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Sustainable healthcare and environmental life-cycle impacts of disposable supplies: a focus on disposable custom packs

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ABSTRACT

Disposable materials contribute to healthcare's estimated production of 33 pounds of waste per patient bed per day or approximately 5.9 million tons of waste each year. The shift toward disposable materials was initially driven by a variety of factors including the potential for infection control, convenience, and cost. The current use of single-use disposables in healthcare, however, has become costly, wasteful, and to some extent, unnecessary. Disposable custom packs, a set of products prepackaged for a specific procedure to reduce time and error, are utilized in nearly every medical procedure performed in the US and internationally. This study analyzed 15 custom packs from geographically diverse hospitals using life cycle assessment and design for the environment. Polypropylene, the material used to make gowns and drapes, was the most prominent material by weight, followed by cotton. However, the life cycle assessment results show that cotton composed the largest portion of environmental impacts in every category. Finally, a new green custom pack was designed. By using tools and strategies such as life cycle assessment and design for the environment, healthcare institutions can make educated streamlining efforts for their disposable custom packs.

1. Introduction

Healthcare is one of the largest industries in the United States; it accounts for 17.9% of the total US GDP, consumes 73 billion kWh of electricity annually, employs over 5.3 million people, and spends nearly $320 billion on goods and services (CEA, 2009; DOE, 2012; Vogt and Nunes, 2014; WorldBank, 2014). Consequently, the healthcare industry is estimated to produce 8% of the total US carbon dioxide emissions, a majority of which may be attributable to buildings and their energy use (Chung and Meltzer, 2009). The UK's National Health Service further estimates that inpatient admissions produce 380 kg of CO_2 equivalents per patient, 80 kg of CO_2 equivalents per inpatient day, and 50 kg of CO_2 equivalents per outpatient appointment (Tennison, 2010). Despite these statistics on consumption and emissions, only 0.03% of the $29 billion US National Institutes of Health budget is allocated to research focused on increasing sustainability in healthcare delivery (OSTP, 2014). The healthcare industry needs quantitative information to curb excess waste and develop sustainable solutions for maintaining and exceeding the current level of care, expertise, and patient outcomes (Berwick and Hackbarth, 2012).

One research area in need of further study is the use of disposable and single-use materials in healthcare delivery. The shift toward disposable materials was initially driven by a variety of factors including the potential for infection control, convenience, and cost-savings. The current use of single-use disposables in healthcare, however, has become costly, wasteful, and to some extent, unnecessary (Karlsson and Pigretti Öhman, 2005; Tudor et al., 2007; PGH, 2008; Swensen et al., 2011). Disposable materials contribute to healthcare's estimated production of 33 pounds of waste per patient bed per day or approximately 5.9 million tons of waste each year (PGH, 2008). Proper waste management programs and source-reduction strategies could save hospitals up to 55% in waste hauling costs (Zimmer and McKinley, 2008). The

Abbreviations: LCA, life cycle assessment; DfE, design for the environment; EOL, end of life; MSW, municipal solid waste; LEED, leadership in energy and environmental design; OR, operating room; GWP, global warming potential; PVC, polyvinyl chloride; LDPE, low-density polyethylene; HDPE, high-density polyethylene; PP, polypropylene; GL, Global Links.

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production, use, cost, and waste generation of disposable materials provide opportunities for improvements within healthcare, as the industry attempts to reduce expenditures.

To address the use of disposable materials in healthcare, this study analyzed the life cycle environmental impacts of disposable custom packs. A disposable custom pack is a set of sterile, disposable products prepackaged for a specific procedure with the aim of reducing time, errors, and contamination risk. Specifically, we investigated the custom pack used to deliver a child, see Fig. 1. Once a custom pack is opened, every item is discarded, even if an item is not used. Clinicians have the ability to add items to a pack, yet often find it more difficult to remove unnecessary or obsolete items. This tends to result in inflated packs with extraneous items. In 2010, there was over 51 million inpatient procedures performed in the US (CDC, 2010). Because at least one disposable custom pack is used for every procedure, a few excess products in each pack could significantly contribute to unnecessary waste (economic and environmental) in the healthcare industry. To determine the potential design and impact of sustainable custom packs, design for environment (DfE) principles and environmental life cycle assessment (LCA) were applied to the *disposable* custom packs analyzed in this study. It should also be noted that there are often *reusable* custom packs also associated with most procedures. A reusable custom pack is a set of sterile, reusable products, typically stainless steel instruments or cotton linens that are cleaned via the hospital's central service autoclaves or commercial laundry facilities. The *reusable* custom pack used to deliver a child was not considered in this study.

1.1. Sustainability assessment tools

Design for the environment (DfE) provides a suite of sustainable strategies for designers, engineers, and organizations to consider. Life cycle assessment is often used in concert with DfE to quantify the environmental impacts and trade-offs of DfE strategies. LCA has become more widely recognized over the years, as evidenced by ISO 14040 standards and published reports (ISO, 1997, 2010; Baumann and Tillman, 2004; Birch et al., 2012). For this study, we applied DfE strategies to the custom packs and quantified the environmental changes through LCA, developing recommendations that can be applied to custom packs in general.

1.1.1. Design for the environment

The term DfE emerged in the early 1990's, around the same time as environmental management ISO 14000 standards were established. DfE developed from manufacturers' desire to better understand, manage, and reduce the environmental impacts throughout the manufacturing process (Fiksel, 1996; ISO, 1997, 2010). DfE in a broader sense is a set of principles that outline the necessary steps to design and develop environmentally responsible products and processes (Fiksel, 1996).

Typically, DfE strategies are applied during the design phase of a product (Lagerstedt et al., 2003; Pujari, 2006; González-García et al., 2012). One study examined the functional profile of radio equipment, highlighting that there are multiple demands in product development, such as environmental, profitability, political, and safety (Lagerstedt et al., 2003). Using DfE strategies helped frame the goals of the product in this particular study, reducing environmental impacts while increasing product functionality (Lagerstedt et al., 2003). Another study addressed the marketability of eco-products, applying DfE strategies to incorporate several functional demands and multidisciplinary representation such as designers, engineers, marketers, and investors (Pujari, 2006). And most recently, another study used both DfE and LCA to address the environmental impacts and alternatives for a wooden wall product (González-García et al., 2012). First, an LCA of the wooden wall product was conducted, defining the processes and material flows of the product and associated environmental impacts. DfE strategies were then applied based on the LCA results, ensuring that the focal areas had maximum output potential (González-García et al., 2012). Explicitly using DfE strategies for product development can increase the number of product alternatives. In the healthcare industry, DfE strategies could address current challenges, such as the use of disposable materials or waste management, by applying life cycle thinking and developing alternative options.

For this study, three DfE strategies were utilized, as described in Fig. 2. The first strategy, *Design for Dematerialization*, aims to reduce the total amount of materials used (in this case, products within the

Fig. 1. Examples of opened disposable custom packs.

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