Alliance Journal of Business Research (AJBR)

Hospital Sustainability: Reducing Operating Room Waste with Reusable Medical Supplies and Instruments

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Acknowledgments:

- The authors would like to acknowledge Dr. Hamid Sheikh for his contribution to the origination of the idea for this research.

Conflicts of Interest and Source of Funding: None

Abstract

Recent years have witnessed a profound interest in healthcare waste given its impact on costs and the environment. This paper examines the impacts of seven factors: quality of care, healthcare costs, liability (safety) concerns, organizational culture concerns, social and environmental concerns, space limitations, and operating room (OR) turnaround time on healthcare personnel perceptions which ultimately impact adoption decisions regarding reusable medical supplies and instruments versus counterpart disposable items in hospital ORs. The study objectives include identifying the relative importance of the seven factors and an assessment of healthcare personnel perceptions by participant gender, age, occupational area, and education level regarding the usage of disposable versus reusable medical supplies and instruments. A seventeen question web-based survey was sent to approximately 3250 hospital personnel in eight hospital systems in southeast Michigan and central Kentucky. An estimated response rate of 6.03 percent was received. Parametric statistics and nonparametric statistical analyses were used to assess responses. This study provides clear evidence with highly significant differences among the seven factors. This understanding is important if hospitals are to switch from disposable to equivalent reusable alternatives to lower healthcare costs and lessen environmental impacts. Survey results demonstrate higher respondent receptiveness for reusable instruments versus counterpart disposable instruments and for higher respondent receptiveness towards disposable supplies versus counterpart reusable supplies. Male, older, providers such as physicians, and more formally educated respondents indicated a statistically significant preference for reusable items.

Keywords: sustainability, healthcare waste, medical waste, healthcare costs, reusable medical supplies, reusable medical instruments, environmental impacts, hospitals, operating rooms

Introduction

There is a profound societal interest in reducing healthcare costs. It is well documented over recent years healthcare costs have been increasing at rates far exceeding consumer price index values (Agency for Healthcare Research and Quality, 2002; Kavilanz, 2011; Milliman Research Report, 2015). Shown in Figure 1 are ten year projected healthcare expenditures per Capita in the United States (Office of the Actuary in Centers for Medicare and Medicaid Services, 2014). As shown, this expenditure is projected to increase from $9,695 in 2014 to $15,618 in 2024 representing an increase of more than 61 percent.

Simultaneously, there is an emerging societal interest in reducing healthcare waste given its impact on the environment. One study describes evidence of an "environmental crisis" in hospitals (Topf, 2005). Incinerated medical wastes, excessive energy and water consumption, and a lack of plastics recycling are noted contributors to this environmental crisis. Although estimates vary widely, several reports note the following statistics: (1) hospital systems contribute 6,600 tons of daily waste, much of which is transported and buried in landfills (Kaplan, et al., 2012), (2) hospitals produce more than 5.9 million tons of annual garbage (Rastogi, 2010), (3) hospitals generate nearly 7,000 tons of daily waste resulting in $10 billion annually in disposal costs (Sustainability Roadmap for Hospitals, 2013), and (4) hospitals and health systems combined produce 14,000 tons of daily waste (Healthier Hospitals Initiative 2012 Milestone Report, 2012). One estimate suggests that waste management initiatives in healthcare organizations can reduce waste disposal outlays from 40 to 70 percent representing anywhere from $4 to $7 billion annually (Sustainability Roadmap for Hospitals, 2013). Anecdotal evidence

suggests the operating room (OR) serves as a major source of medical waste producing anywhere from 20 to 30% of the hospital's overall waste volume (Rastogi, 2010).

Due to mounting economic, environmental, and social concerns, there is growing global interest in sustainability (a.k.a., "greening") given its dual focus on cost and waste reduction (Kleindorfer, et al., 2005). However, sustainability initiatives in service and technology industries to date, including healthcare, lag resource-intensive industries as it is perceived to be less of a competitive necessity (Haanaes, et al., 2012). Yet, it is noted that service and technology industries increasingly understand the merits of sustainability initiatives to offer a competitive advantage. One estimate suggests that sustainability initiatives could save hospitals $5.4 billion over five years and $15 billion over ten years (Kaplan, et al., 2012).

Rising healthcare cost and waste trends have prompted recent hospital cost reduction and sustainability efforts which have focused upon waste reductions (e.g., recycling aluminum and plastic and less paper use), energy and water use reductions, safer chemicals, and purchase choices (e.g., surgical kit reformulations) (Healthier Hospitals Initiative 2012 Milestone Report, 2012; Kaplan, et al., 2012). An emerging interest within the healthcare industry that can address both rising cost and waste trends relies upon the use of reusable medical supplies and instruments (both multiple-use and reprocessed single-use devices or SUDs) to simultaneously address cost and sustainability efforts. For instance, many items used in hospital ORs are disposable items which when measured over a longer-term time horizon may have less expensive reusable alternatives. Examples of reusable medical supply items include linens, gowns, delivery totes, basins, trays, and blue wrap. Examples of reusable medical instruments include scalpels, forceps, and hemostats.

Reusable items may either be indefinite (multiple) use items or reprocessed SUDs. In order to market an item as reusable, a manufacturer must provide premarket submission data to the U.S. Food and Drug Administration (FDA) demonstrating to FDA satisfaction that the item can be cleaned, sterilized, and if necessary recalibrated and remanufactured, without impairing its function.

Interestingly, there is little research regarding the use of reusable items (multiple use items or SUDs) within hospitals. The personnel using reusable items must be the force behind their adoption if reusable items represent feasible, longer-term cost-saving alternatives to disposable items. Therefore, there is a need to better understand individuals' perceptions of reusable items. This study examines the perceptions of the hospital personnel regarding the adoption and use of reusable medical supplies and instruments versus their counterpart disposable items in hospital ORs.

An important study called for increased research regarding the use of evidence-based management research for the control of hospital costs (Finkler and Ward, 2003). This study represents a step in that direction by offering an organized research framework in the area of healthcare cost control as well as sustainability practices. This study promotes the adoption of evidence-based decision-making practices among healthcare practitioners. An electronic survey was used to solicit perceptions from healthcare personnel regarding the adoption and use of reusable medical supplies and instruments (multiple-use and reprocessed SUDs) with the primary objective being to identify the relative importance of seven factors which are commonly incorporated in the decision to adopt reusable or disposable medical supplies and instruments. Both parametric and nonparametric statistical analysis of survey responses offer practice insight

which may be used to overcome perceptual and cultural organizational resistance for long-term cost saving and more sustainable practices regarding the adoption and use of reusable medical supplies and instruments in hospital ORs.

Background Information

Prior to 1985, reusable medical supplies and instruments were commonplace. Disposable supplies and instruments were largely limited to items that did not have a reusable equivalent. Over the past three decades numerous drivers encouraged hospital systems to switch to disposable supplies and instruments (Hussain, et al., 2012). For instance, in the 1980's hospital systems began transitioning to the use of disposable supplies and instruments due in part to the rise of HIV and other blood borne pathogens (Freinkel, 2011) as well as to regulatory requirements. At that time, some disposable medical supplies were more effective in preventing infection as some items (e.g., textiles) were not impervious and barrier free unlike today's reusable equivalents. Some studies claim reusable items can lead to infections (e.g., see Brown, 2006). It should be recognized that many of these studies have been offered by disposable item manufacturers which may have led to an inherent bias. This may have given rise to the anecdotal evidence promoting a common misperception that utilizing reusable medical supplies and instruments leads to higher infection rates and therefore lower quality of care and higher care costs.

Rival studies suggest that reprocessing medical devices do not represent an elevated health risk when properly cleaned and sterilized. An FDA report identifies that limited data does not suggest reprocessed SUDs represent an elevated health risk (U.S. Government Accountability Office, 2008). Often the sources and causes of infection can not been clearly

attributed when infections occur (Rutala, et al., 1992; Schultz, 2006). However, significant costs can be incurred if an infection specifically attributable to a reusable item does occur. The 2015 occurrence of endoscopes infected with carbapenem-resistant enterobacteriaceae (CRE bacteria) was attributed with the two deaths. When infections are attributed to reusable items, it is typically instrument intricacy, confusing disassembly instructions, and failure to follow proper disassembly procedures that may make complete sterilization leading to higher infection potential (e.g., see U. S. Government Accountability Office, 2008; Pyrek, 2012). These causes of infections are preventable; however, stringent decontamination processes that conform to manufacturer's standards and national guidelines may not be sufficient for reusable items. Healthcare facilities must continuously assess internal processes to ensure infection prevention regardless of the source. Likewise, care must be given to the idea that disposable items have acquired a perception for promoting lower infection rates.

Another prime motivator that drove hospitals to utilize disposable items was profit. Five examples exist within this driver set follow. First, reimbursements for medical services were switched to a cost-plus system creating a financial incentive to use disposable items. Second, short-term financial viewpoints provide support for disposable items as initial acquisition costs for reusable instrument sets are typically several times more expensive than disposable counterparts (Demoulin, et al., 1997; Eddie, et al., 1996; Schaer, et al., 1995). For instance, in 2015, a southeast Michigan hospital identified a Nellcor pulse oximetry probe that had an initial acquisition cost of $42. Its disposable counterpart cost only $12. Third, initial item acquisition costs must be coupled with the observation that profit margins of hospital systems have emphasized increasing revenue generation per square foot. As a result, in the absence of

sufficient long-term economic life-cycle analyses (incorporating factors such as unit volumes and costs such as initial acquisition, sterilization, risk, maintenance, recalibration, remanufacturing, space requirement costs, as well as other potential costs), the financial returns associated with long-term sustainable practices of reusable items have historically been ignored over the past three decades due largely to multiple costs associated with item recovery, sterilization processes, and risk avoidance. One study estimated that if hospitals nationwide adopted the examined hospitals' SUD reprocessing intervention practices, extrapolated cost savings of $540 million annually could be achieved (Kaplan, et al., 2012). Fourth, a perception has developed that disposable items promote a faster turnaround time (TAT) for limited OR capacity. Faster OR TAT drives higher profitability. Fifth, reusable items require storage space and sterilization departments, either internally or externally. Hospitals administrators have been reluctant to devote limited space to the cost-incurring activities of storage and sterilization.

Examples of additional drivers promoting disposable medical supplies and instruments exist. For instance, plastic technology advances in disposable items represented an alternative to reusable items and this alternative has been heavily promoted by disposable item manufacturers. Surgeon preference may dictate disposable instruments as they may be sharper given their single-use despite offering lower quality designs to promote lower acquisition costs. Although not an exhaustive list, drivers promoting disposable medical supplies and instruments are summarized in Table 1.

There are equally important drivers which are promoting a return to reusable items. Included among these are improved performance of reusable items (e.g. imperviousness) and sterilization processes which prevent or eradicate infection, bundled medical fee reimbursements

which promote lower coordinated system and episode costs, disposal costs of regulated medical waste (RMW), physician preference attributable to a higher quality of design (e.g., superior materials) providing improved reusable performance, environmental concerns (Adler, et al., 2005; Clark, et al., 2008; Gilden, et al., 1992; Overcash, 2012), corporate image, and the potential for lower long-term life cycle costs (McGain, 2010; McGain, et al., 2012b; Overcash, 2012).

The potential for lower long-term life cycle costs prompted the southeast Michigan hospital identified above, to begin a project in 2014 to transition from disposable to reusable items. The Nellcor pulse oximetry probe, an instrument with an indefinite reuse, was examined for reuse potential for children over 9 years of age requiring outpatient surgery. Prior to the transition, the Anesthesia Department averaged using 1,200 units, or $17,000 in monthly acquisition costs of the $12 disposable item. Post transition results utilizing the $45 reusable probes provided estimated cost savings of $3,500 per month, or $42,000 annually for this single item. Furthermore, this cost savings ignored the environmental impact of disposal. The same hospital identified a Bovie cord, a reusable supply item, possessing a reusable version with an initial acquisition cost of $40 (with an $80 sterilization cycle cost) versus $25 for the disposable equivalent. Less than three sterilizations cycles would promote profitability for just ten cord sets. Although not an exhaustive list, drivers promoting reusable medical supplies and instruments are summarized in Table 2.

Method

Prior to conducting this study, a review of the literature (e.g., McGain, et al., 2012a) as well as numerous conversations and interviews with hospital healthcare personnel representing

various occupational areas were utilized to identify seven factors commonly incorporated in the reusable or disposable item decision. The literature review and discussions with hospital personnel provided *a priori* expectations of factor importance. These seven factors, in expected order of importance were: (1) quality of care concerns, (2) healthcare costs, (3) liability (patient safety) concerns, (4) organizational culture concerns, (5) social and environmental concerns, (6) space limitations for recovery, sterilization, and storage activities, and (7) OR TAT. These seven factors were used to solicit healthcare personnel perceptions regarding the potential adoption and use of reusable or disposable medical supplies and instruments.

An invitation to participate in a web-based survey was sent to approximately 3,250 hospital personnel, including providers (physicians, specialists, nurse practitioners), clinicians (registered and licensed practical nurses, pharmacists, therapists, phlebotomists, and medical assistants), and administrators (CEOs, Unit/Floor Directors, Quality/Infection Control, Purchasing, Central Processing, Environmental Services, Food Services, and Materials Managers) in eight hospital systems in southeast Michigan and central Kentucky. These eight hospital systems were identified given our administrative contacts that could encourage participation as well as authorize the invitation distribution.

Qualtrics online survey software was utilized to design a web-based survey instrument consisting of seventeen questions. Radio button responses to four demographic questions, twelve close-ended questions and assertions which utilized a 5-point Likert scale (a response of 1 represented “strongly agree,” 2 was “agree,” 3 was “neither agree nor disagree”, 4 was “disagree,” and 5 was “strongly disagree”), and one seven-factor sliding scale question were

used to solicit perceptions for the adoption and use of reusable versus disposable medical supplies and instruments.

Institutional Review Board procedures were followed to minimize potential biases, respondent risks, and to ensure respondent anonymity. It is estimated the survey could be completed in five minutes or less. Respondents were not forced to answer any question in the survey, therefore responses per question varied, although minimally. Furthermore, all responses were aggregated and no unique, personal identifiers were collected.

It was not possible to ascertain an overall survey response rate as access to hospital system survey invitation distribution lists was not possible. However, the administrative contacts were asked to provide an estimated number of distribution list recipients. Based upon the numbers provided, it is estimated that approximately 3,250 invitations were distributed. 196 respondents participated providing an estimated survey response rate of 6.03 percent.

Parametric statistics (means and standard deviations) and nonparametric statistical analyses are reported. As much of the responses sought rank data, the Mann-Whitney nonparametric test, which is appropriate for the comparison of rank data from two, independent populations, and the Kruskal-Wallis test, which is an appropriate nonparametric test for comparing the medians of multiple independent samples utilizing rank data were used for this analyses.

Results

As part of the survey, simple demographic information was solicited. The demographic information solicited included gender (2 categories), age (4 categories), occupational area (4 categories), and level of education (6 categories). For the statistical analysis purposes, some of

these categories were subsequently combined to form stratified groups for nonparametric statistical analyses. This information, including the respective categories, number of responses, and how these responses were stratified for statistical analysis, is shown in Table 3. As previously noted, the number of responses received for each question varied slightly as survey responses to any question were not forced.

Gender data was requested because we were curious to examine potential response differences. We did have *a priori* expectations for how the three demographic factors (age, occupational area, and education level) would influence responses. Age information was sought as we expected individuals born prior to 1966 (baby boomers and earlier) to be more receptive to the use of reusable items having been exposed to their use earlier in their careers (e.g., during the early 1980's). We believed occupation area would influence reusable receptiveness. Anecdotal evidence suggested providers such as the physicians may be more receptive to reusable items given higher quality of design and improved reusable performance; clinicians (C) would be more receptive to disposables for reasons including faster OR TAT and convenience; while administrators (A) may be more receptive to disposables for lower short-term acquisition costs. We also expected education levels may influence receptiveness to reusable items as we expected individuals with more advanced degrees (master's or doctoral) to have a greater ability to distinguish between the perception that disposables provide for an improved quality of care and fact that no empirical evidence exists that the use of reusable items lead to higher infection rates if stringent reclamation procedures are followed.

Respondents were asked to rank order from most important (1) to least important (7) their perception of the importance of seven factors commonly used for the decision to adopt and use

reusable medical supplies and instruments. These seven factors, along with their aggregated rankings and simple parametric statistics, are identified in Table 4 in order of our *a priori* expectations of importance.

A simple examination of the respondents' relative rankings for the seven factors depicts important differences. For example, 66 percent of the respondents ranked quality of care as most important while 89 percent selected it as being one of the top two choices. 89 percent of respondents ranked healthcare costs from first to third in importance. 70 percent of the respondents ranked space limitation sixth or last while 70 percent ranked OR TAT from fifth to last in importance. A Kruskal-Wallis test using these relative rankings was conducted in order to understand the significance of the differences among these seven adoption factors. This nonparametric test is appropriate for comparing the medians of independent samples utilizing rank data. This test yielded a highly significant 0.0000 p-value confirming important differences among rank orderings.

The respondents clearly perceive the most important factor for medical system adoption of reusable items to be quality of care followed by total healthcare costs. The third most significant factor is thought to be liability concerns. Social and environmental concerns are ranked fourth with organizational culture issues being fifth. Based on its mean ranking, OR TAT is ranked sixth followed closely by space limitations for recovery, sterilization, and storage activities. It is interesting to note that these rankings are fairly consistent with prior expectations. The most important difference of these rankings with our *a priori* expectations was the fifth ranking for organizational culture. It was expected that greater resistance would be encountered

to a change in OR procedures that more sustainable practices represent. Although there are significant differences among these adoption factors, they are all clearly important.

In an effort to provide a gauge for the receptiveness of individuals as well as the hospital systems in which they are employed for adoption and the use of reusable items, respondents were asked three related questions. First, they were asked to indicate how strongly they value environmental sustainability. Second, they were asked to indicate how strongly hospital systems value environmental sustainability. And third, they were asked if more could be done to reduce landfill waste in hospital environments. A 5-point Likert scale with 1 representing strongly agree, 2 being agree, 3 being neutral, 4 representing disagree, and 5 being strongly disagree was used for responses.

As shown in Table 5, 98 percent of respondents strongly agreed or agreed suggesting healthcare workers value environmental sustainability highly. Interestingly, respondents suggested hospital systems value environmental sustainability less as fewer than half of the total respondents, 41 percent, either strongly agreed or agreed with the statement. This indicates that although they themselves value sustainability, they believe hospitals in general value it less. An overwhelming 97 percent of respondents believe more can be done within hospital systems to reduce landfill waste. This observation alone offers strong evidence that reusable items may have a place within hospital system sustainability strategies. Mann-Whitney tests utilizing the stratification groups identified in Table 3 revealed no significant differences due to gender, age, occupational area, or level of education for these three questions.

In an effort to gauge the proclivity of individuals and hospital systems to return to greater reliance upon reusable items, perceptions were solicited for three sets of additional questions

regarding: (1) respondents' preferences for both disposable medical supplies and instruments versus a reusable equivalent, (2) quality of care for both reusable medical supplies and instruments, and (3) cost performance perceptions for both reusable medical supplies and instruments. These results are shown in Table 6.

As shown in Table 6, in the first set of two questions, 63.43 percent of respondents prefer disposable supplies over a reusable equivalent while only 17.72 percent noted a preference for reusable supply equivalents. Interestingly, only 29.14 percent of respondents prefer disposable instruments over a reusable equivalent while 54.29 percent of respondents prefer reusable instruments versus a disposable equivalent. The second set of two questions reveal another interesting result in that respondents distinguish a difference between reusable supplies and instruments and the perceived likelihood for increasing the chance of infection. 42.29 percent of the responses suggest a perception that reusable supplies when compared to a disposable equivalent increase infections but only 29.14 percent perceive reusable instruments when compared to a disposable equivalent increase infection rates. The third set of two questions also suggests a marked difference between reusable supplies and instruments. A majority of respondents, 61.85 percent, perceive that reusable instruments can reduce healthcare costs versus only 46.82 percent for reusable supplies.

The four demographic factors; gender, age, area of occupational practice, and level of education were used to provide greater insight into the differences in these three sets of questions. A nonparametric Mann-Whitney analysis of the response rankings for each these four factors is appropriate for the comparison of rank data from two, independent populations. Therefore, the responses were stratified into the two roughly equal-sized groups noted in Table 3.

Results for the first factor, gender, including sample sizes, medians, means, standard deviations, and the Likert score (1-5) counts of the individuals' responses for the six questions are shown in Table 7. Although not expected, there is a clear difference between male and female respondents for the first four questions. The first two questions reveal females prefer both disposable supplies and instruments. The second two questions reveal female respondents perceive reusable items increase infection likelihoods. Any distinguishable difference between male and female respondents for the two questions regarding the ability for reusable items to reduce healthcare costs is less apparent. Mann-Whitney (MW) tests for the level of significance between male and female respondents for these six questions are shown in Table 8. As shown, these pairwise tests reveal a highly significant difference for the first four questions. Although responses suggest the respondents do perceive reusable items have the ability to reduce healthcare costs, there is largely no difference attributable to gender.

Results for the second factor, age, including sample sizes, medians, means, standard deviations, and the Likert score (1-5) counts of the individuals' responses for the six questions are shown in Table 9. It was expected that individuals born prior to 1966 (age 48 and older) would be more receptive to the use of reusable items given their usage exposure earlier in their careers. However, as shown by the MW tests in Table 10, only the third and sixth questions yielded significantly different results between the two age populations. The younger population perceives reusable supplies have a greater likelihood for increasing infection while the older population perceives reusable instruments have the ability to reduce healthcare costs. Overall, responses suggest the all of the respondents perceive reusable items, both supplies and instruments, have the ability to reduce healthcare costs.

Results for the third factor, occupational area, including sample sizes, medians, means, standard deviations, and the Likert score (1-5) counts of the individuals' responses for the six questions are shown in Table 11. It was expected that this factor would influence reusable receptiveness as anecdotal evidence suggested providers; physicians in particular, may be more receptive to reusable items given higher quality of design (e.g., superior materials) while clinicians (C) would be more receptive to disposables for reasons including faster OR TAT and convenience while administrators (A) may be more receptive to disposables for reduced healthcare cost potential. The MW test results for questions one and especially two shown in Table 12 suggest that providers do indeed prefer reusable items between the two populations. Although our survey results do not provide a definitive reason, the highly significant MW results for questions three and four suggest at least one reason; the second population (Clinicians, Administrators, and Other) clearly perceive reusable items increase the likelihood of infection. Although responses suggest the respondents do perceive reusable items have the ability to reduce healthcare costs, there is largely no difference attributable to occupational area.

Results for the fourth factor, education level, including sample sizes, medians, means, standard deviations, and the Likert score (1-5) counts of the individuals' responses for the six questions are shown in Table 13. As previously noted, it was expected that education levels may influence receptiveness to reusable items. We expected individuals with more advanced degrees (master's or doctoral) to have a greater ability to distinguish between the perception that disposables provide for an improved quality of care and the evidence suggesting reusable items do not lead to higher infection rates if proper procedures are followed. Although educational level overlaps with occupational factor (respondents with advanced degrees include physicians),

as depicted by the MW tests in Table 14, holders of advanced degrees prefer reusable items, especially reusable instruments. Again, although our survey results do not provide a definitive reason, the highly significant MW results for questions three and four suggest the holders of advanced degrees do not perceive reusable items necessarily increase the chance of infection. Although responses suggest the respondents do perceive reusable items have the ability to reduce healthcare costs, there is largely no difference attributable to educational level.

Discussion

Conversations with healthcare personnel as well as the research literature identified seven factors (quality of care; healthcare costs; liability concerns; organizational culture; social and environmental concerns; space limitations for recovery, sterilization, and storage activities; and OR TAT) frequently used to choose between reusable or disposable medical supplies and instruments. Although all seven of these factors are important, the results of this study clearly identify quality of care as being most important. In order, this was followed by healthcare costs, liability concerns, social and environmental responsibility, organizational culture, OR TAT, and finally space limitations. An understanding of relative importance of these factors is important if hospitals are to switch from disposable to equivalent reusable alternatives.

Results of the survey suggest healthcare workers value environmental sustainability highly and would be receptive to sustainability initiatives. The survey results also suggest that hospital systems value environmental sustainability, but to a lesser degree than healthcare employees. It should be apparent that although hospital systems value sustainability, alternative strategic objectives that value profitability versus sustainability have prevailed to date (Hettenbach, 1998).

Solely within the category of reusable items, the survey responses suggest a clear difference between reusable medical supplies and reusable medical instruments. Although it is unknown why this difference exists, it may be due to a perception of greater likelihood for infection, initial item acquisition costs, the inherent recovery ability or the associated recovery costs, or some other reason. This difference suggests that initial efforts to adopt reusable items should focus more on instruments and less on supplies. This observation is attributable to respondents' majority preference for reusable instruments versus an equivalent disposable instrument as well as their perceptions that reusable instruments are less likely to increase infection and have a greater ability to reduce healthcare costs.

It is interesting to note the significant differences attributable to the four factors; gender, age, occupational area, and education level. Although not initially suspected, female respondents have a stronger preference for both disposable supplies and instruments when compared to male respondents. One feasible answer to this is that the majority of OR nurses, being female, are members of the Association of periOperative Registered Nurses (AORN) which has voiced its support for the use of disposable items for years. This organization has more recently acknowledged the potential for reusable items to reduce RMW and disposal costs and evaluating the environmental effects for using reusable items (Conrardy, et al., 2010). Older respondents, provider respondents (physicians, specialists, nurse practitioners), and more formally educated respondents (master's or doctoral degrees) seem to prefer reusable items. These observations are congruent with *a priori* expectations.

An important conclusion is that there is a significant need for increased innovation in the healthcare industry. Alternatives to disposal must be innovated. One good example of this is

MetroWest Medical Center's initiative to invest $75,000 to convert from blue wrap to closed containers for instrument set transport. $30,000 blue wrap purchase costs were avoided as well as diverting 5,600 pounds of waste providing a 40 percent payback in the first year alone (Cook, 2012). There needs to be end of life alternatives rather than just simple disposal. For example, reprocessing initiatives have recently emerged for partial instrument disposal. Alternative designs may enhance sustainability opportunities.

The scant amount of research regarding whether reusable medical supplies and instruments makes it clear that an infection source is difficult to detect at best (Rutala, et al., 1992; Schultz, 2006). Life cycle cost analyses regarding reusable items must play a more prevalent role in the healthcare industry in meeting this need. Impacts on the environment, the public's perception of corporate image, consumers' demand for green products, and RMW disposal costs have led to a surge in research activities in the field of life cycle cost analysis (Asiedu, et al., 1998). Unfortunately, many sustainability initiatives focus internally on small-sized cost savings projects while ignoring environmental impacts (Fliedner, 2010).

Responses captured in this study suggest healthcare professionals are receptive to the adoption and use of reusable items as a means to reduce medical costs and wastes. It must be made clear that stringent decontamination processes that conform to manufacturer's standards and national guidelines may not be sufficient for reusable items given infection risks which arise from instrument intricacy, confusing disassembly instructions, and failure of personnel to properly follow proper disassembly procedures making complete sterilization impossible. Healthcare facilities must continuously assess internal processes to ensure infection preventions regardless of the source. Developing compliant, safe, sustainable practices requires modification

of staff behavior through ongoing education and empirical, evidence-based research. Finding services providers that focus on education and compliance is one of the most critical elements to effectively managing waste streams. It is hoped that this study will serve to provide greater information and insight to advance cost and waste reduction (sustainability) efforts in hospital ORs and as an impetus for improvement efforts.

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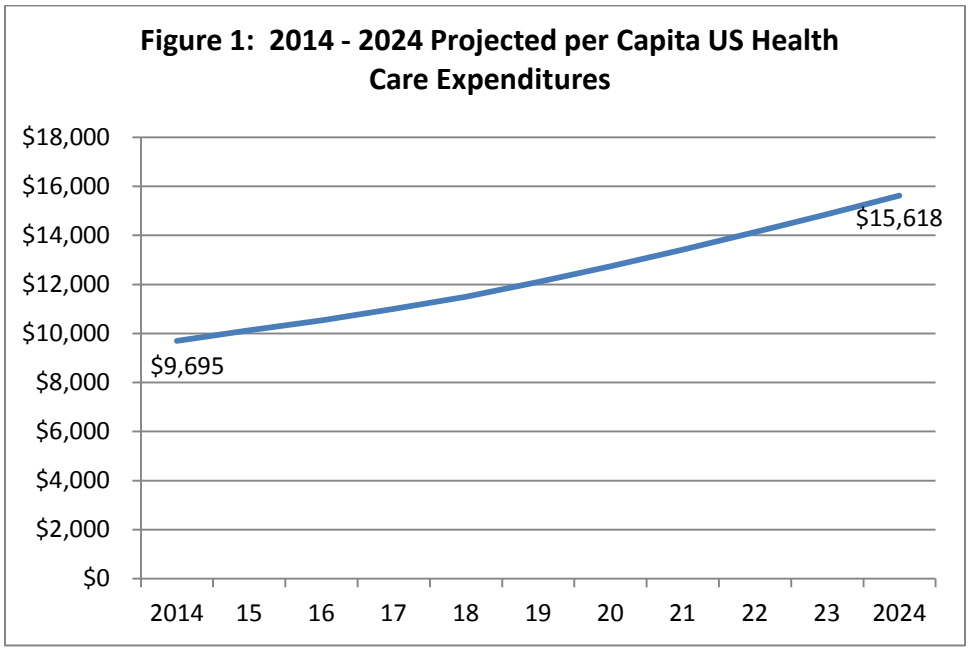
Figure 1: 2014 - 2024 Projected per Capita US Health Care Expenditures
$18,000
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
$9,695
$15,618
2014
15
16
17
18
19
20
21
22
23
2024

Table 1: Drivers Promoting Disposable Medical Supplies and Instruments

1. Perceived infection risks and regulatory requirements due to HIV and other blood borne pathogens
2. Cost-plus medical fee reimbursement
3. Short-term financial incentive of lower initial costs for disposables (reusable items incur longer-term costs: cleaning solution, labor, maintenance and repair, obsolescence, and storage space requirements)
4. Absence of long-term economic life-cycle analysis returns for sustainable practices
5. Faster turnaround time for limited operating room capacity
6. Advancements in plastic technologies offer heavily promoted alternatives
7. Surgeon preference for disposable instruments which may be sharper given single use

Table 2: Drivers Promoting Reusable Medical Supplies and Instruments

1. Improved reusable item performance and sterilization processes which eradicate infection
2. Bundled medical fee reimbursements
3. Regulated medical waste disposal costs
4. Physician preference given higher quality of design of reusable items
5. Environmental concerns
6. Corporate image
7. Potential for lower long-term, life cycle costs

Table 3: Demographic Survey Information		
Gender (2 categories):	Number of Responses	Stratification Group within Category
Male	91	1
Female	102	2
Age Group (4 categories):		
> 66 years	4	1
48-66 years	111	1
36-47 years	47	2
18-35 years	34	2
Primary Area of Occupational Practice (4 categories):		
Provider (physicians, specialists, nurse practitioners)	88	1
Clinical Staff (registered and licensed practical nurses, pharmacists, therapists, phlebotomists, and medical assistants)	38	2
Administrators (CEO, Unit/Floor Directors, Quality/Infection Control, Purchasing, Central Processing, Environmental Services, Food Services, and Materials Managers)	53	2
Other (O)	15	2
Education Level (6 categories):		
Doctoral Degree	68	1
Master's Degree	33	1
BS/BA Degree	53	2
Associates Degree	20	2
High School Diploma	20	2
Other	8	2

Table 4: 7 Common Factors for the Adoption of Reusable Medical Supplies and Instruments							
Rank	Quality of Care	Healthcare Costs	Liability	Culture	Social/Enviro Responsibility	Space Limitations	OR TAT
1st (Most Import)	112	34	7	2	10	1	3
2nd	21	71	33	12	22	1	9
3rd	15	46	41	20	24	4	19
4th	18	10	35	35	37	14	20
5th	1	5	23	44	39	31	26
6th	2	1	19	28	25	55	39
7th (Least Import)	0	2	11	28	12	63	53
Parametric Statistics							
Count (n)	169	169	169	169	169	169	169
Median Rank	1.00	2.00	4.00	5.00	4.00	6.00	6.00
Mean Rank	1.70	2.36	3.80	4.79	4.16	5.90	5.28
Standard Dev.	1.16	1.12	1.59	1.52	1.63	1.16	1.66

Table 5: Employee Perceptions Regarding Sustainability Receptiveness			
Response Data	Q: I value environmental sustainability?	Q: Hospital systems value environmental sustainability?	Q: More can be done to reduce landfill medical waste within hospitals?
1: Strongly agree	86	17	81
2: Agree	82	54	87
3: Neutral	3	44	4
4: Disagree	0	49	1
5: Strongly disagree	1	9	0
Count (n)	172	173	173
Median	1.50	3.00	2.00
Mean	1.53	2.88	1.57
Standard Deviation	0.60	1.09	0.57

Table 6: Perceptions of Reusable versus Disposable Medical Supplies and Instruments

	Set 1: What is your preference for disposable item or reusable equivalent?				Set 2: Do reusable items increase infection?				Set 3: Can reusable items reduce healthcare costs?			
	Q: I prefer disposable supplies over reusable equivalents.		Q: I prefer disposable instruments over reusable equivalents.		Q: Reusable supplies increase infection.		Q: Reusable instruments increase infection.		Q: Can reusable supplies reduce healthcare costs?		Q: Can reusable instruments reduce healthcare costs?	
Responses	n = 175	%	n = 175	%	n = 175	%	n = 175	%	n = 173	%	n = 173	%
S. Agree	69	39.43	31	17.71	33	18.86	28	16.00	16	9.25	26	15.03
Agree	42	24.00	20	11.43	41	23.43	23	13.14	65	37.57	81	46.82
Neutral	33	18.86	29	16.57	44	25.14	44	25.14	56	32.37	39	22.54
Disagree	18	10.29	54	30.86	34	19.43	52	29.71	32	18.50	20	11.56
S.Disagree	13	7.43	41	23.43	23	13.14	28	16.00	4	2.31	7	4.05

Table 7: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Stratified by Gender										
Question/Assertion	Variable	Sample Size (n)	Median	Mean	Standard Deviation	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I prefer single-use disposable medical supplies versus a reusable equivalent.	Totals	173*	2.00	2.22	1.27	68	42	33	18	13
	Male	79	2.00	2.46	1.32	24	21	16	10	8
	Female	94	2.00	2.04	1.22	44	20	17	8	5
I prefer single-use disposable medical instruments versus a reusable equivalent.	Totals	173*	4.00	3.31	1.41	31	19	29	53	41
	Male	79	4.00	3.81	1.24	7	5	12	27	28
	Female	94	3.00	2.89	1.42	24	14	17	26	13
Reusable supplies increase infection.	Totals	173*	3.00	2.85	1.30	33	41	44	32	23
	Male	79	3.00	3.06	1.26	8	23	17	18	13
	Female	94	3.00	2.64	1.31	25	18	27	14	10
Reusable instruments increase infection.	Totals	173*	3.00	3.17	1.30	27	23	44	51	28
	Male	79	4.00	3.57	1.16	6	8	17	31	17
	Female	94	3.00	2.84	1.31	21	15	27	20	11
Reusable supplies reduce healthcare costs.	Totals	171**	3.00	2.67	0.96	26	80	38	20	7
	Male	79	3.00	2.81	1.03	13	34	15	10	7
	Female	92	2.00	2.55	0.89	13	46	23	10	0
Reusable instruments reduce healthcare costs.	Totals	171**	2.00	2.43	1.01	16	64	55	32	4
	Male	79	2.00	2.54	1.17	8	23	27	18	3
	Female	92	2.00	2.33	0.85	8	41	28	14	1

*Two respondents did not indicate a gender

** Four respondents either did not indicate a gender or response was omitted

Table 8: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Mann-Whitney Tests by Stratified by Gender				
Question/Assertion	Group 1	Group 2	MW Test z-Statistic	Significance Level
I prefer single-use disposable medical supplies versus a reusable equivalent.	Male	Female	2.11	**0.0280**
I prefer single-use disposable medical instruments versus a reusable equivalent.	Male	Female	4.18	**0.0000**
Reusable supplies increase infection.	Male	Female	2.05	**0.0361**
Reusable instruments increase infection.	Male	Female	3.62	**0.0002**
Reusable supplies reduce healthcare costs.	Male	Female	1.68	0.0787
Reusable instruments reduce healthcare costs.	Male	Female	-0.76	0.4179

Table 9: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Stratified by Age										
Question/Assertion	Variable	Sample Size (n)	Median	Mean	Standard Deviation	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I prefer single-use disposable medical supplies versus a reusable equivalent.	Totals	175*	2.00	2.22	1.27	69	42	33	18	13
	Age ≥ 48	102	2.00	2.20	1.25	40	26	19	10	7
	Age ≤ 47	72	2.00	2.25	1.32	29	16	13	8	6
I prefer single-use disposable medical instruments versus a reusable equivalent.	Totals	175*	4.00	3.31	1.41	31	20	29	54	41
	Age ≥ 48	102	4.00	3.28	1.43	20	10	16	33	23
	Age ≤ 47	72	4.00	3.35	1.40	11	10	12	21	18
Reusable supplies increase infection.	Totals	175*	3.00	2.85	1.30	33	41	44	34	23
	Age ≥ 48	102	3.00	3.05	1.31	16	20	25	25	16
	Age ≤ 47	72	2.00	2.56	1.25	17	21	18	9	7
Reusable instruments increase infection.	Totals	175*	3.00	3.17	1.30	28	23	44	52	28
	Age ≥ 48	102	3.00	3.23	1.28	15	13	24	34	16
	Age ≤ 47	72	3.00	3.08	1.34	13	10	19	18	12
Reusable supplies reduce healthcare costs.	Totals	173	3.00	2.67	0.96	16	65	56	32	4
	Age ≥ 48	102	3.00	2.76	0.99	10	31	37	21	3
	Age ≤ 47	71	2.00	2.54	0.91	6	34	19	11	1
Reusable instruments reduce healthcare costs.	Totals	173	2.00	2.43	1.01	26	81	39	20	7
	Age ≥ 48	102	2.00	2.58	1.07	15	38	29	15	5
	Age ≤ 47	71	2.00	2.21	0.89	11	43	10	5	2

*One respondent did not indicate an age but provided responses

Table 10: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Mann-Whitney Tests by Stratified by Age				
Question/Assertion	Group 1	Group 2	MW Test z-Statistic	Significance Level
I prefer single-use disposable medical supplies versus a reusable equivalent.	≥ Older, 48 Years	≤ Younger, 47 Years	-0.15	0.8782
I prefer single-use disposable medical instruments versus a reusable equivalent.	≥ Older, 48 Years	≤ Younger, 47 Years	-0.27	0.7894
Reusable supplies increase infection.	≥ Older, 48 Years	≤ Younger, 47 Years	2.49	**0.0127**
Reusable instruments increase infection.	≥ Older, 48 Years	≤ Younger, 47 Years	0.72	0.4722
Reusable supplies reduce healthcare costs.	≥ Older, 48 Years	≤ Younger, 47 Years	1.68	0.0924
Reusable instruments reduce healthcare costs.	≥ Older, 48 Years	≤ Younger, 47 Years	2.48	**0.0131**

Table 11: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Stratified by Occupational Area										
Question/Assertion	Variable	Sample Size (n)	Median	Mean	Standard Deviation	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I prefer single-use disposable medical supplies versus a reusable equivalent.	Totals	175	2.00	2.22	1.27	69	42	33	18	13
	Provider	82	2.00	2.40	1.34	27	23	12	12	8
	C/A/O*	93	2.00	2.06	1.20	42	19	21	6	5
I prefer single-use disposable medical instruments versus a reusable equivalent.	Totals	175	4.00	3.31	1.41	31	20	29	54	41
	Provider	82	4.00	3.84	1.27	8	6	8	29	31
	C/A/O	93	3.00	2.83	1.36	23	14	21	25	10
Reusable supplies increase infection.	Totals	175	3.00	2.85	1.30	33	41	44	34	23
	Provider	82	3.00	3.18	1.23	7	21	17	24	13
	C/A/O	93	3.00	2.55	1.30	26	20	27	10	10
Reusable instruments increase infection.	Totals	175	3.00	3.17	1.30	28	23	44	52	28
	Provider	82	4.00	3.56	1.16	7	7	17	35	16
	C/A/O	93	3.00	2.82	1.33	21	16	27	17	12
Reusable supplies reduce healthcare costs.	Totals	173**	3.00	2.67	0.96	16	65	56	32	4
	Provider	82	3.00	2.78	0.94	4	33	24	19	2
	C/A/O	91	3.00	2.57	0.97	12	32	32	13	2
Reusable instruments reduce healthcare costs.	Totals	173**	2.00	2.43	1.01	26	81	39	20	7
	Provider	82	2.00	2.34	1.02	12	46	13	6	5
	C/A/O	91	2.00	2.51	1.00	14	35	26	14	2

*C/A/O = Clinicians, Administrators, and Other

**Two respondents omitted responses

Table 12: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Mann-Whitney Tests by Stratified by Occupational Area

Question/Assertion	Group 1	Group 2	MW Test z-Statistic	Significance Level
I prefer single-use disposable medical supplies versus a reusable equivalent.	Providers	C/A/O	1.69	0.0917
I prefer single-use disposable medical instruments versus a reusable equivalent.	Providers	C/A/O	4.95	**0.0000**
Reusable supplies increase infection.	Providers	C/A/O	3.25	**0.0012**
Reusable instruments increase infection.	Providers	C/A/O	3.84	**0.0001**
Reusable supplies reduce healthcare costs.	Providers	C/A/O	1.29	0.1969
Reusable instruments reduce healthcare costs.	Providers	C/A/O	-1.46	0.1454

Table 13: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Stratified by Education										
Question/Assertion	Variable*	Sample Size (n)	Median	Mean	Standard Deviation	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I prefer single-use disposable medical supplies versus a reusable equivalent.	Totals	175	2.00	2.22	1.27	69	42	33	18	13
	M & D	92	2.00	2.37	1.29	30	25	18	11	8
	B/A/HS/O	83	2.00	2.05	1.24	39	17	15	7	5
I prefer single-use disposable medical instruments versus a reusable equivalent.	Totals	175	4.00	3.31	1.41	31	20	29	54	41
	M & D	92	4.00	3.65	1.31	10	9	13	31	29
	B/A/HS/O	83	3.00	2.93	1.42	21	11	16	23	12
Reusable supplies increase infection.	Totals	175	3.00	2.85	1.30	33	41	44	34	23
	M & D	92	3.00	3.09	1.25	9	25	22	21	15
	B/A/HS/O	83	3.00	2.58	1.32	24	16	22	13	8
Reusable instruments increase infection.	Totals	175	3.00	3.17	1.30	28	23	44	52	28
	M & D	92	4.00	3.38	1.21	10	10	23	33	16
	B/A/HS/O	83	3.00	2.93	1.36	18	13	21	19	12
Reusable supplies reduce healthcare costs.	Totals	173**	3.00	2.67	0.96	16	65	56	32	4
	M & D	91	3.00	2.71	0.97	7	35	29	17	3
	B/A/HS/O	82	3.00	2.62	0.95	9	30	27	15	1
Reusable instruments reduce healthcare costs.	Totals	173**	2.00	2.43	1.01	26	81	39	20	7
	M & D	91	2.00	2.40	1.07	15	45	17	8	6
	B/A/HS/O	82	2.00	2.46	0.95	11	36	22	12	1

*M & D = Master's and Doctoral degrees; B/A/HS/O = Bachelor's, Associates, High School, and other degrees

**Two respondents omitted responses

Table 14: Perceptions of Reusable versus Disposable Medical Supplies and Instruments Mann-Whitney Tests by Stratified by Education				
Question/Assertion	Group 1	Group 2	MW Test z-Statistic	Significance Level
I prefer single-use disposable medical supplies versus a reusable equivalent.	Master's & Doctorate	Bachelor's and lower	1.75	0.0802
I prefer single-use disposable medical instruments versus a reusable equivalent.	Master's & Doctorate	Bachelor's and lower	3.45	**0.0006**
Reusable supplies increase infection.	Master's & Doctorate	Bachelor's and lower	2.55	**0.0107**
Reusable instruments increase infection.	Master's & Doctorate	Bachelor's and lower	2.25	**0.0245**
Reusable supplies reduce healthcare costs.	Master's & Doctorate	Bachelor's and lower	0.50	0.6172
Reusable instruments reduce healthcare costs.	Master's & Doctorate	Bachelor's and lower	-0.87	0.3854