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Major Article

Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives

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Background: Isolation gowns serve a critical role in infection control by protecting healthcare workers, visitors, and patients from the transfer of microorganisms and body fluids. The decision of whether to use a reusable or disposable garment system is a selection process based on factors including sustainability, barrier effectiveness, cost, and comfort. Environmental sustainability is increasingly being used in the decision-making process. Life cycle assessment is the most comprehensive and widely used tool used to evaluate environmental performance.

Methods: The environmental impacts of market-representative reusable and disposable isolation gown systems were compared using standard life cycle assessment procedures. The basis of comparison was 1,000 isolation gown uses in a healthcare setting. The scope included the manufacture, use, and end-of-life stages of the gown systems.

Results: At the healthcare facility, compared to the disposable gown system, the reusable gown system showed a 28% reduction in energy consumption, a 30% reduction in greenhouse gas emissions, a 41% reduction in blue water consumption, and a 93% reduction in solid waste generation.

Conclusions: Selecting reusable garment systems may result in significant environmental benefits compared to selecting disposable garment systems. By selecting reusable isolation gowns, healthcare facilities can add these quantitative benefits directly to their sustainability scorecards.

BACKGROUND

Isolation gowns serve a critical role in infection control by protecting healthcare workers, visitors, and patients from the transfer of microorganisms and body fluids in isolation settings. These gowns and other medical textiles are available in reusable and disposable alternatives. The selection of a reusable or disposable textile system for use in hospitals is a decision that depends on factors such as barrier effectiveness, cost, comfort, and sustainability.[1-3]

The barrier effectiveness, cost, and comfort of isolation gowns have been covered previously in the literature. The American National Standards Institute (ANSI) and the Association for the Advancement of Medical Instrumentation (AAMI) have established standards to quantify the liquid-barrier performance of isolation gowns and other medical textiles.[4] A reusable gown and a disposable gown with the same barrier rating are expected to exhibit similar barrier effectiveness. A recent case study showed that reusable isolation gown systems resulted in a 30% reduction in costs compared to disposable gown systems.[5] Similar case studies have shown that reusable operating room linens, surgical packs, and towels provide significant cost savings compared to disposable alternatives.[1,6-8] The evaluation of the comfort of isolation gowns is complex and involves human perception. Although individual features of isolation gowns have been found to affect hospital staff and visitor compliance, whether a gown is reusable or disposable has been found to have little to no impact on compliance.[9]

Sustainability is a significant factor to consider when selecting between reusable and disposable textile systems. Previous environmental studies have focused on surgical gowns and packs, with isolation gown systems being largely ignored.[10-12] As hospitals and healthcare providers move toward more sustainable or "green" practices, publicly available, transparent environmental information is needed to support product decisions.

Comparative life cycle studies by McDowell[10], Carre[13], Van den Berghe and Zimmer[14], and Overcash[12] compared reusable and disposable surgical gown systems. A study by Jewell and Wentsel[15] compared reusable and disposable isolation gown, automotive wiper,

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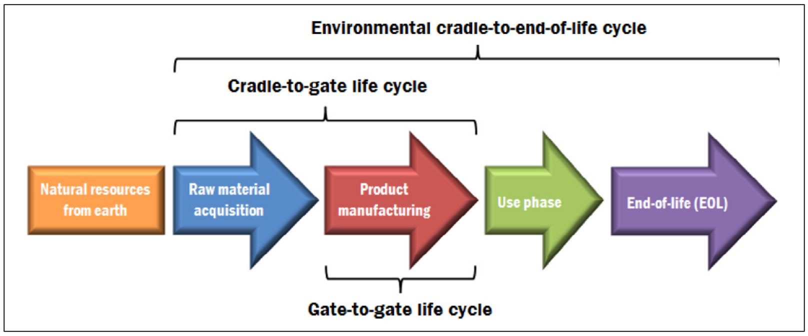

Fig 1. Life cycle scope for product analysis

and restaurant napkin systems. All five of these studies found that reusable textile systems provided substantially better environmental profiles than disposable systems. However, analysis of these available life cycle data is often limited by the transparency and depth of information in these respective reports. Thus, the objectives of this study were (1) to compare 4 environmental impacts (energy, global warming potential, water use, and solid waste consumption) of reusable and disposable isolation gowns; (2) to clearly show what parts of the life cycle are important to the result; and (3) to provide a sensitivity analysis for important parameters.

MATERIAL AND METHODS

The most common analyitcal tool to evaluate the environmental benefits and impacts of products is the life cycle assessment (LCA). An LCA is a structured approach to environmental research that includes 4 phases. The first phase is to determine the goal(s) and scope of the study. The second phase, known as the life cycle inventory (LCI) analysis, includes the compilation of an inventory of material and energy inputs and outputs for a complete product system. In the third phase, known as the life cycle impact assessment, the material and energy inventories compiled in the second phase are used to determine the potential environmental impacts of the system, such as global warming potential. The final phase is the interpretation, which includes a discussion of the results, sensitivity analysis, and conclusions. The process is iterative, so that the interpretation can help lead to refinements in the study.

The backbone of an LCA is the LCI. An LCI is the estimation of energy use and material use (and loss) of each manufacturing plant or node, such as a fabric manufacturing plant or oil refinery. Each plant or node is referred to as a gate-to-gate (GTG) LCI. The GTGs are added together to give a cradle-to-gate (CTG) LCI, from the cradle (natural materials in the earth) to the gate (a final product, such as a reusable isolation gown). Energy use is given as electricity, the use of steam (from boilers) or high-temperature furnaces (for metals), whereas material use is given by the mass balance on each process or service.

After all of the necessary LCIs are compiled, the data are weighted and summed to determine the total impact in environmental categories. For example, several chemical emissions result in global warming effects. Each of these emissions is multiplied by the relevant factor to calculate the total global warming effect as carbon dioxide (CO_2) equivalents. The environmental impacts comprise the life cycle impact assessment.

The LCI data used in the isolation gown LCA were from the Environmental Clarity, Inc. LCI Database.[16] LCI data were transparent, with a strong emphasis on process or design-based methodology. Detailed reports for all GTG LCIs used in this LCA are available from Environmental Clarity, Inc. Each LCI report included a summary of the process mass and energy flows as well as a review of literature pertinent to the process. The LCIs used for this study included data on the production of intermediate materials in the supply chains, the manufacture of gowns, the laundry process, wastewater treatment, end-of-life landfill disposal, and transportation.

Reusable and disposable isolation gown systems were compared following LCA guidelines established by the International Organization for Standardization.[17,18] The scope of the study included the complete cradle-to-end-of-life analysis of representative isolation gown systems. The system boundaries included all activities from natural resource extraction from the earth, to gown manufacture, to gown use and/or reuse in healthcare settings, to end-of-life disposition (Figure 1).

The isolation gown was defined as a single-piece, long sleeve, extra-large or one-size-fits-most garment with ANSI/AAMI PB70 Level 1 barrier protection rating. The study did not include other medical textiles used in healthcare settings such as gloves, wipes, or masks. It was recognized that a wide variety of isolation gowns are used in healthcare facilities, with ANSI/AAMI PB70 barrier protection ratings ranging from no rating to Level 2. To determine the specifications of representative reusable and disposable isolation gowns for the study, 24 gowns from 8 suppliers were analyzed to determine the typical material compositions and weights. This information was obtained from manufacturer specifications and product data sheets. The suppliers included High Five (Company 1), Kimberley-Clark (Company 2), Medline (Company 3), Precept (Company 4), S2S Global (Company 5), American Dawn (Company 6), Encompass (Company 7), and Fashion Seal (Company 8). Eight of the gowns were individually sampled and found to be within 20% of the manufacturer-specified weight, with 7 of the gowns within 10%. The weights of specific gowns were excluded from reporting to protect the intellectual property of the gown manufacturers. Instead, the average, minimum, maximum, and standard deviation of the weights are given. Sixteen disposable isolation gowns from 5 suppliers were examined (Table 1). All 16 disposable gowns were found to be composed primarily of nonwoven polypropylene fabric. The average weight of the disposable gowns was 63 g, with a minimum of 41 g, maximum of 91 g, and standard deviation of 12 g. Eight reusable isolation gowns from 4 suppliers were examined (Table 2). All 8 reusable gowns were found to be composed of primarily woven polyester fabric. The average weight of the reusable gowns was 240 g, with a minimum of 220 g, maximum of 255 g, and standard deviation of 13 g. Thus, in this study, a 63-g nonwoven polypropylene gown was chosen as representative of disposable isolation gowns. A 240-g woven polyester gown was chosen as representative of reusable gowns.

The basis of comparison, or functional unit, was 1,000 isolation gown uses in a healthcare setting. For disposable or single-use gowns, this included the manufacture, delivery, and disposal of 1,000 gowns.