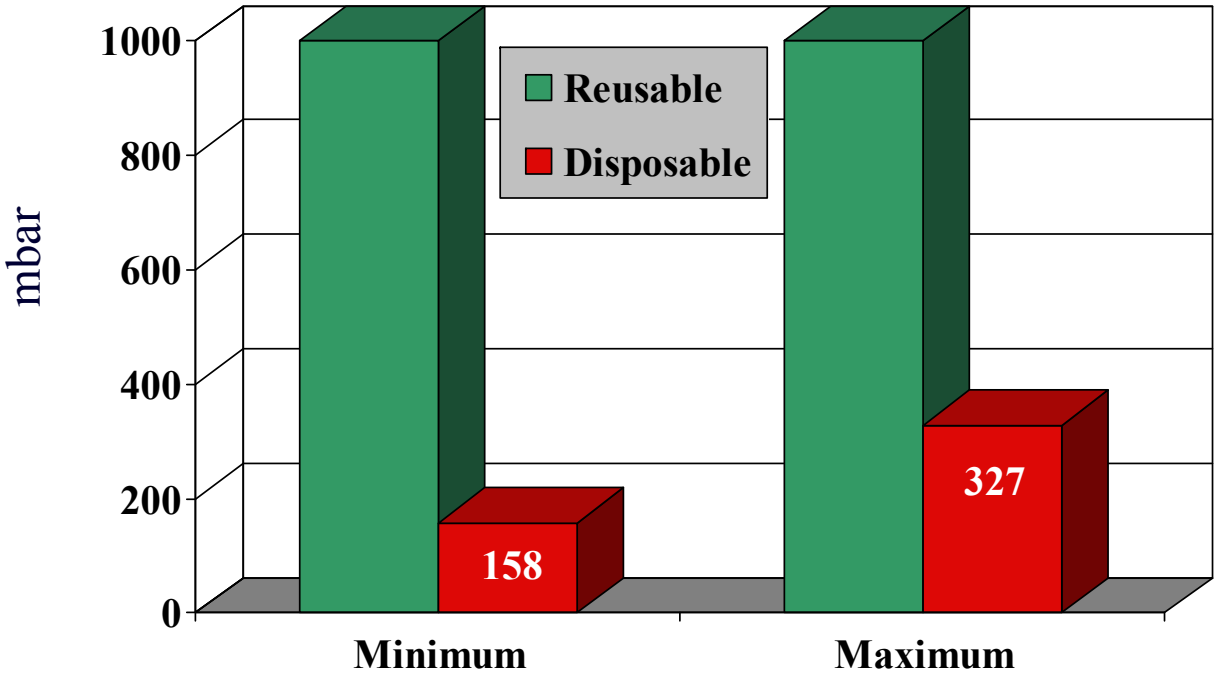
E.T.S.A.

BURSTING STRENGTH

- Bursting strength describes the strength of the product in all directions of the material
- Heavy mechanical action, e.g. bent arm at elbow
- It is measured in a dry and a wet state in accordance with EN 13938-1

E.T.S.A.

REUSABLES BEYOND THE MEASURING LIMIT IN ALL CASES



Reusable products offer substantially higher bursting strength than disposable products both for minimum and maximum performance levels

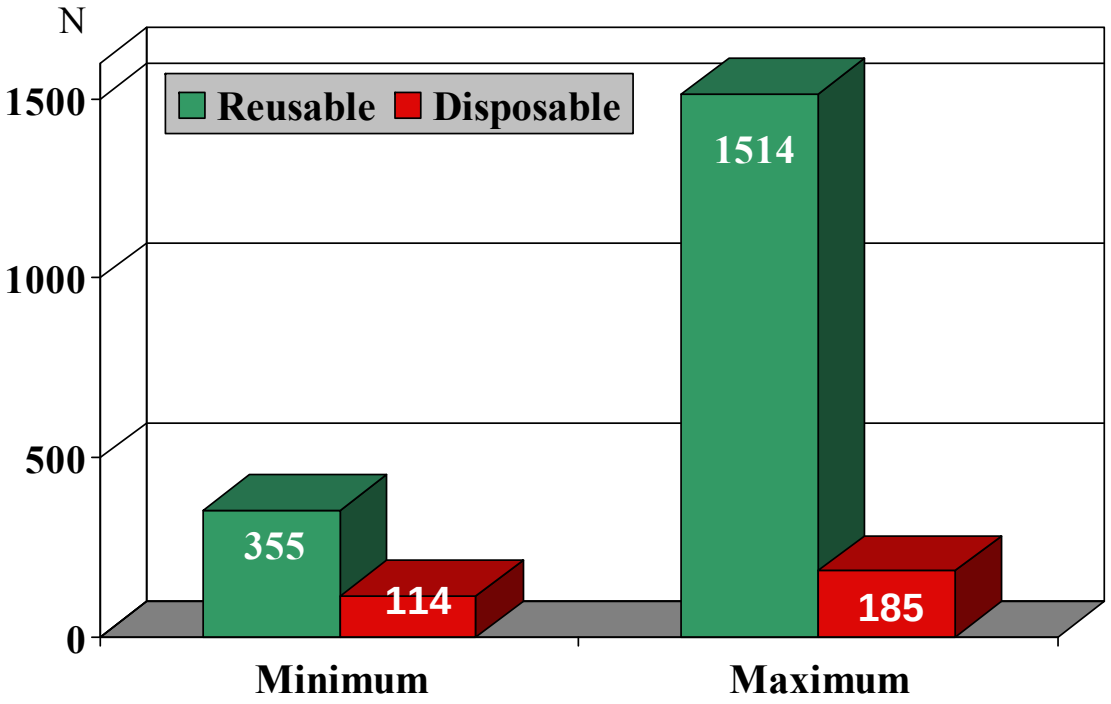
E.T.S.A.

TENSILE STRENGHT

- Resistance to tearing describes the strength of the product in the longitudinal (machine or warp) and horizontal direction (weft)
- For example, as surgeon bends forward, the gown can be stretched in different directions at shoulder and back
- It is measured in a dry and a wet state in accordance with EN 29073-3

E.T.S.A.

WEAKEST REUSABLES CONSIDERABLY BETTER THAN DISPOSABLES



Even weak reusable products offer considerably higher resistance to tearing than disposable products

E.T.S.A.

COMFORT

- Wear comfort is not just a convenience; it is a physiological requirement
- It is of particular concern to the OR team, whose efficiency needs to be supported rather than impaired
- However, the drape should also offer adequate physiological comfort in order to benefit the patient (EN 13795-1)
- If this is not the case, additional help is often given in the form of increased medication or blankets
- Wear comfort is measured in accordance with EN 31092 (skin model) by calculating water vapour transfer resistance R_{et}

E.T.S.A.

PHYSIOLOGICAL REQUIREMENT PROFILE FAVOURS REUSABLES

Rating	**Requirement value** in m^2Pa/W	**Properties**	**Products**
Very good	$R_{et\ B} \leq 8$	Can be used in burn-related ORs (approx. 32°C)	Microfibres, non-wovens, laminates
Good	$8 < R_{et\ B} < 17$	Adequate comfort in normal ORs	Laminates
Satisfactory	$17 < R_{et\ B} < 40$ or $R_{et\ R} < 4$	Acceptable discomfort in normal ORs	Laminates
Unsatisfactory	$R_{et\ B} > 40$ and $R_{et\ R} > 4$	Excessive heat stress	Foil laminates

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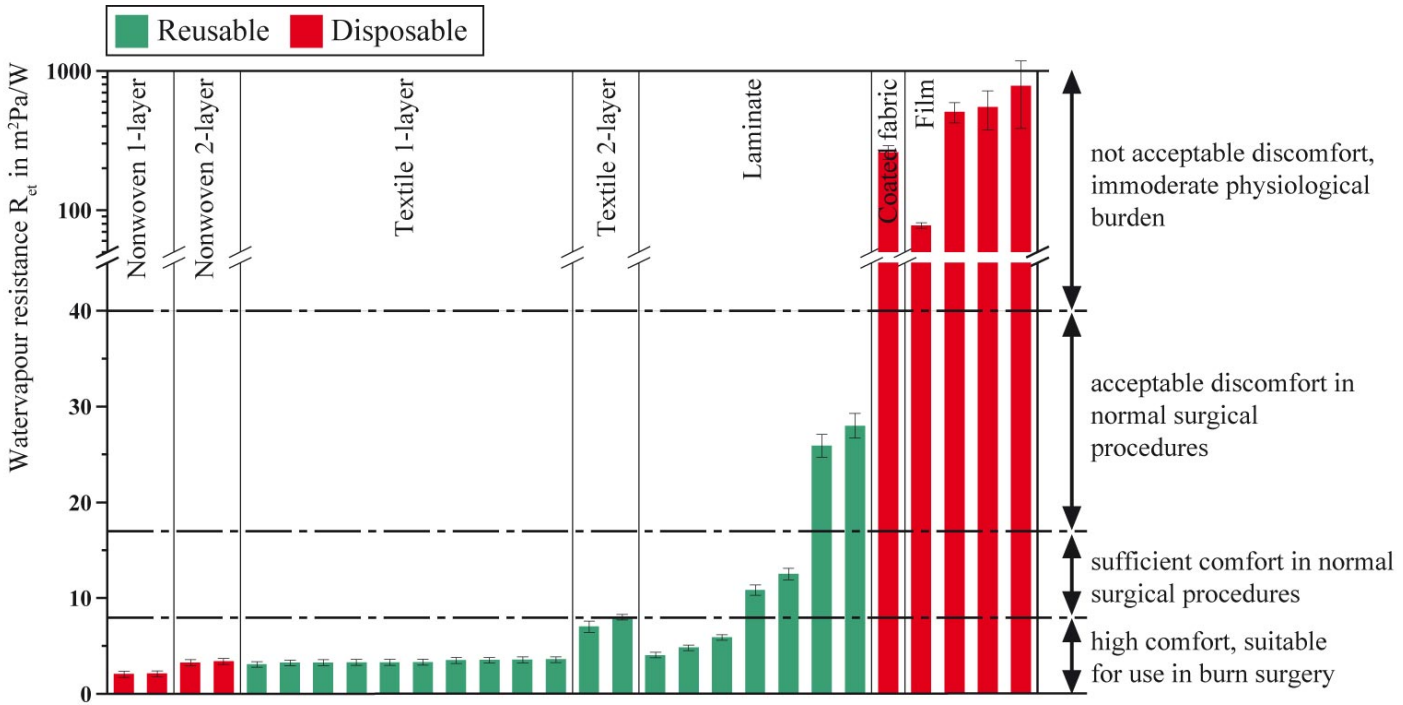
REUSABLE PRODUCTS PROVIDE MORE COMFORT



Comfort (or discomfort respectively) of various surgical textiles from nonwovens without significant barrier to laminates and films with high barrier performance

E.T.S.A.

ENVIRONMENTAL IMPACT IS MEASURED IN A LIFE-CYCLE ANALYSIS

- The environmental impact of products and their resource consumption are taken very seriously and assessed extensively at both national and international level
- In order to obtain rigorous data, environmental impacts are now determined in accordance with standardised procedures
- Yesterday's "ecobalance" has become today's "life-cycle analysis"

E.T.S.A.

BASICS OF LIFE-CYCLE ANALYSES

- Carried out in accordance with the ISO 14040 series of standards
- Extensive ecological examination: products as systems with defined system limits
- Comparison of functionally equivalent products
- Determination of data (dependability and relevance)
- Differentiated overall assessment

E.T.S.A.

METHODOLOGY AND ANALYSIS

- **Inventory**
  - Consumption of energy resources in MJ
  - Consumption of raw material resources in g
  - Emissions into the air in g
  - Emissions into the water in g
  - Waste quantities in g
- **Impact categories**
  - Consumption of renewable and non-renewable energy in MJ
  - Global warming (greenhouse effect) in kg of CO_2 equivalent
  - Acid rain in g of SO_2 equivalent
  - Eutrophication (nutrient pollution) in g of phosphate equivalent

E.T.S.A.

TESTING THE ENVIRONMENTAL IMPACT OF SURGICAL GOWNS

- Test conducted by dk-TEKNIK Energy & Environment, Denmark for E.T.S.A., Brussels
- Life-cycle analysis of surgical gowns in accordance with the ISO 14040 series of standards
- Data sources:
  - for reusable products: literature and member information (practically relevant)
  - for disposable products: literature

E.T.S.A.

3 REUSABLE AND 2 DISPOSABLE SURGICAL GOWNS TESTED

- Types of gown examined:
  - 50/50% CO/PES/FC (blended fabric, reusable)
  - 100% PES/FC (microfibre, reusable)
  - PES/laminate (Gore® and PU, reusable)
  - Pulp/PES/FC (disposable)
  - Pulp/PES/PE (film, disposable)
- All gowns comply with the relevant directives and standards

E.T.S.A.

"BEST CASE" AND "WORST CASE" SCENARIOS

Products	Best case	Worst case
Disposable	Waste incineration with heat recovery Sterilisation with lowest energy consumption	Waste incineration without heat recovery Sterilisation with highest energy consumption
Reusable	Waste incineration with heat recovery Processing with lowest energy consumption	Waste incineration without heat recovery Processing with highest energy consumption

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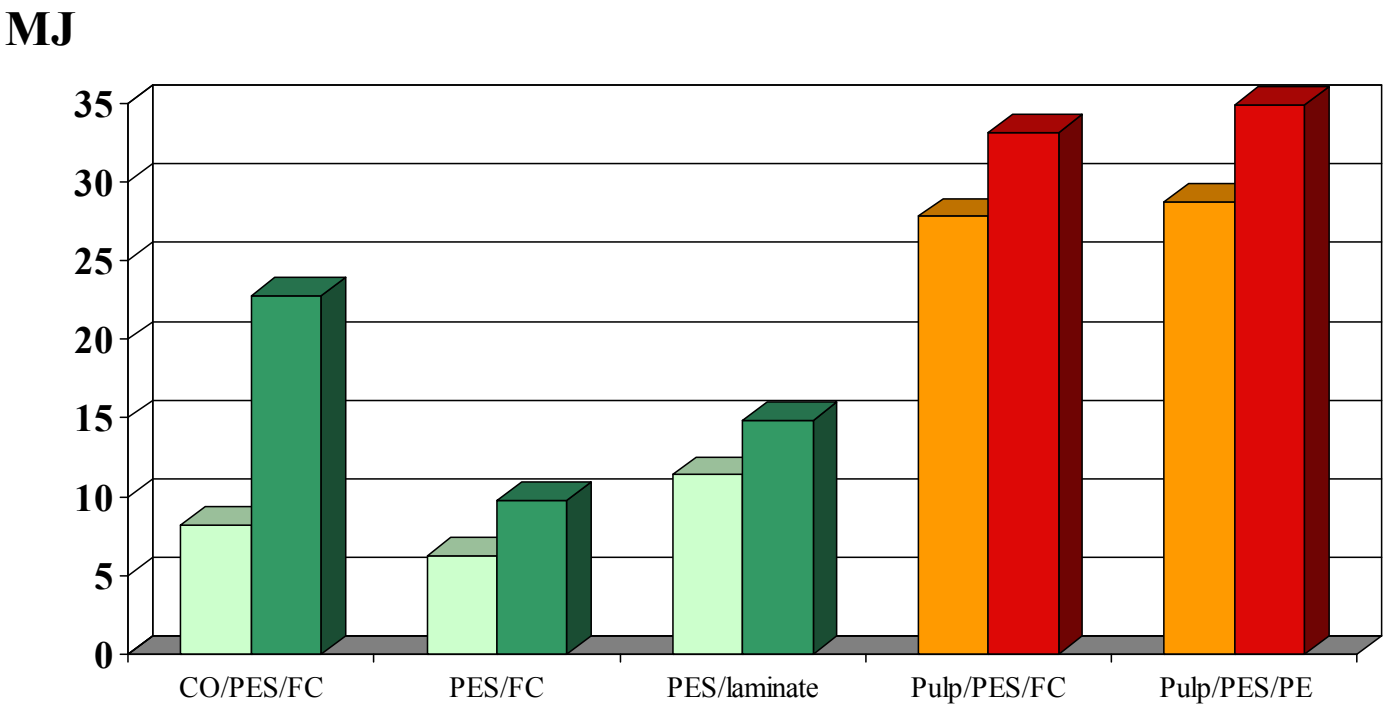
REUSABLES USE LESS ENERGY



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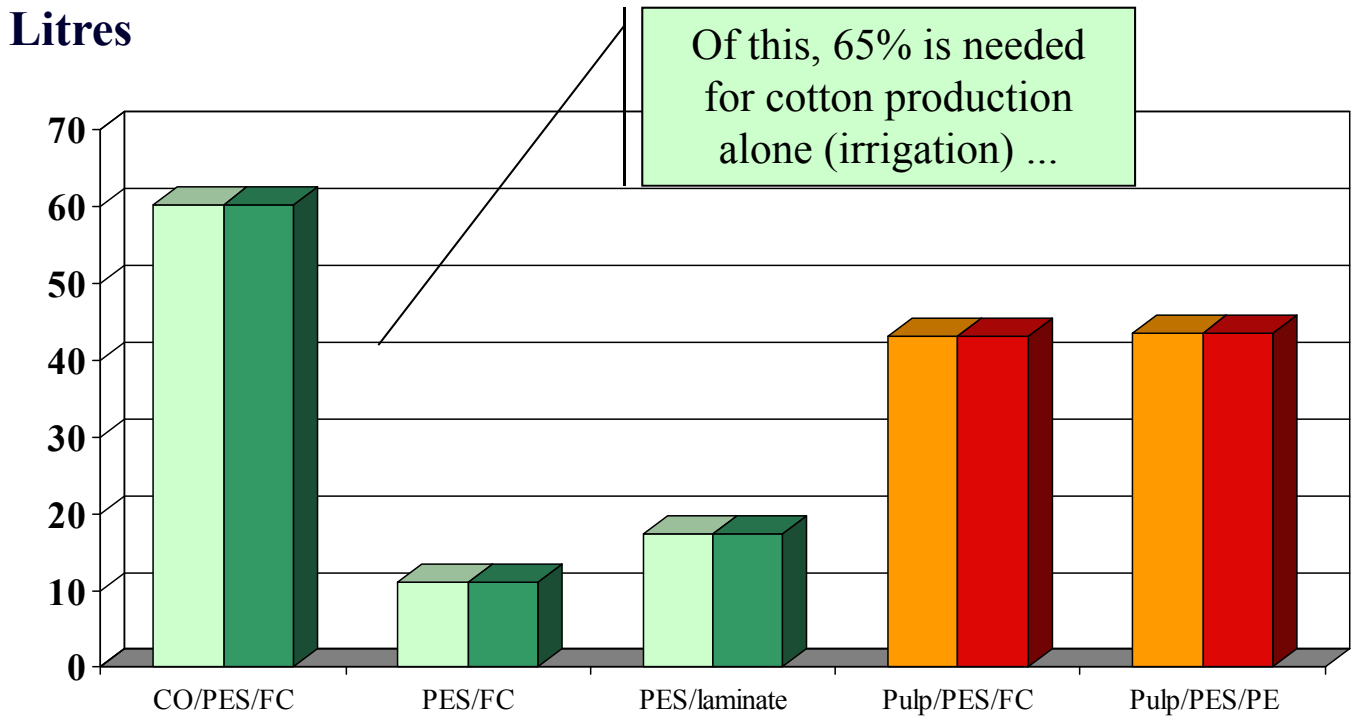
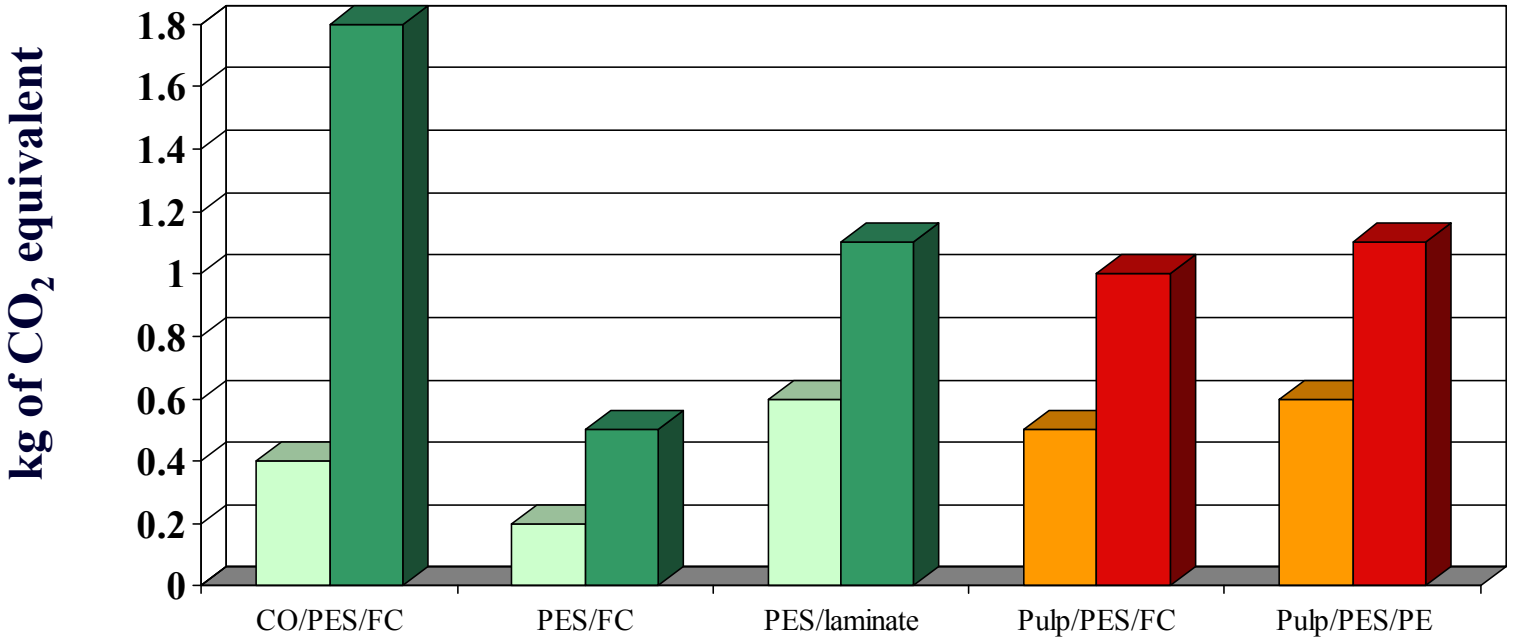
MODERN REUSABLES USE LESS WATER



E.T.S.A.

MODERN REUSABLES DO WELL ON GREENHOUSE EFFECT



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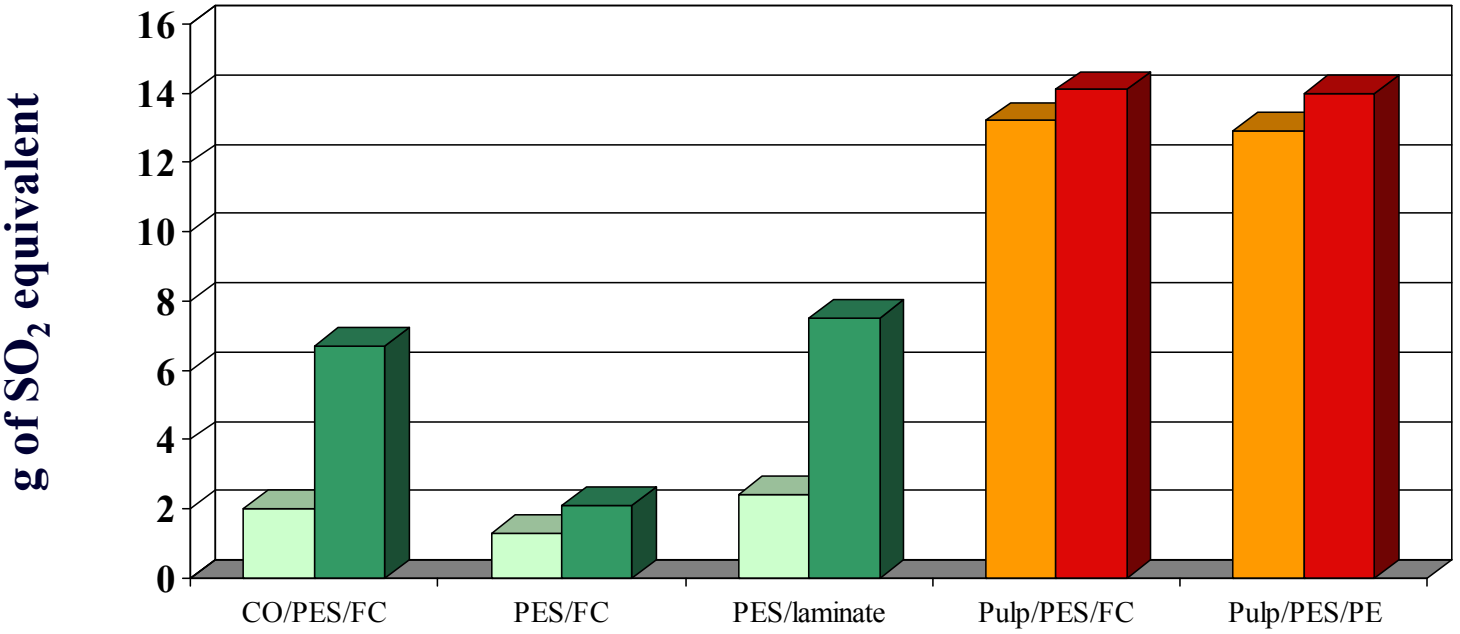
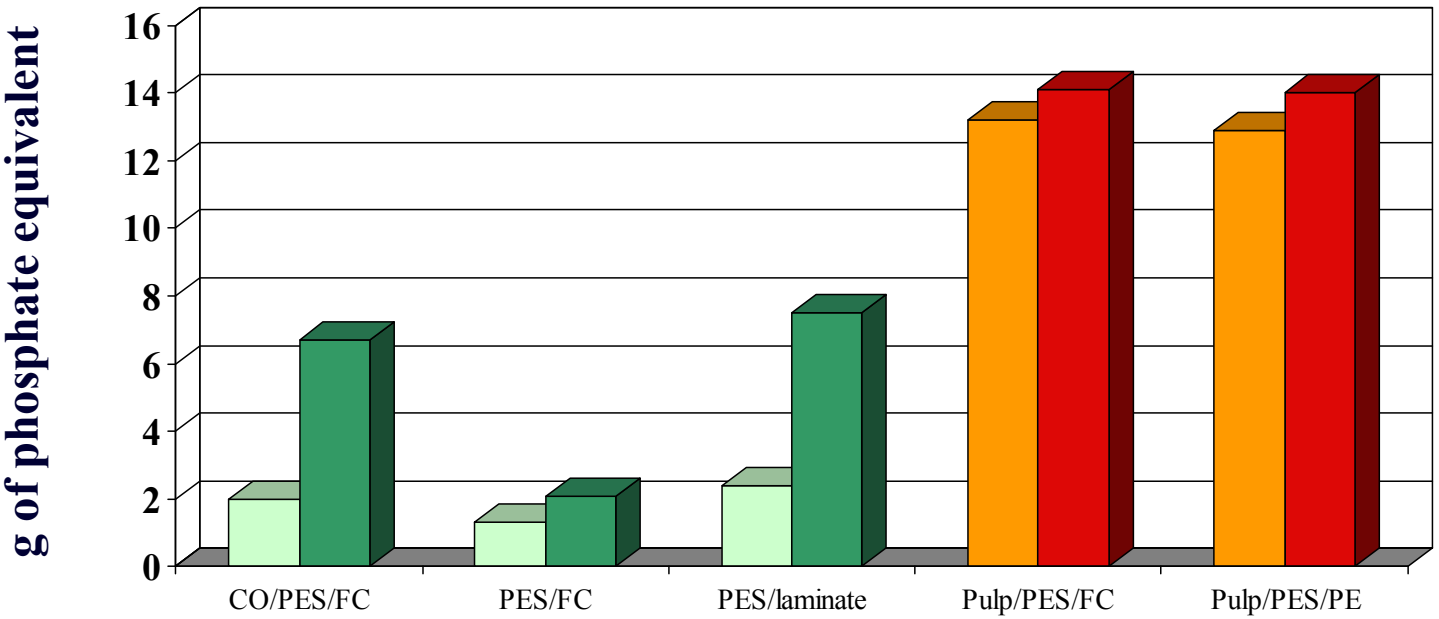
REUSABLES CAUSE LESS ACID RAIN



E.T.S.A.

LOWER IMPACT OF REUSABLES ON EUTROPHICATION (NUTRIENT POLLUTION IN WATER)



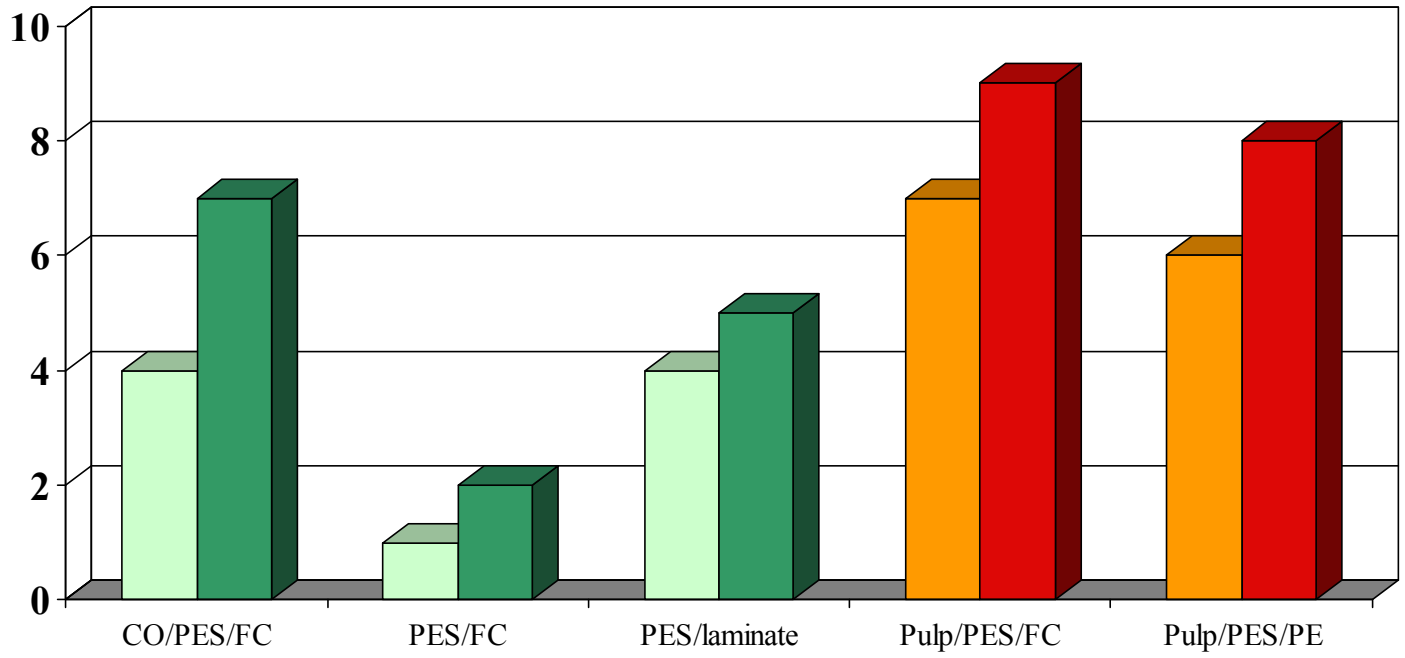
E.T.S.A.

ADDITIONAL FINDINGS

- Packaging materials have a considerable impact
- Service lifetime of a surgical gown has a moderate to major influence
- Detergents and washing chemicals have only a moderate influence
- Rewashing and the distance from customers has only a minor influence
- Disposal methods are less relevant for reusables than for disposables

E.T.S.A.

OVERALL, REUSABLES ARE FAR KINDER TO THE ENVIRONMENT



E.T.S.A.

FUNCTIONALITY OF SURGICAL TEXTILES

- Modern surgical textiles not only offer safety; they also have high functionality
- Application-specific materials, compresses and sets, application-oriented packing sequence and folding are now standard for reusable and disposable systems
- Both types of product are easy to handle

COMPREHENSIVE INTEGRATION OF LOGISTICS CHAIN THROUGH REUSABLES

- Process costs are often considerable, especially in large, complex organisations – like hospitals – and can be many times higher than production costs
- Providers of disposables sometimes offer combinations of their products as complete surgical sets (CPT) in order to optimise logistics
- Some providers of reusable products also offer to take over the entire logistics process

COST EFFECTIVENESS ON A CASE-BY-CASE BASIS

- Difficult to generalise conclusions of sporadic publications claiming greater economic efficiency on the part of respective product and service suppliers
- Individual cases seeking the most economical solution need individual assessment
- At the national economic level, providers of reusables make a substantially higher contribution to the value added in their country

E.T.S.A.

OVERALL COMPARISON BETWEEN REUSABLES AND DISPOSABLES

	High-tech reusable	Cotton reusable	Disposable
Barrier effect	+	–	+
Cleanliness	+	+	?
Particle emission	+	–	–
Strength	+	+	–
Thermal management	+	–	–
Comfort/breathability	+	+	–
Environmental impact	+	+/–	–
Functionality	+	–	+
Cost effectiveness	+/–	+/–	+/–
Value for money	+	–	+/–
Balance	**9**	**3**	**2**

E.T.S.A.