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Effect of Convenience on Participation in Recycling by
Anesthesia Providers in the Operating Room: A Pilot Study
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Abstract

Anesthesia providers are in a position to contribute to the financial and environmental health of their institution through recycling. One of the barriers to participation in recycling by anesthesia staff as identified by the researchers of this study is a lack of convenience. Researchers sought to measure the effect of convenience on participation in recycling by anesthesia providers working in the seventeen operating room suites at NorthShore University HealthSystem Evanston Hospital. The researchers conducted a pilot study implementing a program to enhance the convenience of recycling. Participation, measured by weight in kilograms (kg) of recycled material, was compared pre- and post-intervention. The study demonstrated a 409% increase in recycling participation following distribution of an informational email, posting of recyclable materials in each room, and placement of convenient recycling receptacle on each anesthesia cart. Paired *t*-test for total material collected as well as for average waste per case collected in the pre- and post-intervention periods revealed statistically significant results. Convenient placement of a receptacle for recycling is positively correlated with an increase in recycling participation among anesthesia providers at this institution.

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Background

Twenty to thirty percent of all hospital waste has been shown to originate from operating rooms, with at least 40% of this waste demonstrated to be recyclable and 25% to be of anesthetic origin (McGain et al., 2012). One explanation for why operating rooms generate large amounts of waste is the need for sterility of supplies and equipment (Esaki & Macario, 2009). In the U.S., infected medical wastes are disposed of primarily through incineration while most municipal solid waste, including non-hazardous medical waste, is disposed of by landfilling. The number of operating landfills has decreased in the last several decades and the construction of new landfills is challenging due to high construction cost and limited space (Lee, Ellenbecker, & Moure-Eraso, 2002). In order to save landfill space and to reduce expensive disposal cost of medical waste, recycling of plastics in medical waste should be increased. Anesthesia providers are ideally placed to facilitate operating room plastic recycling (McGain, Clark, Williams, & Wardlaw, 2008).

Operating room wastes have a great potential to be infected and, as such, have historically not been considered for material recycling (Lee et al., 2002). Other barriers to recycling plastics in the operating room include: lack of knowledge regarding which plastics are recyclable, difficulty separating various plastics, reluctance to change practices and an attitude that environmental concerns are irrelevant to medicine (McGain et al., 2008). Anesthesia providers' attitudes toward recycling are important to address when considering improvements in operating room recycling programs. In a survey examining anesthesiologists' attitudes toward

OR waste recycling, respondents reported that the major barriers to recycling were (1) inadequate recycling facilities, (2) staff attitudes, and (3) inadequate information on how to recycle. Minor barriers included lack of time, safety issues, inadequate space for a receptacle, and cost. Most anesthesiologists regarded operating room recycling to be important overall, regardless of barriers (McGain, White, Mossenson, Kayak, & Story, 2012).

In a pilot program for recycling, a small hospital in Melbourne, Australia entered into an agreement with a local plastic recycling company to take plastics from the hospital free of charge. Over a one-year period, operating room staff recycled approximately 200 kilograms per week of non-infectious plastics that would otherwise have been dumped into a landfill at a cost of 10 cents per kilogram. The hospital savings was \$20 per week. Staff reported no increase in delays between cases or leaving work as a result of recycling (McGain et al, 2008). In another study, anesthesia providers responded to a questionnaire regarding attitude toward recycling and the majority were found to be concerned about environmental pollution; however, they would not participate in a recycling program unless it was mandated legislatively (Goldberg, Vekeman, Torjman, Selzr, & Kynes, 1996).

The benefits of a recycling program are altruistic, may help reduce hospital costs, and may secondarily improve public relations. Proper source separation of waste, development of recycling infrastructure, education of workers and managers, and the efforts of hospital administrators are the vital components of a successful recycling program (Lee et al., 2002).

Problem Statement

A study evaluating anesthesia providers' perceptions of recycling in the operating room found that perceived barriers to recycling by providers included inadequate knowledge regarding the recycling capabilities of the hospital and a lack of space for recycling receptacles (McGain et

al, 2012). At NorthShore University HealthSystem, Evanston Hospital, a recycling program has already been implemented in the operating rooms. Recycling bins are placed near separate waste receptacles close to the surgeon and operating room nursing staff. Anesthesia personnel are usually separated from the majority of non-anesthesia staff and equipment as they are required to remain in close proximity to the patient they are caring for, usually at the head of the operating table near their anesthesia equipment. Restrictions to movement within the operating room, in addition to time constraints and other set priorities and responsibilities, present a challenge for anesthesia providers who might otherwise participate in the recycling program. Despite the current recycling practice at this institution, barriers such as inconvenient access to recycling bins, poor staff prioritization regarding recycling, and misinformation about recyclable items prevent staff from consistently contributing to recycling efforts.

Theoretical Framework

Nursing intellectual capital theory suggests that the nursing capital of a healthcare organization is a combination of the knowledge possessed by the nurses that work for that organization and of the information existing within the organizations systems, including practice guidelines (Covell & Sidani, 2013). Hospitals can maximize their intellectual capital by providing guidelines for a waste recycling program as well as resources for anesthesia providers in order to maximize participation in the recycling program. “Participation” is a concept defined as “the state of being related to a larger whole” (Merriam-Webster, 2015). An antecedent to participation of anesthesia providers in a recycling program is maximized intellectual capital by way of provision of resources. The outcome of participation is higher yield recyclable waste.

Purpose of the Project

The purpose of the project was to determine whether or not a modified recycling program that incorporated convenient placement of a receptacle for recyclable materials would increase anesthesia providers' participation in a recycling program. Participation in the program was measured in weight (kilograms) of collected recyclables after designated recycling receptacles had been placed near each anesthesia cart.

Research Questions

1. What is the current level of participation in recycling at NorthShore University HealthSystem Evanston Hospital by anesthesia providers?
2. How does convenient placement of a receptacle for recyclable waste affect participation in recycling program among anesthesia providers in the operating rooms at NorthShore University HealthSystem Evanston Hospital, measured by the difference in weight of recycled material over a one-month period?

Literature Review

A literature review was conducted to evaluate current research pertaining to the perceived barriers to participation in operating room recycling programs by anesthesia providers. Databases used include PubMed, CINAHL Complete, and ProQuest Nursing & Allied Health Source. Medical subject heading (MeSH) terms searched were: 'recycling', 'operating rooms', 'plastic', 'medical waste disposal' and 'anesthesia'. Within these databases, a total of 106 journal articles were discovered ranging in publication dates from 1993 to 2014. Inclusion criteria used to narrow the results for qualifying articles or studies included a focus on recycling of plastic material, identification of (or methods for overcoming) barriers to recycling, and recycling initiative programs within the anesthesia sector of the operating room. Based on these

inclusion criteria, ten articles were chosen for literature review. For the purpose of this study, the authors chose to focus solely on the regulation of medical waste and barriers preventing participation in recycling initiatives, specifically that of non-hazardous plastic waste encountered by anesthesia providers. A comprehensive research article table has been compiled summarizing influential articles used to develop this project and its concepts (see Appendix A).

Identification of Barriers

An article review by Esaki (2009) summarized what is known about waste generation in hospitals and discussed various strategies for waste management. Authors reported that operating rooms generated 20-33% of total hospital waste. Potential anesthesia-related waste was identified and included syringes, bottles and vials, and airway equipment and hoses. A barrier to recycling identified by the authors is that operating rooms are crowded with so much equipment that there may not be additional space for recycling bins (Esaki & Macario., 2009).

Lee et al (2002) studied the recycling potential of medical plastic wastes generated by five hospitals in Massachusetts. They analyzed the sources, disposal costs, and plastic content of medical wastes. They then evaluated the recycling potential of plastic wastes in various departments, including operating rooms. Operating rooms were identified as a major source of plastic waste. Large volumes of plastic waste were found to be mainly due to a chance of contamination or infection, and simplification of purchasing plastic components and lack of classification of plastics for recycling (Lee et al., 2002).

McGain et al (2008) reported a pilot program to recycle operating room plastic in Melbourne, Australia. The authors discussed barriers to recycling and noted that, unlike household plastics, most medical plastics are not classified by a code or number. Other barriers identified were concerns about infection risks, difficulty separating different types of plastics,

reluctance to change work practices and an attitude that environmental concerns are irrelevant to medicine. This pilot recycling program resulted in 200kg per week of recycled material with a savings to the hospital of \$20 per week (McGain et al., 2008).

A feasibility study of recycling of single-use breathing systems among anesthesia providers was conducted by Goldberg et al (1996). The design included a two-part analysis: analysis of responses to a questionnaire regarding anesthesia providers' attitude toward recycling, and a cost-benefit analysis of a recycling program. The authors found that the recycling program is cost-effective and environmentally beneficial; however, most anesthesia providers would not participate in a recycling program unless mandated by law (Goldberg et al., 1996).

In a more recent survey of anesthesiologists' views of operating room recycling, McGain et al (2012) investigated attitudes toward and barriers to recycling. A survey was distributed to anesthesia providers in Australia, New Zealand and the UK. More than 90% of respondents reported that they would like to recycle at work. The greatest barriers to recycling most frequently reported by respondents were inadequate recycling facilities, staff attitudes, and inadequate information on how to recycle. Time, safety, inadequate recycling space, and cost were each thought to be the greatest barriers to recycling by less than 5% of respondents (McGain et al., 2012).

Identification of Suggested Solutions

Investigation into literature regarding recycling practices within the operating room setting would not be complete without review of proposed suggestions for change and development of successful recycling programs. Many articles found within the database searches included solutions for management of medical waste (namely plastics) and the methods through which a recycling initiative should be developed. Hospitals for a Healthy Environment

(H2E) is a national program that provides “hospitals across the nation with the framework, tools, and resources they need to change their waste-disposal practices” (Brannen, 2003, p. 25). The H2E program encourages institutions to consider their current waste disposal practice and as well as the potential impact simple, methodical change may have on the hospital and world environment (Brannen, 2003).

In 2011, Riedel published a study in the American Association of Nurse Anesthetists Journal regarding the multifaceted impacts of a hospital-wide recycling program (Riedel, 2011). In this study, financial and environmental incentives to recycle were discussed due to generation of “2.7 metric tons of waste per day” (Riedel, 2011, p. S9) by hospitals alone. Interventions created to address this problem were implemented in phases: Phase 1 included education of staff regarding environmental benefits of recycling and types of materials appropriate for the recycling receptacles; Phase 2 was placement of designated containers throughout the hospital with printed lists of acceptable items; Phase 3 meant collection of all bins into a designated area for weekly weight and disposal by a pre-determined company. After a year of waste collection, weight of materials was compared to the pre-intervention year to determine cost-effectiveness of an increased waste diversion from solid-waste to recycling receptacles. Riedel (2011) found that the “annual recycling increased 9.3metric tons (10.3 US tons) after single-stream recycling began” (p. S11). Significant financial benefits to this shift in waste separation were illustrated by the \$4,672.88 decrease in non-hazardous waste disposal cost (Riedel, 2011). Landfill waste was subsequently reduced by 40.2 metric tons, resulting in a cost-savings of \$4,114.75. Riedel suggested ease of use due to single-stream recycling and effective education of staff as major contributors to success of the program.

Practice Greenhealth, an online healthcare community, focused on efficiency and environmental friendliness within patient care and developed a template for creation of an operating room recycling initiative (Practice Greenhealth, 2011). Ten steps were outlined within the plan for improved operating room recycling compliance. ‘Step One: Enlist Allies’ stresses the importance of designating passionate, involved team of stakeholders to spearhead the new program. ‘Step Two: Identify Hauling Partner’ identifies the real challenge finding a reliable hauling company may pose for hospitals; clear communication lines between hauler and environmental services (EVS) director are necessary when establishing pick-up date, time and location, differentiation between nonhazardous/hazardous material, as well as single versus multi-stream capabilities. ‘Step Three: Have a Sense of What Can Be Recycled’ is critical in development of a coherent staff education program; without complete understanding of acceptable items within the spearhead committee, effective communication of items to participating staff members will be nearly impossible. ‘Step Four: Work with EVS to Define Containers and Collection Schedule’ suggests involvement of EVS in placement/replacement of designated receptacles and development of collection schedules for maximal effectiveness/cleanliness; use of a certain color receptacle specifically for recycled plastic waste may serve to facilitate workflow for EVS and anesthesia staff. This suggestion proved to be effective within the University of Chicago Medical Center operating rooms. According to Dr. Catherine Bachman, blue recycling containers were placed next to each anesthesia cart for the sole diversion of anesthesia related plastic materials such as syringe packaging, IV bag protectors, etc. Staff grew to recognize these blue containers as a reminder to recycle and ease of use/convenience of placement served to increase the amount of recycling products diverted from

solid waste disposal. The University of Chicago has since been nationally recognized for its efforts in environmental improvement and awareness (Bachman, 2010).

‘Step Five: Develop Signage to Highlight New Segregation Practices’ suggests implementation of pictures into signage placed near/above each receptacle to provide visual guidance for easy identification of acceptable plastic materials. ‘Step 6: Educate and Engage Staff on Appropriate Segregation Procedures’ stresses the crucial nature of a well-developed staff education plan; in-services regarding change to practice, color of receptacles and appropriate recyclable materials should be communicated in multiple staff meetings during times when majority of staff is available and receptive to information. ‘Step Seven: Divert Recyclable Waste Pre-Incision’ recommends starting recycling diversion during procedure set-up. ‘Step Eight: Segregate Recyclable Waste After Procedure’ is in place to maintain cleanliness of materials collected and prevent mixing of hazardous and non-hazardous waste between patients; a decision must be made regarding continuance of receptacle use between patients or if a new receptacle (bag) will be obtained for each patient. ‘Step Nine: Problem Identification and Resolution Plan’ encourages members of the planning committee to anticipate hiccups in implementation of the plan and brainstorm regarding how to prevent/troubleshoot those roadblocks. ‘Step Ten: Track Progress and Recognize Success’ realizes the need to recognize effective change within an institution and use the new-found success to implement policies to ensure continued success. These guidelines were established without bias or conflict of interest and were developed to aid hospitals in development of an effective recycling initiative (Practice Greenhealth, 2011).

The push for potential plastic reuse has also been recognized by the Healthcare Plastics Recycling Council (HPRC) as a significant potential contribution to the future health and

wellness of our society (Healthcare Plastics Recycling Council, 2013). Historically, recycling efforts within hospitals have been largely focused on administration and food service areas. However, the need to expand these efforts throughout an institution is anticipated by the HPRC and subsequent guidelines have been developed to aid hospitals in disposal of specific plastic waste. Links to appropriate resources regarding characterization to waste, commitment to sustainability, economic analysis, and clinical infrastructure are all provided within the pamphlet (Healthcare Plastics Recycling Council, 2013). Waste characterization tools such as “The Plastics Mapping Tool” are provided to help distinguish between types of plastics accepted by most hauling companies; the HPRC also suggests an in-depth conversation and detailed contract to be drawn up between hospital and recycling partner to prevent blurred lines regarding acceptable plastics. Guideline tools for best placement of receptacles, necessary equipment, training tools and posters, as well as tools for evaluation of program effectiveness are also provided in the HPRC pamphlet (Healthcare Plastics Recycling Council, 2013). Periodic review and audit of the program is recommended by the HPRC to ensure sustainability of the chosen program. Provision of useful resources such as these is advantageous in development of new plastic recycling initiatives.

Research Design

A single group post-intervention evaluation design was utilized for this study.

Sampling Approach

There are seventeen operating rooms at Evanston hospital with 125 anesthesia providers on staff including doctors, nurse anesthetists, and residents. Depending on the number of scheduled surgical cases, there were 40-50 anesthesia providers scheduled daily for patient care.

All anesthesia providers at Evanston Hospital were included in the sample as each of these providers had the opportunity to participate in recycling.

Recruitment Procedure

Recruitment activities were conducted by the primary investigators of this study. After a two-week, blind collection of materials used to measure baseline recycling participation, an email was distributed to all NorthShore anesthesia staff using a listserv via EasyCall software system. In the email, researchers notified anesthesia staff of the pilot program and emphasized the availability and location of conveniently-placed recycling receptacles in each OR. A list of recyclable materials was attached to the email. Laminated copies of this list of recyclable materials were posted above each new recycling receptacle.

Inclusion criteria for participation in the study were: Participants must have been current anesthesia providers (doctor, resident, CRNA, or SRNA) at NorthShore University HealthSystem, Evanston Hospital. Materials collected included all non-contaminated plastic waste except that identified as #6-type plastic (polystyrene), all non-contaminated paper waste except that covered in waxy film, and all glass waste except those medication vials containing greater than 3% of the original contents of the vial. Exclusion criteria for participants were operating room employees in non-anesthesia role (such as operating room nurses, surgeons, and technicians). Exclusion criteria for materials collected included biohazardous waste or solid waste collected in waste receptacles other than that provided by researchers. Participants did not receive a material incentive to participate in the study.

Ethical Considerations

This project obtained Institutional Review Board approval from NorthShore University HealthSystem and DePaul University. Protection of human subjects was upheld by the

anonymous nature of data collection for the study, with recycled material weighed daily in a single measurement separate from interaction with anesthesia providers. Participants were informed of the purpose of the study, protection of their privacy, their right not to participate without penalty, and the contact information of researchers. All data collected was stored on a password-protected computer that only the primary researchers could access. Permission to wave consent from eligible participants with support from the Director of Anesthesia at Northshore University HealthSystem, Dr. Joe Szokol, was approved by the Office of Research Services at DePaul University.

Methods

Data collection for this study was conducted in the 17 operating rooms at NorthShore University HealthSystem Evanston Hospital from February 15, 2016 to March 15, 2016, with a total of 20 days of data collection. Pre-intervention data collection consisted of 10 days of collection of recycled material from each operating room by a member of the research team between the hours of 3 and 4 pm. Collected material was weighed in kilograms (kg) daily using a Tariss JetSetter luggage scale, which was zeroed prior to each use. The daily number of cases was tracked using the operating room status board (OpTime, Epic Systems, Verona, Wisconsin), with cases starting prior to 6 am and at or after 3 pm each day excluded from the case count. Following completion of the pre-intervention 10-day period, an email describing the study and placement of receptacles was distributed to all anesthesia staff using the listserv provided on NorthShore's EasyCall server (see Appendix B). A paper copy of the email notification as well as an updated list of materials acceptable for recycling were posted above the anesthesia cart in each operating room. Each morning between 6 and 6:30 am, a recycling bag was placed on the left side of the anesthesia cart by a member of the research team (see Figure 1). The same bags,

later containing recyclable waste, were collected between the hours of 3 and 4 pm daily using the same collection protocol as in the pre-intervention period. The number of cases was again tracked using the operating room status board, with cases starting prior to 6 am and at or after 3pm each day excluded from the count. Microsoft Excel 2013 was used to record daily collection throughout.

Results

Pre-intervention collected waste totaled 6.5 kg over the 10-day collection period (for 346 cases) with an average of 0.65 kg per day and 0.0192 kg/case. Post-intervention collected waste totaled 34.5kg of recyclables (for 371 cases) with an average of 3.45 kg per day and 0.0978 kg/case. Kilograms per case of recycled waste increased by 409% after the intervention period. The highest collection day in the pre-intervention period resulted in 1.3 kg of waste; the highest collection in the post-intervention period resulted in 7.0 kg of waste. Statistical analysis was completed using IBM SPSS software to determine mean, standard of deviation, and significance ($p < 0.05$) of pre- and post-intervention measured values using a paired t -test (see Table A).

The difference between total recycled material collected pre-intervention (6.50 kg) and total recycled material post-intervention (34.50 kg) was statistically significant, with paired t -test yielding a p -value of 0.001. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant, with paired t -test yielding a p -value of 0.01. To ensure that the pre- and post-intervention arms are not systematically biased, a t -test was also performed to determine the statistical significance of the variation in the number of cases during the pre-intervention versus post-intervention periods (346 cases pre and 371 cases post). The t -test for this data set gave a p -value of 0.498, indicating that the two arms are not statistically significant in terms of the number of cases during the study period (see Table B).

Discussion

Results indicate that participation in recycling by anesthesia providers is largely dependent on the convenience of recycling. In our literature search, we identified a lack of convenience in the face of numerous other high-priority tasks as a barrier to operating room recycling by anesthesia providers. We addressed this barrier by placing recycling bags and a recycling guide at a convenient location next to each anesthesia cart. This allowed anesthesia providers to recycle appropriate waste without having to leave their patients and walk across crowded, often sterile-prepared operating rooms to the designated recycling bins used by scrub and circulating nurses. Recycled waste per case increased by 409% overall after the intervention.

Recycled material collected during the pre-intervention period reflected participation in recycling by anesthesia providers in Evanston Hospital at baseline. The amount of recycled material per case varied considerably from day to day. The lowest amount of recycled material collected in a day was 0.0056 kg per case and the most recycled material collected in a day was 0.0382 kg per case (see Chart 1).

Variation in recycling by day may be attributed to variation in recycling practices among anesthesia staff; in other words, some anesthesia providers participated more than others in recycling at baseline, and on the days those providers were working, more material was collected.

Another potential reason for daily variation in waste per case at baseline may be that on certain days or with certain surgeries, there is a higher prevalence of more complicated procedures requiring the use of more supplies and, therefore, increased yielded waste. For example, surgeries requiring general anesthesia include use of an airway circuit with heavy corrugated plastic tubing as well as packaging for: oral gastric tubes, at least six to ten medication syringes, eye protection, intravenous fluid bags and wrappers, etc.. The increase in

demand for supplies during general anesthesia cases is much higher than for that of monitored anesthesia care cases, which may only require a nasal cannula, three to four syringes, and less intravenous fluid. Provider preference for supplies may also impact this disparity as some providers take a “less is more” approach and generally use less supplies than their peers.

Patient acuity may also explain variation in recycling practice. Anesthesia providers are trained to place patient safety as top priority. If a patient is critically ill or unstable, or the surgery is particularly high-risk, speed and efficiency on the part of the anesthesia provider are paramount to safety. In some cases it must be recognized that even when a receptacle for recycling is conveniently placed, the act of sorting materials may take time and attention away from the care of an unstable patient. The anesthesia provider must use his or her judgment to decide whether or not it is safe to prioritize recycling in high-acuity cases.

Another explanation for the variation in recycling from day to day is possible contamination of recyclable waste by hazardous material (i.e. blood or other bodily fluids), which renders waste inappropriate for recycling. Plastic material that has come into contact with blood, sputum, gastric contents, or urine/feces, must always be disposed of via biohazardous solid waste receptacles. Provider understanding of contamination by bodily fluids may not always be clear. For example, the plastic corrugated tubing used for breathing circuits contains condensation from the moisture in patients’ exhaled gases. This moisture is not considered contamination and therefore does not render the used circuit unsuitable for recycling. If, however, a patient’s sputum contaminates the tubing, the circuit must be disposed of with biohazardous waste.

The recycled material collected during the post-intervention period reflected participation in recycling at Evanston Hospital after bags were provided on the anesthesia cart in each operating room. Again, the amount of recycled material per case varied considerably from day to day and this was likely due to variation in recycling practices by different staff, the types of cases that were performed on different days, the level of patient acuity, and the possibility of hazardous waste making some waste unsuitable for recycling. The lowest amount of recycled material that was collected in a day was 0.0229 kg per case and the most recycled material that was collected in a day was 0.1707 kg per case.

It was noted that during the post-intervention data collection phase, the amount of recycled material increased steadily over time. On day one, the total collected waste was 1.1 kg and on day ten the total collected waste was 4 kg (see Chart 2). This increase in participation over time may be attributed to increased awareness of the study among anesthesia providers over the 2-week period, as some providers may not have immediately read the email sent to them or noticed the sign and recycling bag. Additionally, momentum and support for the researchers' project may have built among anesthesia staff over the two-week period, causing them to increase their participation in recycling. In their template for creation of an operating room recycling initiative, Practice Greenhealth stresses the importance of educating and engaging staff on recycling behaviors. They suggest that the plan for recycling should be communicated repeatedly in order to reach staff when they are most receptive to information (Practice Greenhealth, 2011). Increasing staff engagement during the data collection period explains why there was a dramatic increase in providers' participated in recycling efforts for this pilot study over time.

The null hypothesis for this study was that there would be no statistically significant difference in the amount of recycled material collected pre-intervention versus post-intervention. Paired *t*-tests allowed us to examine the relationships between pre- and post-intervention data. The difference between total recycled material collected pre-intervention and total recycled material post-intervention was statistically significant. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant. These findings suggest that participation in recycling by anesthesia providers, both overall and per case, increased significantly after signs and recycling bags were placed conveniently at the anesthesia cart in each operating room.

A *t*-test was also performed to determine the statistical significance of the difference in the number of cases during the pre-intervention versus post-intervention periods. The *t*-test for this data set gave a p-value of 0.498, which is not statistically significant (see Table B). This suggests that the overall caseload was not a confounding factor for recycling participation, and therefore it can be inferred that the difference in recycling practice pre- and post-intervention is attributable to the convenient placement of recycling bags rather the difference in caseload.

Strengths and Limitations

Strengths of the study include valid, statistically significant comparisons between baseline provider participation and participation following the implemented intervention. As stated, the difference in total cases performed during pre- and post-intervention data collection was not statistically significant and is, therefore, not a confounding factor in this study. Study approval from both the NorthShore University Health System and the DePaul University Institutional Review Board upheld participant anonymity throughout the data collection period. Increased recycling convenience improved participation by 409% in this institution's anesthesia

department; when extrapolated to one year of participation at the post-intervention rate, an estimated 900.45kg of waste could be diverted from municipal solid waste (see Appendix D) compared to the pre-intervention forecast of 169.65kg. The environmental implications of an increase in waste diversion of this magnitude are impressive and may serve as motivation for providers to continue recycling participation. It is believed that during the data collection period most of the enthusiasm demonstrated by anesthesia providers at Evanston Hospital was for recycling itself.

A limitation of the study is that it was not blinded; the study took place amongst anesthesia colleagues who were aware of the data collection taking place and whose support for the researchers may have influenced the outcomes of the study. Inability of researchers to control for the type of cases performed during the pre- and post-intervention collection period must also be identified as a limitation in this study as the type of case is suggested as having an impact on recycling practice. Inability to control for scheduling variation among anesthesia providers who work on different days of the week is also a potential limitation of the study, as some providers were more motivated than others to participate in recycling.

Implications for Further Research

Further studies could be conducted, perhaps by administering a post-intervention survey, to explore staff attitudes regarding the effect of convenience on recycling. As stated by McGain, et al. (2008), reluctance to change work practice or belief that recycling is not a priority may serve as major barriers to recycling participation. A study that examines staff attitudes regarding the recycling program might serve as the first of multiple, ongoing evaluations of the program. These evaluations can serve to identify areas for improvement that ultimately engage more participants and enhance recycling in the institution.

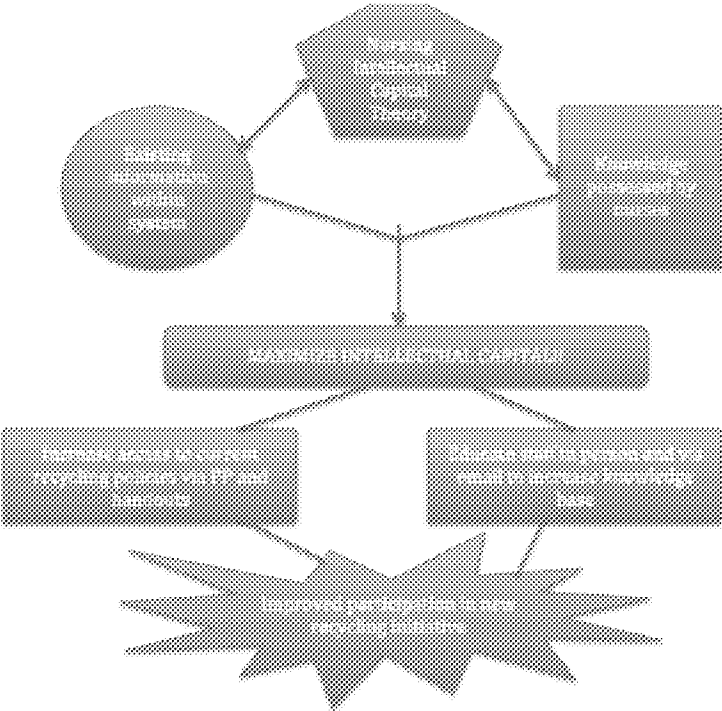
Additionally, further studies might emphasize the impact of education in recycling practice on staff participation. A thorough understanding of which materials are acceptable for recycling is crucial for the success of any recycling program. A study might examine the most effective ways to keep staff informed. For example, as supplies and equipment change over time, the list of approved materials will need revision and will, therefore, provide researchers with opportunities to re-educate staff on a regular basis. This repetition may enhance learning and reinforce participation.

Finally, a study focusing on cost analysis may provide insight as to the financial benefit of increased recycling to the hospital. NorthShore University HealthSystem reports a solid waste cost of \$0.03/lb and a recyclable waste cost of \$0.01/lb. An exhaustive cost-benefit analysis would highlight the financial gains that a recycling program can offer the institution. This could enhance support from administration and ultimately lead to changes in policy and practice.

Conclusion

Anesthesia providers are in a position to help their institution separate recyclable waste from municipal waste. The results of this study suggest that the provision of a conveniently-placed receptacle can greatly increase participation in recycling by anesthesia providers, as evidenced by a 409% increase in recycling after the intervention. The benefits of recycling are many and include reduced landfill waste and environmental pollution, institutional cost savings, improved staff morale and better public image for the institution.

Conceptual Map



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Appendix A: Research Article Review Table

Study Purpose	Research Design	Sampling	Human Subjects Issues	Extraneous Variables	Intervention Offered	Outcome Measures Used	Adverse Effects of Intervention	Study Variables	Statistical Analysis	Study Findings
"A Survey of Anesthesiologists' Views of Operating Room Recycling" - (McGain Forbes; White, 2012)										
To determine the importance of recycling operating room waste to anesthesia providers; To identify barriers preventing OR recycling	Qualitative ; Survey emailed to 500 randomly selected fellows via the ANZC Trials group and to approx..5000 consultant anesthetists in English National Health Service; Survey developed using Survey Monkey	Survey of Anesthesiologists or anesthesia fellows ; No gender/age /ethnicity variables; -Total of 780 surveys received.	Study methodology approved by Human Research Ethics Committee at Western Health, Melbourne, Australia . Written informed consent was waived by ethics committee.	Survey included one open-ended question to attain additional potential information regarding barriers to recycling within the OR	No Intervention measured	Outcomes measured are the survey response s; Low rate of return on survey distribution serves as major limitation of the study.	None	- Questionnaire used could be comparable across other studies -Used an established study tool, Survey Monkey for easy distribution/access for survey participants	Statistical analysis completed via Wilson's Method to calculate the 95% confidence intervals for the proportions,	95% agreed that they would like to recycle anesthesia waste; 11% agreed that recycling does take place; 3 most influential barriers to recycling identified as: 1. Inadequate recycling facilities, 2. Staff attitudes, 3. Inadequate information on how to recycle; Time, safety, inadequate space, and cost were less influential barriers to recycling
"Analysis of an Organization's Waste Stream" – outlines how to complete a waste stream analysis - (Hayne, 1993)										
Development of thorough waste stream analysis for hospitals to utilize in order maintain safe, cost effective methods of waste disposal from beginning to end or to develop new	Review of a system – not study in sense of qualitative vs quantitative; More of an outline on how to perform a waste stream analysis	Explains how to perform this analysis within one institution	No human subjects involved in this article	- Individuals within the organization who are current with the local, state, and federal regulations may need to be included in the analysis	Analysis of the amount/type of waste disposal within an institution to provide suggestions for improvement and identify areas of need	None	None	None	None	Waste Stream Analysis worksheet provided as suggested format for analysis

policy regarding waste management in that institution				committ ee -Should include status of local landfills , waste management of other major community polluters						
The Green Operating room: simple changes to reduce cost and our carbon footprint - (Wormer, 2013)										
Assess improvement in waste reduction and recycling after implementation of a Green Operating Room Committee	GORC formed and Green OR initiative campaigns instituted throughout the ORs. Quarterly meetings held to discuss the impact of the initiatives and their effectiveness; Results of the 'score cards' were recorded and downstream effects on cost analyzed. Methods were effective in analyzing the potential for cost savings and identifying the areas for improvement within cost containment.	Study performed at one large Level-1 trauma institution in North Carolina; 100 consecutive MDs, Nurses, Scrub techs monitored during scrub patterns regarding water consumption; Education campaigns provided to all other OR staff in regard to solid reusable waste, Red Bag biohazardous waste, and Recyclables/ Reusables. -Population of this study well matches that of interest in our project. - Gender/age/ethnicity not pertinent variables -Sample size was not justified through use of statistical analysis.	Methodology approval not mentioned; GORC formed by Division of Gastrointestinal and Minimally Invasive Surgery and joined by Nursing, Environmental Services, and Anesthesia at Carolina's Medical Center in 2008.	Study did not control for confounding variables, but did take them into account in regard to outside cost of waste disposal ; involved multiple departments in the project as well.	Education campaigns for each recycling initiative was completed over the course of a year to evaluate the effectiveness of each campaign on cost/staff behavior change.	Effectiveness is measured through comparison of \$\$ before and after the initiatives were completed; through their studied initiatives, this institution saved approximately 158,000 annually .	None	Variables of interest: Solid Waste Reduction, OR Recyclables & Reusables, Energy & Water Reduction, Charitable Donations. Researchers performed their own data collection with the help of environmental services staff in which the weight of waste was measured and compared throughout the year.	None	-Avg cost of disposal of regulated medical trash is \$0.28/lb. -Annual cost savings after implementation of 4 different recycling/energy saving initiatives was \$158,000. -12,000lbs solid waste was diverted, 75% decrease in Red Bag waste, 500lbs alkaline waste diverted, Complete reduction of foam waste, 2.7million liters of water saved.
People, Planet, and profits: the case for greening operating rooms - (Kagoma, 2012)										
Purpose is to identify ORs as	Analysis/Literature Review;	138 article resulted, 65 of which	No IRB approval needed	No extraneous	Suggested interventions	No measure of	None	No study variables	None	-Hauling costs for recyclable

major contributors to waste and to identify waste-reduction strategies that “satisfy the ‘triple bottom line’ (people, planet, profits), by reducing health care costs and environmental effects without compromising patient care” (p. 1905).	predefined search strategy explained and total of 138 articles resulted, 65 of which were used in the analysis.	were used to complete the literature analysis.	b/c no human subjects were involved in this literature review.	variables	included for ways to reduce waste via segregation of waste products, fluid waste management, energy savings, and equipment packaging are all provided. -No direct intervention is evaluated in this review	effectiveness as this is just a lit review.					plastics are nearly half that of solid waste disposal; Institutions may negotiate rebates for recycled plastics.
Reduce – Recycle – Reuse: Guidelines for Promoting Perioperative Waste Management (Lausten, 2007)											
Literature review to promote greener waste management objectives	-“Green team” of nurses recruited voluntarily to explore the excessive waste generated in the perioperative setting. - Descriptive analysis of contents of one red bag completed. -	One red bag analyzed; may be a limitation that only one bag was analyzed.	No IRB approval mentioned; only human subjects at risk were the authors themselves during the removal of contents of potentially biohazardous material in the red bag. No mention of consent obtained from the members of the “Green Team”.	Did not control for extraneous variables such as type of procedure performed in red-bag associated OR; does state that limitations of study are that only one bag is analyzed results may vary institutionally.	Guidelines for greening of the operating room after realizing the mis-education demonstrated by the contents of a red bag	None	Benefits are worth the cost of implementing the recommended guidelines	Descriptive analysis was performed	None	-Majority of waste found in red bag is not actually biohazardous waste -Providers need to be more aware of what they place in the red bag and guidelines are recommended for future practice; time table should be included b/c will be a slow process to change the behavior and make all those involved feel that their actions matter.	
Greening critical Care - (Chapman, 2011)											
Map ways	Review of	Population	No	No	No	No	Benefits	No study	None.	Recomm	

to green up an ICU and reduce negative environmental effects on patients with suggestions targeted at individuals as well as whole institutions.	methods used to increase green initiative awareness within an ICU/hospital. Four areas of focus are considered: consumption, waste, toxins, and personal footprint of staff.	targeted is ICU staff. → not our target population, but same idea to increase awareness within a smaller portion of the entire hospital organization.	approval was gained or warranted b/c no intervention was executed.	extraneous variables	intervention offered to be examined; only recommendations for practice.	outcomes measured.	of this review outweigh the potential risks.	variables b/c this is just a recommendation for practice within the ICU.		recommendations for reducing waste, increasing reuse, and decreasing the carbon footprint of those working within the ICU in this institution evaluated.
Environmental and financial impact of a hospital recycling program (Rieder, 2011)										
Purpose: To determine the environmental and financial impact of recycling at 148-bed acute care hospital.	Current non-hazardous waste disposal practices were kept in place and single-stream recycling was added and measured over a year period. Staff was educated about environmental benefits of recycling and what to recycle via PP presentations and at nursing leadership meetings; Newsletters were published promoting the program. Recycle bins were placed in staff common areas with notification acceptable items for collection; Bins were collected by disposal company at	Entire hospital staff is the sample population. -Good match to our target population, although larger participant sample than anticipated for our study b/c we are focusing in OR only, not entire 148-bed facility.	Robert Morris University granted exempt IRB status. Mercy Foundation granted money for the purchase of recycling bins.	Confounding variables possible within the study include disposal of inappropriate material in the recycle bins; this was controlled as much as possible by prior education of staff as well as informational sheets placed on bins. Seasonal variation in waste generation was considered and eliminated as a confounding variable by considering an entire	- Intervention offered was placement of recycling bins in common areas for easy, single-stream recycling opportunities. -Control group subjects received education about recycling benefits and items before placement of bins in common area. -Study lasted a year.	Effectiveness of the study was measured via comparison of nonhazardous waste streams from 2008-2009 to those of 2007-2008. Environmental Protection Agency's Waste Reduction Model used to calculate the GHG emissions and energy savings of new practices compared with the baseline year;	Benefits of the study are work the potential harm. No cost was involved in this study due to money obtained from a grant to purchase the bins.	Variables include hospital operations during the control and study period → nullified by statistical correlation. -No questionnaires were used to complete the study. -Tools used were Environmental Protection Agency's Waste Reduction Model to calculate the GHG emissions and energy savings of new practices → reliable tool.	SPSS analysis of waste generation and facility operations was performed. Pearson Correlation was used to compare waste generation and facility operations for control and intervention periods. -Waste generation and facility operations between the two time periods noted to be very similar	- Nonhazardous waste disposal cost decreased \$4,672.88. -Revenue for the hospital increased by \$390 and overall landfill waste was reduced by 40.2 metric tons.

	the end of each week. Tonage of non-hazardous waste for this year time period was compared with previous year (control).			year time frame in the study and comparison group.						
Managing Medical Waste - (Brannen, 2003)										
Hospitals for a Healthy Environment (H2E) helps hospitals change waste-disposal practices; Article outlines ways in which this policy guideline can beneficially impact waste management and respond to demands of currently evolving environmental awareness.	Review of one policy → may be considered as type of case study? Case review? H2E provides healthcare organizations with the framework, tools, and resources needed to change their waste disposal practices.	Populations targeted are any and all healthcare organizations → either in the “partner” or “champion” classification depending on what type of institution it is.	No approval needed.	None	Interventions offered are just suggestions for resources regarding waste management start-ups.	No outcomes measured.	No adverse effects of intervention or procedure	NO study variables	No statistical analyses.	Organizations interested in beginning a new recycling initiative should utilize the framework and tools provided via H2E. Mercury assessments should be conducted. Recommendations for starting a waste management plan.
Wastage of Supplies and Drugs in the Operating Room (Esaki & Macario, 2009)										
Identification of anesthesia related waste in the OR including drugs, packaging, etc.; Explanation of Reduce-Reuse-Recycle-Restrict practice suggestions	Review of current RRRR practices within the OR and related to anesthesia	Populations targeted are anesthesia providers who have contact with waste associated with direct patient care and surgical set up	No approval needed.	None	Reduce, Reuse, Recycle, Restrict – suggestions for implementation of these principles within the OR; Restrict = Segregation of waste into classes for easier distribution to the proper waste	No outcomes measured	No adverse effects of intervention or procedure	No study variables	No statistical analyses	Identification of barriers to recycling include space for a recycling bin, potential infectious risk if providers don't follow the proper organization of waste

					stream.					
Medical Waste in the Environment: Do Anesthesia Personnel Have a Role to Play? (Goldberg et al., 1996)										
To conduct a feasibility study of the mechanics of recycling single-use anesthesia breathing systems and practices of anesthesiologists and nurse anesthetists in a tri-state region.	Two-part, open, prospective analysis using pre-printed questionnaire and cost-time analysis of labor and materials	Anesthesia departments in PA, NJ, and Delaware	No approval discussed although questionnaire was completed by providers involved in the study	Cost-time analysis of breakdown of single-use breathing circuit only examines the effectiveness of breaking down this ONE type of circuit – many types exist and some are more complex than others with potential for non-recyclable components	Breathing circuits were collected and sent to a laundry facility where they were broken down to evaluate time/cost relationship or benefit. A survey was distributed to anesthesia providers to determine willingness to participate in a recycling program if one was offered.	Outcomes measured were cost of disassembly of the breathing circuits → showed a potential savings of over \$4,000 in a year's time. Survey outcomes were measured with a questionnaire.	No adverse effects of the interventions	Study variables were type of breathing circuit chosen for the study.	Anova and Kruskal-Wallis tests	The disassembly program proposed is economically feasible and has many cost benefits. The questionnaire found that many anesthesia providers are concerned about environmental benefits of recycling but wouldn't participate in a program unless legally mandated.
Recycling plastics from the operating suite (McGain, F., Clark, M., Williams, T. & Wardlaw, T., 2008)										
Identification of types of plastic to be recycled and contacted within patient care by an anesthesia provider as well as identification of barriers to recycling.	Pilot study to determine potential savings of increased recycling	OR "theatre" staff were targeted for one year in a small Melbourne Australia hospital.	No approval discussed	Extraneous variables were the different types of plastic considered within the study, potential for contamination of materials, etc.	Intervention: Agreement was reached with local plastics recycling company willing to accept used plastic materials from the OR and these were collected for one year	Cost and environmental savings over the study period of one year.	No adverse effects of the study. Staff did not experience delays between cases due to the new recycling initiative.	None	None discussed.	Good information about the prevalence of plastics capable of being recycled within the OR and identification of barriers to recycling such as different types of plastic, infection concerns, etc. Shows improvement in participation when staff is educated properly.

Medical Plastics Recycling in the OR (Practice Greenhealth, 2011).										
Purpose of this module is to list steps useful in designing a new recycling initiative for a hospital/operating room setting	Suggestion for practice, not a study.	Operating room staff are targeted as well as administrators interested in developing a system for recycling	No approval discussed.	None	Steps 1-10 of how to develop and evaluate the effectiveness of a new recycling program	No outcomes measured	No adverse effects of the study	None	None	Great tips to ensure success of a new program as well as things to look out for when putting a new program together.
Hospicycle: A plastics recycling guide for hospitals (HPRC, 2013)										
Purpose of this compilation is to serve as a outline for development of a new plastics recycling program – many links provided for administrators	Suggestion for practice, not a study.	Operating room staff and administrators who are involved in development of a new program.	No approval discussed.	None	Outlines steps to take before beginning, as well as links useful in determining commitment to sustainability, economic analysis, infrastructure of the program, waste characterization, the importance of choosing the right recycling partner, and how to run a successful program.	No outcomes were measured since this is a suggestion for practice	No adverse effects of the study	None	None	Good for outlining how to set up a new program
Analyses of the recycling potential of medical plastic wastes (Lee, B.K., Ellenbecker, M., Moure-Eraso, R., 2001)										
Purpose is to analyze the recycling potential of plastic wastes generated by health care facilities.	Collection of materials and evaluation of type of plastic, amount of each type,	Five Massachusetts hospitals – all areas of recycling were considered, not just ORs	No approval discussed	None	Collection of materials in the ambulances, ORs, cafeterias, etc to compare amount and type of plastics capable of being recycled.	Outcomes measured were waste characteristics, components of waste, cost of disposal of waste, and collection from the ORs compared with	No adverse effects of the study	Types of plastic collected 5 area hospitals involved -Unable to compare to other studies	Unknown	Identified the major risk of recycling as spread of infection

						ambulan ces, cafeteria s, and other areas of the hospital.				
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Appendix B: Email to Anesthesia Staff

Dear Anesthesia Colleagues,

Hello! We are sending this email to notify you of the recycling project we are working on as part of our graduation requirements at NorthShore. Our clinical time here has alerted us to inconsistencies in recycling practice at Evanston and we would like to know whether or not anesthesia providers are more willing to recycle when they are provided with a conveniently placed receptacle.

Over the next weeks we will provide plastic bags on the side of each anesthesia cart in the morning; these bags will be collected each afternoon at 4pm. **DO NOT DISPOSE OF THESE BAGS!! THEY ARE TO BE USED FOR DATA COLLECTION!!**

Please **DO** use these bags to recycle packaging and equipment. A comprehensive list of recyclable materials is attached and this list will also be available to use as a reference on anesthesia carts.

Here are some general guidelines for recycling:

DO recycle

- All plastics packaging, including syringe/ETT/IV fluid packaging, etc.? **YES!**
- IV tubing that is **NOT** contaminated with biohazardous materials (ie. blood)? **YES!**
- Any other plastic peel-back from materials packaging? **YES!**
- Paper without waxy film? **YES!**
- Used Anesthesia Circuit? **YES!**
- Paper **INSIDE** nasal cannula package? **YES!**
- Empty glass drug vials? **YES!**
- Empty IV Bags themselves? **YES!**

DO NOT recycle

- Paper with waxy film? **NO** -- if you can't tear the paper, you can't recycle it!
- Nasal Cannula plastic packaging? **NO**
- #6 plastic items (will have # on them)? **NO**
- Glass vials containing drugs? **NO**

Thank you in advance for your participation!

Sincerely,

Alaina Becker, SRNA, Class of 2016
Brittany Schuler, SRNA, Class of 2016

NorthShore Anesthesia Cart: Items by Drawer**1: MEDICATIONS**

YES	NO
Plastic back of black rubber syringe cap package	Paper portion of black rubber syringe cap package
Glass vials/ampules with <3% med remaining	Glass vials containing >3% of med

2: SYRINGES/IV CANNULAS

YES	NO
Plastic portion of syringe wrapper	Paper on syringe packaging
Plastic portion of needle wrapper	Paper on needle wrapper
Entire 20cc syringe wrapper	
Plastic portion of IV catheter package	Paper on IV catheter package

3: AIRWAY ACCESSORIES

YES	NO
Oral airway wrapper/package	Paper with waxy film
Plastic bags covering extra blades	
Plastic breathing circuit (not contaminated with blood)	

4: ETTs/STYLETS

YES	NO
Plastic portion of ETT package	Paper on ETT package
Plastic portion of Stylet wrapper	Paper portion of stylet wrapper

5: NGTs/BLUE TOWEL/TEMP PROBES

YES	NO
All plastic from NGT package	Contaminated NGT itself
Clear plastic from temp probe wrapper	Temp probe itself
Entire 60cc syringe wrapper	

6: IV FLUIDS

YES	NO
IV bag outer package	
IV bag itself (without fluid, non-contaminated)	
IV tubing, non-contaminated w/ blood	
Clear plastic from IV tubing packaging	

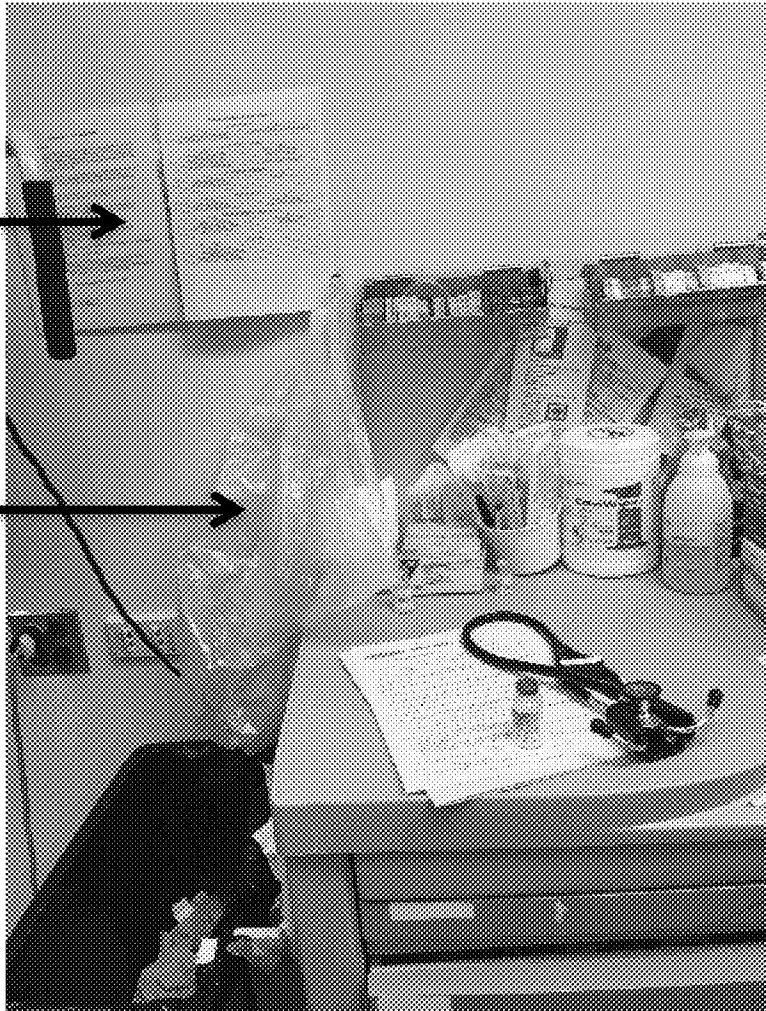
Appendix C: Figures & Tables

Figure 1:

Email to anesthesia staff posted
on wall above cart



Receptacle placed on left side of
cart for collection



Effect of Convenience on Participation in Recycling by
Anesthesia Providers in the Operating Room: A Pilot Study
Alaina Murley and Brittany Schuler
NorthShore University School of Nurse Anesthesia

Abstract

Anesthesia providers are in a position to contribute to the financial and environmental health of their institution through recycling. One of the barriers to participation in recycling by anesthesia staff as identified by the researchers of this study is a lack of convenience. Researchers sought to measure the effect of convenience on participation in recycling by anesthesia providers working in the seventeen operating room suites at NorthShore University HealthSystem Evanston Hospital. The researchers conducted a pilot study implementing a program to enhance the convenience of recycling. Participation, measured by weight in kilograms (kg) of recycled material, was compared pre- and post-intervention. The study demonstrated a 409% increase in recycling participation following distribution of an informational email, posting of recyclable materials in each room, and placement of convenient recycling receptacle on each anesthesia cart. Paired *t*-test for total material collected as well as for average waste per case collected in the pre- and post-intervention periods revealed statistically significant results. Convenient placement of a receptacle for recycling is positively correlated with an increase in recycling participation among anesthesia providers at this institution.

Effect of Convenience on Participation in Recycling by Anesthesia Providers in the Operating
Room: A Pilot Study

Background

Twenty to thirty percent of all hospital waste has been shown to originate from operating rooms, with at least 40% of this waste demonstrated to be recyclable and 25% to be of anesthetic origin (McGain et al., 2012). One explanation for why operating rooms generate large amounts of waste is the need for sterility of supplies and equipment (Esaki & Macario, 2009). In the U.S., infected medical wastes are disposed of primarily through incineration while most municipal solid waste, including non-hazardous medical waste, is disposed of by landfilling. The number of operating landfills has decreased in the last several decades and the construction of new landfills is challenging due to high construction cost and limited space (Lee, Ellenbecker, & Moure-Eraso, 2002). In order to save landfill space and to reduce expensive disposal cost of medical waste, recycling of plastics in medical waste should be increased. Anesthesia providers are ideally placed to facilitate operating room plastic recycling (McGain, Clark, Williams, & Wardlaw, 2008).

Operating room wastes have a great potential to be infected and, as such, have historically not been considered for material recycling (Lee et al., 2002). Other barriers to recycling plastics in the operating room include: lack of knowledge regarding which plastics are recyclable, difficulty separating various plastics, reluctance to change practices and an attitude that environmental concerns are irrelevant to medicine (McGain et al., 2008). Anesthesia providers' attitudes toward recycling are important to address when considering improvements in operating room recycling programs. In a survey examining anesthesiologists' attitudes toward

OR waste recycling, respondents reported that the major barriers to recycling were (1) inadequate recycling facilities, (2) staff attitudes, and (3) inadequate information on how to recycle. Minor barriers included lack of time, safety issues, inadequate space for a receptacle, and cost. Most anesthesiologists regarded operating room recycling to be important overall, regardless of barriers (McGain, White, Mossenson, Kayak, & Story, 2012).

In a pilot program for recycling, a small hospital in Melbourne, Australia entered into an agreement with a local plastic recycling company to take plastics from the hospital free of charge. Over a one-year period, operating room staff recycled approximately 200 kilograms per week of non-infectious plastics that would otherwise have been dumped into a landfill at a cost of 10 cents per kilogram. The hospital savings was \$20 per week. Staff reported no increase in delays between cases or leaving work as a result of recycling (McGain et al, 2008). In another study, anesthesia providers responded to a questionnaire regarding attitude toward recycling and the majority were found to be concerned about environmental pollution; however, they would not participate in a recycling program unless it was mandated legislatively (Goldberg, Vekeman, Torjman, Selzr, & Kynes, 1996).

The benefits of a recycling program are altruistic, may help reduce hospital costs, and may secondarily improve public relations. Proper source separation of waste, development of recycling infrastructure, education of workers and managers, and the efforts of hospital administrators are the vital components of a successful recycling program (Lee et al., 2002).

Problem Statement

A study evaluating anesthesia providers' perceptions of recycling in the operating room found that perceived barriers to recycling by providers included inadequate knowledge regarding the recycling capabilities of the hospital and a lack of space for recycling receptacles (McGain et

al, 2012). At NorthShore University HealthSystem, Evanston Hospital, a recycling program has already been implemented in the operating rooms. Recycling bins are placed near separate waste receptacles close to the surgeon and operating room nursing staff. Anesthesia personnel are usually separated from the majority of non-anesthesia staff and equipment as they are required to remain in close proximity to the patient they are caring for, usually at the head of the operating table near their anesthesia equipment. Restrictions to movement within the operating room, in addition to time constraints and other set priorities and responsibilities, present a challenge for anesthesia providers who might otherwise participate in the recycling program. Despite the current recycling practice at this institution, barriers such as inconvenient access to recycling bins, poor staff prioritization regarding recycling, and misinformation about recyclable items prevent staff from consistently contributing to recycling efforts.

Theoretical Framework

Nursing intellectual capital theory suggests that the nursing capital of a healthcare organization is a combination of the knowledge possessed by the nurses that work for that organization and of the information existing within the organizations systems, including practice guidelines (Covell & Sidani, 2013). Hospitals can maximize their intellectual capital by providing guidelines for a waste recycling program as well as resources for anesthesia providers in order to maximize participation in the recycling program. “Participation” is a concept defined as “the state of being related to a larger whole” (Merriam-Webster, 2015). An antecedent to participation of anesthesia providers in a recycling program is maximized intellectual capital by way of provision of resources. The outcome of participation is higher yield recyclable waste.

Purpose of the Project

The purpose of the project was to determine whether or not a modified recycling program that incorporated convenient placement of a receptacle for recyclable materials would increase anesthesia providers' participation in a recycling program. Participation in the program was measured in weight (kilograms) of collected recyclables after designated recycling receptacles had been placed near each anesthesia cart.

Research Questions

1. What is the current level of participation in recycling at NorthShore University HealthSystem Evanston Hospital by anesthesia providers?
2. How does convenient placement of a receptacle for recyclable waste affect participation in recycling program among anesthesia providers in the operating rooms at NorthShore University HealthSystem Evanston Hospital, measured by the difference in weight of recycled material over a one-month period?

Literature Review

A literature review was conducted to evaluate current research pertaining to the perceived barriers to participation in operating room recycling programs by anesthesia providers. Databases used include PubMed, CINAHL Complete, and ProQuest Nursing & Allied Health Source. Medical subject heading (MeSH) terms searched were: 'recycling', 'operating rooms', 'plastic', 'medical waste disposal' and 'anesthesia'. Within these databases, a total of 106 journal articles were discovered ranging in publication dates from 1993 to 2014. Inclusion criteria used to narrow the results for qualifying articles or studies included a focus on recycling of plastic material, identification of (or methods for overcoming) barriers to recycling, and recycling initiative programs within the anesthesia sector of the operating room. Based on these

inclusion criteria, ten articles were chosen for literature review. For the purpose of this study, the authors chose to focus solely on the regulation of medical waste and barriers preventing participation in recycling initiatives, specifically that of non-hazardous plastic waste encountered by anesthesia providers. A comprehensive research article table has been compiled summarizing influential articles used to develop this project and its concepts (see Appendix A).

Identification of Barriers

An article review by Esaki (2009) summarized what is known about waste generation in hospitals and discussed various strategies for waste management. Authors reported that operating rooms generated 20-33% of total hospital waste. Potential anesthesia-related waste was identified and included syringes, bottles and vials, and airway equipment and hoses. A barrier to recycling identified by the authors is that operating rooms are crowded with so much equipment that there may not be additional space for recycling bins (Esaki & Macario., 2009).

Lee et al (2002) studied the recycling potential of medical plastic wastes generated by five hospitals in Massachusetts. They analyzed the sources, disposal costs, and plastic content of medical wastes. They then evaluated the recycling potential of plastic wastes in various departments, including operating rooms. Operating rooms were identified as a major source of plastic waste. Large volumes of plastic waste were found to be mainly due to a chance of contamination or infection, and simplification of purchasing plastic components and lack of classification of plastics for recycling (Lee et al., 2002).

McGain et al (2008) reported a pilot program to recycle operating room plastic in Melbourne, Australia. The authors discussed barriers to recycling and noted that, unlike household plastics, most medical plastics are not classified by a code or number. Other barriers identified were concerns about infection risks, difficulty separating different types of plastics,

reluctance to change work practices and an attitude that environmental concerns are irrelevant to medicine. This pilot recycling program resulted in 200kg per week of recycled material with a savings to the hospital of \$20 per week (McGain et al., 2008).

A feasibility study of recycling of single-use breathing systems among anesthesia providers was conducted by Goldberg et al (1996). The design included a two-part analysis: analysis of responses to a questionnaire regarding anesthesia providers' attitude toward recycling, and a cost-benefit analysis of a recycling program. The authors found that the recycling program is cost-effective and environmentally beneficial; however, most anesthesia providers would not participate in a recycling program unless mandated by law (Goldberg et al., 1996).

In a more recent survey of anesthesiologists' views of operating room recycling, McGain et al (2012) investigated attitudes toward and barriers to recycling. A survey was distributed to anesthesia providers in Australia, New Zealand and the UK. More than 90% of respondents reported that they would like to recycle at work. The greatest barriers to recycling most frequently reported by respondents were inadequate recycling facilities, staff attitudes, and inadequate information on how to recycle. Time, safety, inadequate recycling space, and cost were each thought to be the greatest barriers to recycling by less than 5% of respondents (McGain et al., 2012).

Identification of Suggested Solutions

Investigation into literature regarding recycling practices within the operating room setting would not be complete without review of proposed suggestions for change and development of successful recycling programs. Many articles found within the database searches included solutions for management of medical waste (namely plastics) and the methods through which a recycling initiative should be developed. Hospitals for a Healthy Environment

(H2E) is a national program that provides “hospitals across the nation with the framework, tools, and resources they need to change their waste-disposal practices” (Brannen, 2003, p. 25). The H2E program encourages institutions to consider their current waste disposal practice and as well as the potential impact simple, methodical change may have on the hospital and world environment (Brannen, 2003).

In 2011, Riedel published a study in the American Association of Nurse Anesthetists Journal regarding the multifaceted impacts of a hospital-wide recycling program (Riedel, 2011). In this study, financial and environmental incentives to recycle were discussed due to generation of “2.7 metric tons of waste per day” (Riedel, 2011, p. S9) by hospitals alone. Interventions created to address this problem were implemented in phases: Phase 1 included education of staff regarding environmental benefits of recycling and types of materials appropriate for the recycling receptacles; Phase 2 was placement of designated containers throughout the hospital with printed lists of acceptable items; Phase 3 meant collection of all bins into a designated area for weekly weight and disposal by a pre-determined company. After a year of waste collection, weight of materials was compared to the pre-intervention year to determine cost-effectiveness of an increased waste diversion from solid-waste to recycling receptacles. Riedel (2011) found that the “annual recycling increased 9.3metric tons (10.3 US tons) after single-stream recycling began” (p. S11). Significant financial benefits to this shift in waste separation were illustrated by the \$4,672.88 decrease in non-hazardous waste disposal cost (Riedel, 2011). Landfill waste was subsequently reduced by 40.2 metric tons, resulting in a cost-savings of \$4,114.75. Riedel suggested ease of use due to single-stream recycling and effective education of staff as major contributors to success of the program.

Practice Greenhealth, an online healthcare community, focused on efficiency and environmental friendliness within patient care and developed a template for creation of an operating room recycling initiative (Practice Greenhealth, 2011). Ten steps were outlined within the plan for improved operating room recycling compliance. ‘Step One: Enlist Allies’ stresses the importance of designating passionate, involved team of stakeholders to spearhead the new program. ‘Step Two: Identify Hauling Partner’ identifies the real challenge finding a reliable hauling company may pose for hospitals; clear communication lines between hauler and environmental services (EVS) director are necessary when establishing pick-up date, time and location, differentiation between nonhazardous/hazardous material, as well as single versus multi-stream capabilities. ‘Step Three: Have a Sense of What Can Be Recycled’ is critical in development of a coherent staff education program; without complete understanding of acceptable items within the spearhead committee, effective communication of items to participating staff members will be nearly impossible. ‘Step Four: Work with EVS to Define Containers and Collection Schedule’ suggests involvement of EVS in placement/replacement of designated receptacles and development of collection schedules for maximal effectiveness/cleanliness; use of a certain color receptacle specifically for recycled plastic waste may serve to facilitate workflow for EVS and anesthesia staff. This suggestion proved to be effective within the University of Chicago Medical Center operating rooms. According to Dr. Catherine Bachman, blue recycling containers were placed next to each anesthesia cart for the sole diversion of anesthesia related plastic materials such as syringe packaging, IV bag protectors, etc. Staff grew to recognize these blue containers as a reminder to recycle and ease of use/convenience of placement served to increase the amount of recycling products diverted from

solid waste disposal. The University of Chicago has since been nationally recognized for its efforts in environmental improvement and awareness (Bachman, 2010).

‘Step Five: Develop Signage to Highlight New Segregation Practices’ suggests implementation of pictures into signage placed near/above each receptacle to provide visual guidance for easy identification of acceptable plastic materials. ‘Step 6: Educate and Engage Staff on Appropriate Segregation Procedures’ stresses the crucial nature of a well-developed staff education plan; in-services regarding change to practice, color of receptacles and appropriate recyclable materials should be communicated in multiple staff meetings during times when majority of staff is available and receptive to information. ‘Step Seven: Divert Recyclable Waste Pre-Incision’ recommends starting recycling diversion during procedure set-up. ‘Step Eight: Segregate Recyclable Waste After Procedure’ is in place to maintain cleanliness of materials collected and prevent mixing of hazardous and non-hazardous waste between patients; a decision must be made regarding continuance of receptacle use between patients or if a new receptacle (bag) will be obtained for each patient. ‘Step Nine: Problem Identification and Resolution Plan’ encourages members of the planning committee to anticipate hiccups in implementation of the plan and brainstorm regarding how to prevent/troubleshoot those roadblocks. ‘Step Ten: Track Progress and Recognize Success’ realizes the need to recognize effective change within an institution and use the new-found success to implement policies to ensure continued success. These guidelines were established without bias or conflict of interest and were developed to aid hospitals in development of an effective recycling initiative (Practice Greenhealth, 2011).

The push for potential plastic reuse has also been recognized by the Healthcare Plastics Recycling Council (HPRC) as a significant potential contribution to the future health and

wellness of our society (Healthcare Plastics Recycling Council, 2013). Historically, recycling efforts within hospitals have been largely focused on administration and food service areas. However, the need to expand these efforts throughout an institution is anticipated by the HPRC and subsequent guidelines have been developed to aid hospitals in disposal of specific plastic waste. Links to appropriate resources regarding characterization to waste, commitment to sustainability, economic analysis, and clinical infrastructure are all provided within the pamphlet (Healthcare Plastics Recycling Council, 2013). Waste characterization tools such as “The Plastics Mapping Tool” are provided to help distinguish between types of plastics accepted by most hauling companies; the HPRC also suggests an in-depth conversation and detailed contract to be drawn up between hospital and recycling partner to prevent blurred lines regarding acceptable plastics. Guideline tools for best placement of receptacles, necessary equipment, training tools and posters, as well as tools for evaluation of program effectiveness are also provided in the HPRC pamphlet (Healthcare Plastics Recycling Council, 2013). Periodic review and audit of the program is recommended by the HPRC to ensure sustainability of the chosen program. Provision of useful resources such as these is advantageous in development of new plastic recycling initiatives.

Research Design

A single group post-intervention evaluation design was utilized for this study.

Sampling Approach

There are seventeen operating rooms at Evanston hospital with 125 anesthesia providers on staff including doctors, nurse anesthetists, and residents. Depending on the number of scheduled surgical cases, there were 40-50 anesthesia providers scheduled daily for patient care.

All anesthesia providers at Evanston Hospital were included in the sample as each of these providers had the opportunity to participate in recycling.

Recruitment Procedure

Recruitment activities were conducted by the primary investigators of this study. After a two-week, blind collection of materials used to measure baseline recycling participation, an email was distributed to all NorthShore anesthesia staff using a listserv via EasyCall software system. In the email, researchers notified anesthesia staff of the pilot program and emphasized the availability and location of conveniently-placed recycling receptacles in each OR. A list of recyclable materials was attached to the email. Laminated copies of this list of recyclable materials were posted above each new recycling receptacle.

Inclusion criteria for [participation in](#) the study were: Participants must have been current anesthesia providers (doctor, resident, CRNA, or SRNA) at NorthShore University HealthSystem, Evanston Hospital. Materials collected included all non-contaminated plastic waste except that identified as #6-type plastic (polystyrene), all non-contaminated paper waste except that covered in waxy film, and all glass waste except those medication vials containing greater than 3% of the original contents of the vial. Exclusion criteria for participants were operating room employees in non-anesthesia role (such as operating room nurses, surgeons, and technicians). Exclusion criteria for materials collected included biohazardous waste or solid waste collected in waste receptacles other than that provided by researchers. Participants did not receive a material incentive to participate in the study.

Ethical Considerations

This project obtained Institutional Review Board approval from NorthShore University HealthSystem and DePaul University. Protection of human subjects was upheld by the

anonymous nature of data collection for the study, with recycled material weighed daily in a single measurement separate from interaction with anesthesia providers. Participants were informed of the purpose of the study, protection of their privacy, their right not to participate without penalty, and the contact information of researchers. All data collected was stored on a password-protected computer that only the primary researchers could access. Permission to wave consent from eligible participants with support from the Director of Anesthesia at Northshore University HealthSystem, Dr. Joe Szokol, was approved by the Office of Research Services at DePaul University.

Methods

Data collection for this study was conducted in the 17 operating rooms at NorthShore University HealthSystem Evanston Hospital from February 15, 2016 to March 15, 2016, with a total of 20 days of data collection. Pre-intervention data collection consisted of 10 days of collection of recycled material from each operating room by a member of the research team between the hours of 3 and 4 pm. Collected material was weighed in kilograms (kg) daily using a Tariss JetSetter luggage scale, which was zeroed prior to each use. The daily number of cases was tracked using the operating room status board (OpTime, Epic Systems, Verona, Wisconsin), with cases starting prior to 6 am and at or after 3 pm each day excluded from the case count. Following completion of the pre-intervention 10-day period, an email describing the study and placement of receptacles was distributed to all anesthesia staff using the listserv provided on NorthShore's EasyCall server (see Appendix B). A paper copy of the email notification as well as an updated list of materials acceptable for recycling were posted above the anesthesia cart in each operating room. Each morning between 6 and 6:30 am, a recycling bag was placed on the left side of the anesthesia cart by a member of the research team (see Figure 1). The same bags,

later containing recyclable waste, were collected between the hours of 3 and 4 pm daily using the same collection protocol as in the pre-intervention period. The number of cases was again tracked using the operating room status board, with cases starting prior to 6 am and at or after 3pm each day excluded from the count. Microsoft Excel 2013 was used to record daily collection throughout.

Results

Pre-intervention collected waste totaled 6.5 kg over the 10-day collection period (for 346 cases) with an average of 0.65 kg per day and 0.0192 kg/case. Post-intervention collected waste totaled 34.5kg of recyclables (for 371 cases) with an average of 3.45 kg per day and 0.0978 kg/case. Kilograms per case of recycled waste increased by 409% after the intervention period. The highest collection day in the pre-intervention period resulted in 1.3 kg of waste; the highest collection in the post-intervention period resulted in 7.0 kg of waste. Statistical analysis was completed using IBM SPSS software to determine mean, standard of deviation, and significance ($p < 0.05$) of pre- and post-intervention measured values using a paired *t*-test (see Table A).

The difference between total recycled material collected pre-intervention (6.50 kg) and total recycled material post-intervention (34.50 kg) was statistically significant, with paired *t*-test yielding a p-value of 0.001. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant, with paired *t*-test yielding a p-value of 0.01. To ensure that the pre- and post-intervention arms are not systematically biased, a *t*-test was also performed to determine the statistical significance of the variation in the number of cases during the pre-intervention versus post-intervention periods (346 cases pre and 371 cases post). The *t*-test for this data set gave a p-value of 0.498, indicating that the two arms are not statistically significant in terms of the number of cases during the study period (see Table B).

Discussion

Results indicate that participation in recycling by anesthesia providers is largely dependent on the convenience of recycling. In our literature search, we identified a lack of convenience in the face of numerous other high-priority tasks as a barrier to operating room recycling by anesthesia providers. We addressed this barrier by placing recycling bags and a recycling guide at a convenient location next to each anesthesia cart. This allowed anesthesia providers to recycle appropriate waste without having to leave their patients and walk across crowded, often sterile-prepared operating rooms to the designated recycling bins used by scrub and circulating nurses. Recycled waste per case increased by 409% overall after the intervention.

Recycled material collected during the pre-intervention period reflected participation in recycling by anesthesia providers in Evanston Hospital at baseline. The amount of recycled material per case varied considerably from day to day. The lowest amount of recycled material collected in a day was 0.0056 kg per case and the most recycled material collected in a day was 0.0382 kg per case (see Chart 1).

Variation in recycling by day may be attributed to variation in recycling practices among anesthesia staff; in other words, some anesthesia providers participated more than others in recycling at baseline, and on the days those providers were working, more material was collected.

Another potential reason for daily variation in waste per case at baseline may be that on certain days or with certain surgeries, there is a higher prevalence of more complicated procedures requiring the use of more supplies and, therefore, increased yielded waste. For example, surgeries requiring general anesthesia include use of an airway circuit with heavy corrugated plastic tubing as well as packaging for: oral gastric tubes, at least six to ten medication syringes, eye protection, intravenous fluid bags and wrappers, etc. The increase in

demand for supplies during general anesthesia cases is much higher than for that of monitored anesthesia care cases, which may only require a nasal cannula, three to four syringes, and less intravenous fluid. Provider preference for supplies may also impact this disparity as some providers take a “less is more” approach and generally use less supplies than their peers.

Patient acuity may also explain variation in recycling practice. Anesthesia providers are trained to place patient safety as top priority. If a patient is critically ill or unstable, or the surgery is particularly high-risk, speed and efficiency on the part of the anesthesia provider are paramount to safety. In some cases it must be recognized that even when a receptacle for recycling is conveniently placed, the act of sorting materials may take time and attention away from the care of an unstable patient. The anesthesia provider must use his or her judgment to decide whether or not it is safe to prioritize recycling in high-acuity cases.

Another explanation for the variation in recycling from day to day is possible contamination of recyclable waste by hazardous material (i.e. blood or other bodily fluids), which renders waste inappropriate for recycling. Plastic material that has come into contact with blood, sputum, gastric contents, or urine/feces, must always be disposed of via biohazardous solid waste receptacles. Provider understanding of contamination by bodily fluids may not always be clear. For example, the plastic corrugated tubing used for breathing circuits contains condensation from the moisture in patients’ exhaled gases. This moisture is not considered contamination and therefore does not render the used circuit unsuitable for recycling. If, however, a patient’s sputum contaminates the tubing, the circuit must be disposed of with biohazardous waste.

The recycled material collected during the post-intervention period reflected participation in recycling at Evanston Hospital after bags were provided on the anesthesia cart in each operating room. Again, the amount of recycled material per case varied considerably from day to day and this was likely due to variation in recycling practices by different staff, the types of cases that were performed on different days, [the level of patient acuity](#), and the possibility of hazardous waste making some waste unsuitable for recycling. The lowest amount of recycled material that was collected in a day was 0.0229 kg per case and the most recycled material that was collected in a day was 0.1707 kg per case.

It was noted that during the post-intervention data collection phase, the amount of recycled material increased steadily over time. On day one, the total collected waste was 1.1 kg and on day ten the total collected waste was 4 kg (see Chart 2). This increase in participation over time may be attributed to increased awareness of the study among anesthesia providers over the 2-week period, as some providers may not have immediately read the email sent to them or noticed the sign and recycling bag. Additionally, momentum and support for the researchers' project may have built among anesthesia staff over the two-week period, causing them to increase their participation in recycling. [In their template for creation of an operating room recycling initiative, Practice Greenhealth stresses the importance of educating and engaging staff on recycling behaviors. They suggest that the plan for recycling should be communicated repeatedly in order to reach staff when they are most receptive to information \(Practice Greenhealth, 2011\). Increasing staff engagement during the data collection period explains why there was a dramatic increase in providers' participated in recycling efforts for this pilot study over time.](#)

The null hypothesis for this study was that there would be no statistically significant difference in the amount of recycled material collected pre-intervention versus post-intervention. Paired *t*-tests allowed us to examine the relationships between pre- and post-intervention data. The difference between total recycled material collected pre-intervention and total recycled material post-intervention was statistically significant. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant. These findings suggest that participation in recycling by anesthesia providers, both overall and per case, increased significantly after signs and recycling bags were placed conveniently at the anesthesia cart in each operating room.

A *t*-test was also performed to determine the statistical significance of the difference in the number of cases during the pre-intervention versus post-intervention periods. The *t*-test for this data set gave a p-value of 0.498, which is not statistically significant (see Table B). This suggests that the overall caseload was not a confounding factor for recycling participation, and therefore it can be inferred that the difference in recycling practice pre- and post-intervention is attributable to the convenient placement of recycling bags rather the difference in caseload.

Strengths and Limitations

Strengths of the study include valid, statistically significant comparisons between baseline provider participation and participation following the implemented intervention. As stated, the difference in total cases performed during pre- and post-intervention data collection was not statistically significant and is, therefore, not a confounding factor in this study. Study approval from both the NorthShore University Health System and the DePaul University Institutional Review Board upheld participant anonymity throughout the data collection period. Increased recycling convenience improved participation by 409% in this institution's anesthesia

department; when extrapolated to one year of participation at the post-intervention rate, an estimated 900.45kg of waste could be diverted from municipal solid waste (see Appendix D) compared to the pre-intervention forecast of 169.65kg. The environmental implications of an increase in waste diversion of this magnitude are impressive and may serve as motivation for providers to continue recycling participation. It is believed that during the data collection period most of the enthusiasm demonstrated by anesthesia providers at Evanston Hospital was for recycling itself.

A limitation of the study is that it was not blinded; the study took place amongst anesthesia colleagues who were aware of the data collection taking place and whose support for the researchers may have influenced the outcomes of the study. Inability of researchers to control for the type of cases performed during the pre- and post-intervention collection period must also be identified as a limitation in this study as the type of case is suggested as having an impact on recycling practice. Inability to control for scheduling variation among anesthesia providers who work on different days of the week is also a potential limitation of the study, as some providers were more motivated than others to participate in recycling.

Implications for Further Research

Further studies could be conducted, perhaps by administering a post-intervention survey, to explore staff attitudes regarding the effect of convenience on recycling. As stated by McGain, et al. (2008), reluctance to change work practice or belief that recycling is not a priority may serve as major barriers to recycling participation. A study that examines staff attitudes regarding the recycling program might serve as the first of multiple, ongoing evaluations of the program. These evaluations can serve to identify areas for improvement that ultimately engage more participants and enhance recycling in the institution.

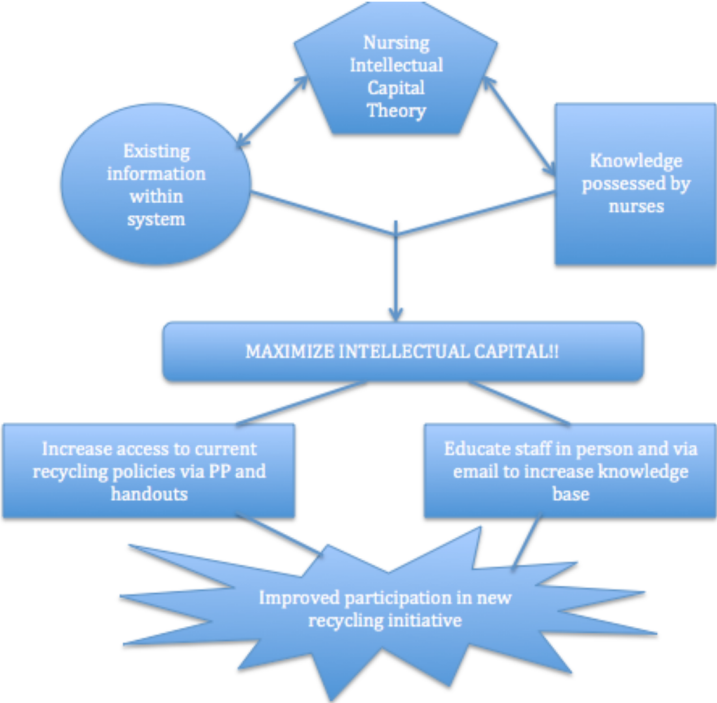
Additionally, further studies might emphasize the impact of education in recycling practice on staff participation. A thorough understanding of which materials are acceptable for recycling is crucial for the success of any recycling program. A study might examine the most effective ways to keep staff informed. For example, as supplies and equipment change over time, the list of approved materials will need revision and will, therefore, provide researchers with opportunities to re-educate staff on a regular basis. This repetition may enhance learning and reinforce participation.

Finally, a study focusing on cost analysis may provide insight as to the financial benefit of increased recycling to the hospital. NorthShore University HealthSystem reports a solid waste cost of \$0.03/lb and a recyclable waste cost of \$0.01/lb. An exhaustive cost-benefit analysis would highlight the financial gains that a recycling program can offer the institution. This could enhance support from administration and ultimately lead to changes in policy and practice.

Conclusion

Anesthesia providers are in a position to help their institution separate recyclable waste from municipal waste. The results of this study suggest that the provision of a conveniently-placed receptacle can greatly increase participation in recycling by anesthesia providers, as evidenced by a 409% increase in recycling after the intervention. The benefits of recycling are many and include reduced landfill waste and environmental pollution, institutional cost savings, improved staff morale and better public image for the institution.

Conceptual Map



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Appendix A: Research Article Review Table

Study Purpose	Research Design	Sampling	Human Subjects Issues	Extraneous Variables	Intervention Offered	Outcome Measures Used	Adverse Effects of Intervention	Study Variables	Statistical Analysis	Study Findings
"A Survey of Anesthesiologists' Views of Operating Room Recycling" - (McGain Forbes; White, 2012)										
To determine the importance of recycling operating room waste to anesthesia providers; To identify barriers preventing OR recycling	Qualitative ; Survey emailed to 500 randomly selected fellows via the ANZC Trials group and to approx..500 consultant anesthetists in English National Health Service; Survey developed using Survey Monkey	Survey of Anesthesiologists or anesthesia fellows ; No gender/age /ethnicity variables; -Total of 780 surveys received.	Study methodology approved by Human Research Ethics Committee at Western Health, Melbourne, Australia . Written informed consent was waived by ethics committee.	Survey included one open-ended question to attain additional potential information regarding barriers to recycling within the OR	No Intervention measured	Outcomes measured are the survey response s; Low rate of return on survey distribution serves as major limitation of the study.	None	- Questionnaire used could be comparable across other studies -Used an established study tool, Survey Monkey for easy distribution/access for survey participants	Statistical analysis completed via Wilson's Method to calculate the 95% confidence intervals for the proportions,	95% agreed that they would like to recycle anesthesia waste; 11% agreed that recycling does take place; 3 most influential barriers to recycling identified as: 1. Inadequate recycling facilities, 2. Staff attitudes, 3. Inadequate information on how to recycle; Time, safety, inadequate space, and cost were less influential barriers to recycling
"Analysis of an Organization's Waste Stream" – outlines how to complete a waste stream analysis - (Hayne, 1993)										
Development of thorough waste stream analysis for hospitals to utilize in order maintain safe, cost effective methods of waste disposal from beginning to end or to develop new	Review of a system – not study in sense of qualitative vs quantitative; More of an outline on how to perform a waste stream analysis	Explains how to perform this analysis within one institution	No human subjects involved in this article	- Individuals within the organization who are current with the local, state, and federal regulations may need to be included in the analysis	Analysis of the amount/type of waste disposal within an institution to provide suggestions for improvement and identify areas of need	None	None	None	None	Waste Stream Analysis worksheet provided as suggested format for analysis

policy regarding waste management in that institution				committ ee -Should include status of local landfills , waste management of other major community polluters						
The Green Operating room: simple changes to reduce cost and our carbon footprint - (Wormer, 2013)										
Assess improvement in waste reduction and recycling after implementation of a Green Operating Room Committee	GORC formed and Green OR initiative campaigns instituted throughout the ORs. Quarterly meetings held to discuss the impact of the initiatives and their effectiveness; Results of the 'score cards' were recorded and downstream effects on cost analyzed. Methods were effective in analyzing the potential for cost savings and identifying the areas for improvement within cost containment.	Study performed at one large Level-1 trauma institution in North Carolina; 100 consecutive MDs, Nurses, Scrub techs monitored during scrub patterns regarding water consumption; Education campaigns provided to all other OR staff in regard to solid reusable waste, Red Bag biohazardous waste, and Recyclables/ Reusables. -Population of this study well matches that of interest in our project. - Gender/age/ethnicity not pertinent variables -Sample size was not justified through use of statistical analysis.	Methodology approval not mentioned; GORC formed by Division of Gastrointestinal and Minimally Invasive Surgery and joined by Nursing, Environmental Services, and Anesthesia at Carolina's Medical Center in 2008.	Study did not control for confounding variables, but did take them into account in regard to outside cost of waste disposal ; involved multiple departments in the project as well.	Education campaigns for each recycling initiative was completed over the course of a year to evaluate the effectiveness of each campaign on cost/staff behavior change.	Effectiveness is measured through comparison of \$\$ before and after the initiatives were completed; through their studied initiatives, this institution saved approximately 158,000 annually .	None	Variables of interest: Solid Waste Reduction, OR Recyclables & Reusables, Energy & Water Reduction, Charitable Donations. Researchers performed their own data collection with the help of environmental services staff in which the weight of waste was measured and compared throughout the year.	None	-Avg cost of disposal of regulated medical trash is \$0.28/lb. -Annual cost savings after implementation of 4 different recycling/energy saving initiatives was \$158,000. -12,000lbs solid waste was diverted, 75% decrease in Red Bag waste, 500lbs alkaline waste diverted, Complete reduction of foam waste, 2.7million liters of water saved.
People, Planet, and profits: the case for greening operating rooms - (Kagoma, 2012)										
Purpose is to identify ORs as	Analysis/Literature Review;	138 article resulted, 65 of which	No IRB approval needed	No extraneous	Suggested interventions	No measure of	None	No study variables	None	-Hauling costs for recyclable

major contributors to waste and to identify waste-reduction strategies that “satisfy the ‘triple bottom line’ (people, planet, profits), by reducing health care costs and environmental effects without compromising patient care” (p. 1905).	predefined search strategy explained and total of 138 articles resulted, 65 of which were used in the analysis.	were used to complete the literature analysis.	b/c no human subjects were involved in this literature review.	variables	included for ways to reduce waste via segregation of waste products, fluid waste management, energy savings, and equipment packaging are all provided. -No direct intervention is evaluated in this review	effectiveness as this is just a lit review.					plastics are nearly half that of solid waste disposal; Institutions may negotiate rebates for recycled plastics.
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Reduce – Recycle – Reuse: Guidelines for Promoting Perioperative Waste Management (Lausten, 2007)

Literature review to promote greener waste management objectives	-“Green team” of nurses recruited voluntarily to explore the excessive waste generated in the perioperative setting. - Descriptive analysis of contents of one red bag completed. -	One red bag analyzed; may be a limitation that only one bag was analyzed.	No IRB approval mentioned; only human subjects at risk were the authors themselves during the removal of contents of potentially biohazardous material in the red bag. No mention of consent obtained from the members of the “Green Team”.	Did not control for extraneous variables such as type of procedure performed in red-bag associated OR; does state that limitations of study are that only one bag is analyzed results may vary institutionally.	Guidelines for greening of the operating room after realizing the mis-education demonstrated by the contents of a red bag	None	Benefits are worth the cost of implementing the recommended guidelines	Descriptive analysis was performed	None	-Majority of waste found in red bag is not actually biohazardous waste -Providers need to be more aware of what they place in the red bag and guidelines are recommended for future practice; time table should be included b/c will be a slow process to change the behavior and make all those involved feel that their actions matter.
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Greening critical Care - (Chapman, 2011)

Map ways	Review of	Population	No	No	No	No	Benefits	No study	None.	Recomm
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to green up an ICU and reduce negative environmental effects on patients with suggestions targeted at individuals as well as whole institutions.	methods used to increase green initiative awareness within an ICU/hospital. Four areas of focus are considered: consumption, waste, toxins, and personal footprint of staff.	targeted is ICU staff. → not our target population, but same idea to increase awareness within a smaller portion of the entire hospital organization.	approval was gained or warranted b/c no intervention was executed.	extraneous variables	intervention offered to be examined; only recommendations for practice.	outcomes measured.	of this review outweigh the potential risks.	variables b/c this is just a recommendation for practice within the ICU.		recommendations for reducing waste, increasing reuse, and decreasing the carbon footprint of those working within the ICU in this institution evaluated.
Environmental and financial impact of a hospital recycling program (Rieder, 2011)										
Purpose: To determine the environmental and financial impact of recycling at 148-bed acute care hospital.	Current non-hazardous waste disposal practices were kept in place and single-stream recycling was added and measured over a year period. Staff was educated about environmental benefits of recycling and what to recycle via PP presentations and at nursing leadership meetings; Newsletters were published promoting the program. Recycle bins were placed in staff common areas with notification acceptable items for collection; Bins were collected by disposal company at	Entire hospital staff is the sample population. -Good match to our target population, although larger participant sample than anticipated for our study b/c we are focusing in OR only, not entire 148-bed facility.	Robert Morris University granted exempt IRB status. Mercy Foundation granted money for the purchase of recycling bins.	Confounding variables possible within the study include disposal of inappropriate material in the recycle bins; this was controlled as much as possible by prior education of staff as well as informational sheets placed on bins. Seasonal variation in waste generation was considered and eliminated as a confounding variable by considering an entire	- Intervention offered was placement of recycling bins in common areas for easy, single-stream recycling opportunities. -Control group subjects received education about recycling benefits and items before placement of bins in common area. -Study lasted a year.	Effectiveness of the study was measured via comparison of nonhazardous waste streams from 2008-2009 to those of 2007-2008. Environmental Protection Agency's Waste Reduction Model used to calculate the GHG emissions and energy savings of new practices compared with the baseline year;	Benefits of the study are work the potential harm. No cost was involved in this study due to money obtained from a grant to purchase the bins.	Variables include hospital operations during the control and study period → nullified by statistical correlation. -No questionnaires were used to complete the study. -Tools used were Environmental Protection Agency's Waste Reduction Model to calculate the GHG emissions and energy savings of new practices → reliable tool.	SPSS analysis of waste generation and facility operations was performed. Pearson Correlation was used to compare waste generation and facility operations for control and intervention periods. -Waste generation and facility operations between the two time periods noted to be very similar	- Nonhazardous waste disposal cost decreased \$4,672.88. -Revenue for the hospital increased by \$390 and overall landfill waste was reduced by 40.2 metric tons.

	the end of each week. Tonage of non-hazardous waste for this year time period was compared with previous year (control).			year time frame in the study and comparison group.						
Managing Medical Waste - (Brannen, 2003)										
Hospitals for a Healthy Environment (H2E) helps hospitals change waste-disposal practices; Article outlines ways in which this policy guideline can beneficially impact waste management and respond to demands of currently evolving environmental awareness.	Review of one policy → may be considered as type of case study? Case review? H2E provides healthcare organizations with the framework, tools, and resources needed to change their waste disposal practices.	Populations targeted are any and all healthcare organizations → either in the “partner” or “champion” classification depending on what type of institution it is.	No approval needed.	None	Interventions offered are just suggestions for resources regarding waste management start-ups.	No outcomes measured.	No adverse effects of intervention or procedure	NO study variables	No statistical analyses.	Organizations interested in beginning a new recycling initiative should utilize the framework and tools provided via H2E. Mercury assessments should be conducted. Recommendations for starting a waste management plan.
Wastage of Supplies and Drugs in the Operating Room (Esaki & Macario, 2009)										
Identification of anesthesia related waste in the OR including drugs, packaging, etc.; Explanation of Reduce-Reuse-Recycle-Restrict practice suggestions	Review of current RRRR practices within the OR and related to anesthesia	Populations targeted are anesthesia providers who have contact with waste associated with direct patient care and surgical set up	No approval needed.	None	Reduce, Reuse, Recycle, Restrict – suggestions for implementation of these principles within the OR; Restrict = Segregation of waste into classes for easier distribution to the proper waste	No outcomes measured	No adverse effects of intervention or procedure	No study variables	No statistical analyses	Identification of barriers to recycling include space for a recycling bin, potential infectious risk if providers don't follow the proper organization of waste

					stream.					
Medical Waste in the Environment: Do Anesthesia Personnel Have a Role to Play? (Goldberg et al,1996)										
To conduct a feasibility study of the mechanics of recycling single-use anesthesia breathing systems and practices of anesthesiologists and nurse anesthetists in a tri-state region.	Two-part, open, prospective analysis using pre-printed questionnaire and cost-time analysis of labor and materials	Anesthesia departments in PA, NJ, and Delaware	No approval discussed although questionnaire was completed by providers involved in the study	Cost-time analysis of breakdown of single-use breathing circuit only examines the effectiveness of breaking down this ONE type of circuit – many types exist and some are more complex than others with potential for non-recyclable components	Breathing circuits were collected and sent to a laundry facility where they were broken down to evaluate time/cost relationship or benefit. A survey was distributed to anesthesia providers to determine willingness to participate in a recycling program if one was offered.	Outcomes measured were cost of disassembly of the breathing circuits → showed a potential savings of over \$4,000 in a year's time. Survey outcomes were measured with a questionnaire.	No adverse effects of the interventions	Study variables were type of breathing circuit chosen for the study.	Anova and Kruskal-Wallis tests	The disassembly program proposed is economically feasible and has many cost benefits. The questionnaire found that many anesthesia providers are concerned about environmental benefits of recycling but wouldn't participate in a program unless legally mandated.
Recycling plastics from the operating suite (McGain, F., Clark, M., Williams, T. & Wardlaw, T., 2008)										
Identification of types of plastic to be recycled and contacted within patient care by an anesthesia provider as well as identification of barriers to recycling.	Pilot study to determine potential savings of increased recycling	OR "theatre" staff were targeted for one year in a small Melbourne Australia hospital.	No approval discussed	Extraneous variables were the different types of plastic considered within the study, potential for contamination of materials, etc.	Intervention: Agreement was reached with local plastics recycling company willing to accept used plastic materials from the OR and these were collected for one year	Cost and environmental savings over the study period of one year.	No adverse effects of the study. Staff did not experience delays between cases due to the new recycling initiative.	None	None discussed.	Good information about the prevalence of plastics capable of being recycled within the OR and identification of barriers to recycling such as different types of plastic, infection concerns, etc. Shows improvement in participation when staff is educated properly.

Medical Plastics Recycling in the OR (Practice Greenhealth, 2011).										
Purpose of this module is to list steps useful in designing a new recycling initiative for a hospital/operating room setting	Suggestion for practice, not a study.	Operating room staff are targeted as well as administrators interested in developing a system for recycling	No approval discussed.	None	Steps 1-10 of how to develop and evaluate the effectiveness of a new recycling program	No outcomes measured	No adverse effects of the study	None	None	Great tips to ensure success of a new program as well as things to look out for when putting a new program together.
Hospicycle: A plastics recycling guide for hospitals (HPRC, 2013)										
Purpose of this compilation is to serve as an outline for development of a new plastics recycling program – many links provided for administrators	Suggestion for practice, not a study.	Operating room staff and administrators who are involved in development of a new program.	No approval discussed.	None	Outlines steps to take before beginning, as well as links useful in determining commitment to sustainability, economic analysis, infrastructure of the program, waste characterization, the importance of choosing the right recycling partner, and how to run a successful program.	No outcomes were measured since this is a suggestion for practice	No adverse effects of the study	None	None	Good for outlining how to set up a new program
Analyses of the recycling potential of medical plastic wastes (Lee, B.K., Ellenbecker, M., Moure-Eraso, R., 2001)										
Purpose is to analyze the recycling potential of plastic wastes generated by health care facilities.	Collection of materials and evaluation of type of plastic, amount of each type,	Five Massachusetts hospitals – all areas of recycling were considered, not just ORs	No approval discussed	None	Collection of materials in the ambulances, ORs, cafeterias, etc to compare amount and type of plastics capable of being recycled.	Outcomes measured were waste characteristics, components of waste, cost of disposal of waste, and collection from the ORs compared with	No adverse effects of the study	Types of plastic collected 5 area hospitals involved -Unable to compare to other studies	Unknown	Identified the major risk of recycling as spread of infection

						ambulan ces, cafeteria s, and other areas of the hospital.				
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Appendix B: Email to Anesthesia Staff

Dear Anesthesia Colleagues,

Hello! We are sending this email to notify you of the recycling project we are working on as part of our graduation requirements at NorthShore. Our clinical time here has alerted us to inconsistencies in recycling practice at Evanston and we would like to know whether or not anesthesia providers are more willing to recycle when they are provided with a conveniently placed receptacle.

Over the next weeks we will provide plastic bags on the side of each anesthesia cart in the morning; these bags will be collected each afternoon at 4pm. **DO NOT DISPOSE OF THESE BAGS!! THEY ARE TO BE USED FOR DATA COLLECTION!!**

Please **DO** use these bags to recycle packaging and equipment. A comprehensive list of recyclable materials is attached and this list will also be available to use as a reference on anesthesia carts.

Here are some general guidelines for recycling:

DO recycle

- All plastics packaging, including syringe/ETT/IV fluid packaging, etc.? **YES!**
- IV tubing that is **NOT** contaminated with biohazardous materials (ie. blood)? **YES!**
- Any other plastic peel-back from materials packaging? **YES!**
- Paper without waxy film? **YES!**
- Used Anesthesia Circuit? **YES!**
- Paper **INSIDE** nasal cannula package? **YES!**
- Empty glass drug vials? **YES!**
- Empty IV Bags themselves? **YES!**

DO NOT recycle

- Paper with waxy film? **NO** -- if you can't tear the paper, you can't recycle it!
- Nasal Cannula plastic packaging? **NO**
- #6 plastic items (will have # on them)? **NO**
- Glass vials containing drugs? **NO**

Thank you in advance for your participation!

Sincerely,

Alaina Becker, SRNA, Class of 2016
Brittany Schuler, SRNA, Class of 2016

NorthShore Anesthesia Cart: Items by Drawer**1: MEDICATIONS**

YES	NO
Plastic back of black rubber syringe cap package	Paper portion of black rubber syringe cap package
Glass vials/ampules with <3% med remaining	Glass vials containing >3% of med

2: SYRINGES/IV CANNULAS

YES	NO
Plastic portion of syringe wrapper	Paper on syringe packaging
Plastic portion of needle wrapper	Paper on needle wrapper
Entire 20cc syringe wrapper	
Plastic portion of IV catheter package	Paper on IV catheter package

3: AIRWAY ACCESSORIES

YES	NO
Oral airway wrapper/package	Paper with waxy film
Plastic bags covering extra blades	
Plastic breathing circuit (not contaminated with blood)	

4: ETTs/STYLETS

YES	NO
Plastic portion of ETT package	Paper on ETT package
Plastic portion of Stylet wrapper	Paper portion of stylet wrapper

5: NGTs/BLUE TOWEL/TEMP PROBES

YES	NO
All plastic from NGT package	Contaminated NGT itself
Clear plastic from temp probe wrapper	Temp probe itself
Entire 60cc syringe wrapper	

6: IV FLUIDS

YES	NO
IV bag outer package	
IV bag itself (without fluid, non-contaminated)	
IV tubing, non-contaminated w/ blood	
Clear plastic from IV tubing packaging	

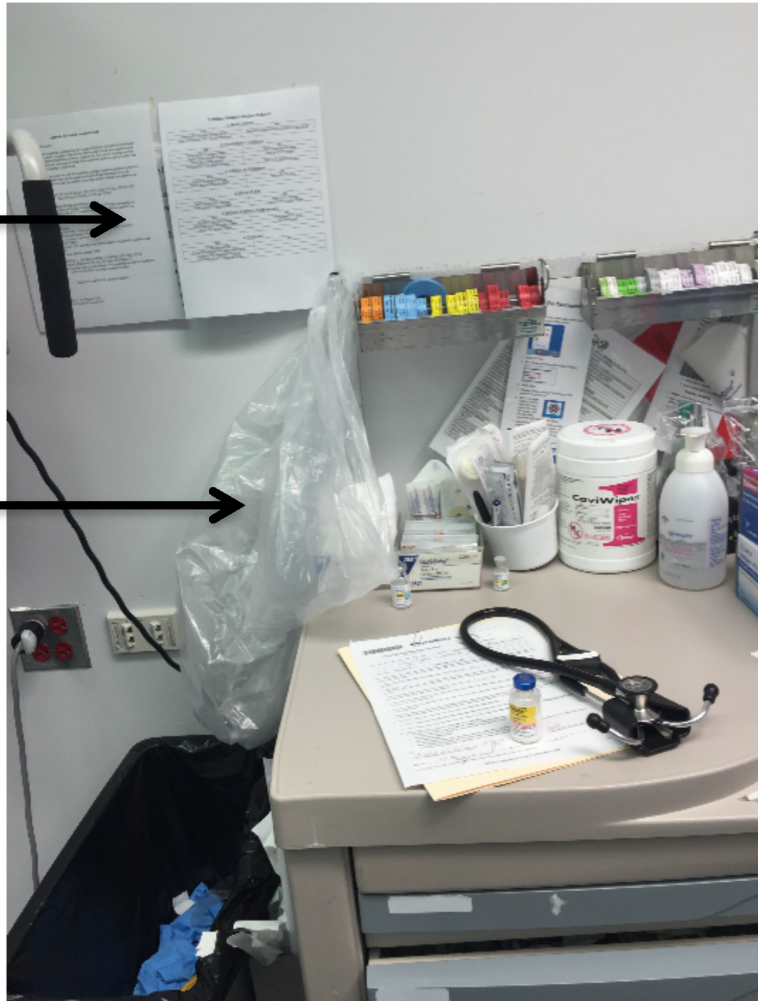
Appendix C: Figures & Tables

Figure 1:

Email to anesthesia staff posted
on wall above cart



Receptacle placed on left side of
cart for collection



Effect of Convenience on Participation in Recycling by
Anesthesia Providers in the Operating Room: A Pilot Study
Alaina Murley and Brittany Schuler
NorthShore University School of Nurse Anesthesia

Abstract

Anesthesia providers are in a position to contribute to the financial and environmental health of their institution through recycling. One of the barriers to participation in recycling by anesthesia staff as identified by the researchers of this study is a lack of convenience. Researchers sought to measure the effect of convenience on participation in recycling by anesthesia providers working in the seventeen operating room suites at NorthShore University HealthSystem Evanston Hospital. The researchers conducted a pilot study implementing a program to enhance the convenience of recycling. Participation, measured by weight in kilograms (kg) of recycled material, was compared pre- and post-intervention. The study demonstrated a 409% increase in recycling participation following distribution of an informational email, posting of recyclable materials in each room, and placement of convenient recycling receptacle on each anesthesia cart. Paired *t*-test for total material collected as well as for average waste per case collected in the pre- and post-intervention periods revealed statistically significant results. Convenient placement of a receptacle for recycling is positively correlated with an increase in recycling participation among anesthesia providers at this institution.

Effect of Convenience on Participation in Recycling by Anesthesia Providers in the Operating
Room: A Pilot Study

Background

Twenty to thirty percent of all hospital waste has been shown to originate from operating rooms, with at least 40% of this waste demonstrated to be recyclable and 25% to be of anesthetic origin (McGain et al., 2012). One explanation for why operating rooms generate large amounts of waste is the need for sterility of supplies and equipment (Esaki & Macario, 2009). In the U.S., infected medical wastes are disposed of primarily through incineration while most municipal solid waste, including non-hazardous medical waste, is disposed of by landfilling. The number of operating landfills has decreased in the last several decades and the construction of new landfills is challenging due to high construction cost and limited space (Lee, Ellenbecker, & Moure-Eraso, 2002). In order to save landfill space and to reduce expensive disposal cost of medical waste, recycling of plastics in medical waste should be increased. Anesthesia providers are ideally placed to facilitate operating room plastic recycling (McGain, Clark, Williams, & Wardlaw, 2008).

Operating room wastes have a great potential to be infected and, as such, have historically not been considered for material recycling (Lee et al., 2002). Other barriers to recycling plastics in the operating room include: lack of knowledge regarding which plastics are recyclable, difficulty separating various plastics, reluctance to change practices and an attitude that environmental concerns are irrelevant to medicine (McGain et al., 2008). Anesthesia providers' attitudes toward recycling are important to address when considering improvements in operating room recycling programs. In a survey examining anesthesiologists' attitudes toward

OR waste recycling, respondents reported that the major barriers to recycling were (1) inadequate recycling facilities, (2) staff attitudes, and (3) inadequate information on how to recycle. Minor barriers included lack of time, safety issues, inadequate space for a receptacle, and cost. Most anesthesiologists regarded operating room recycling to be important overall, regardless of barriers (McGain, White, Mossenson, Kayak, & Story, 2012).

In a pilot program for recycling, a small hospital in Melbourne, Australia entered into an agreement with a local plastic recycling company to take plastics from the hospital free of charge. Over a one-year period, operating room staff recycled approximately 200 kilograms per week of non-infectious plastics that would otherwise have been dumped into a landfill at a cost of 10 cents per kilogram. The hospital savings was \$20 per week. Staff reported no increase in delays between cases or leaving work as a result of recycling (McGain et al, 2008). In another study, anesthesia providers responded to a questionnaire regarding attitude toward recycling and the majority were found to be concerned about environmental pollution; however, they would not participate in a recycling program unless it was mandated legislatively (Goldberg, Vekeman, Torjman, Selzr, & Kynes, 1996).

The benefits of a recycling program are altruistic, may help reduce hospital costs, and may secondarily improve public relations. Proper source separation of waste, development of recycling infrastructure, education of workers and managers, and the efforts of hospital administrators are the vital components of a successful recycling program (Lee et al., 2002).

Problem Statement

A study evaluating anesthesia providers' perceptions of recycling in the operating room found that perceived barriers to recycling by providers included inadequate knowledge regarding the recycling capabilities of the hospital and a lack of space for recycling receptacles (McGain et

al, 2012). At NorthShore University HealthSystem, Evanston Hospital, a recycling program has already been implemented in the operating rooms. Recycling bins are placed near separate waste receptacles close to the surgeon and operating room nursing staff. Anesthesia personnel are usually separated from the majority of non-anesthesia staff and equipment as they are required to remain in close proximity to the patient they are caring for, usually at the head of the operating table near their anesthesia equipment. Restrictions to movement within the operating room, in addition to time constraints and other set priorities and responsibilities, present a challenge for anesthesia providers who might otherwise participate in the recycling program. Despite the current recycling practice at this institution, barriers such as inconvenient access to recycling bins, poor staff prioritization regarding recycling, and misinformation about recyclable items prevent staff from consistently contributing to recycling efforts.

Theoretical Framework

Nursing intellectual capital theory suggests that the nursing capital of a healthcare organization is a combination of the knowledge possessed by the nurses that work for that organization and of the information existing within the organizations systems, including practice guidelines (Covell & Sidani, 2013). Hospitals can maximize their intellectual capital by providing guidelines for a waste recycling program as well as resources for anesthesia providers in order to maximize participation in the recycling program. “Participation” is a concept defined as “the state of being related to a larger whole” (Merriam-Webster, 2015). An antecedent to participation of anesthesia providers in a recycling program is maximized intellectual capital by way of provision of resources. The outcome of participation is higher yield recyclable waste.

Purpose of the Project

The purpose of the project was to determine whether or not a modified recycling program that incorporated convenient placement of a receptacle for recyclable materials would increase anesthesia providers' participation in a recycling program. Participation in the program was measured in weight (kilograms) of collected recyclables after designated recycling receptacles had been placed near each anesthesia cart.

Research Questions

1. What is the current level of participation in recycling at NorthShore University HealthSystem Evanston Hospital by anesthesia providers?
2. How does convenient placement of a receptacle for recyclable waste affect participation in recycling program among anesthesia providers in the operating rooms at NorthShore University HealthSystem Evanston Hospital, measured by the difference in weight of recycled material over a one-month period?

Literature Review

A literature review was conducted to evaluate current research pertaining to the perceived barriers to participation in operating room recycling programs by anesthesia providers. Databases used include PubMed, CINAHL Complete, and ProQuest Nursing & Allied Health Source. Medical subject heading (MeSH) terms searched were: 'recycling', 'operating rooms', 'plastic', 'medical waste disposal' and 'anesthesia'. Within these databases, a total of 106 journal articles were discovered ranging in publication dates from 1993 to 2014. Inclusion criteria used to narrow the results for qualifying articles or studies included a focus on recycling of plastic material, identification of (or methods for overcoming) barriers to recycling, and recycling initiative programs within the anesthesia sector of the operating room. Based on these

inclusion criteria, ten articles were chosen for literature review. For the purpose of this study, the authors chose to focus solely on the regulation of medical waste and barriers preventing participation in recycling initiatives, specifically that of non-hazardous plastic waste encountered by anesthesia providers. A comprehensive research article table has been compiled summarizing influential articles used to develop this project and its concepts (see Appendix A).

Identification of Barriers

An article review by Esaki (2009) summarized what is known about waste generation in hospitals and discussed various strategies for waste management. Authors reported that operating rooms generated 20-33% of total hospital waste. Potential anesthesia-related waste was identified and included syringes, bottles and vials, and airway equipment and hoses. A barrier to recycling identified by the authors is that operating rooms are crowded with so much equipment that there may not be additional space for recycling bins (Esaki & Macario., 2009).

Lee et al (2002) studied the recycling potential of medical plastic wastes generated by five hospitals in Massachusetts. They analyzed the sources, disposal costs, and plastic content of medical wastes. They then evaluated the recycling potential of plastic wastes in various departments, including operating rooms. Operating rooms were identified as a major source of plastic waste. Large volumes of plastic waste were found to be mainly due to a chance of contamination or infection, and simplification of purchasing plastic components and lack of classification of plastics for recycling (Lee et al., 2002).

McGain et al (2008) reported a pilot program to recycle operating room plastic in Melbourne, Australia. The authors discussed barriers to recycling and noted that, unlike household plastics, most medical plastics are not classified by a code or number. Other barriers identified were concerns about infection risks, difficulty separating different types of plastics,

reluctance to change work practices and an attitude that environmental concerns are irrelevant to medicine. This pilot recycling program resulted in 200kg per week of recycled material with a savings to the hospital of \$20 per week (McGain et al., 2008).

A feasibility study of recycling of single-use breathing systems among anesthesia providers was conducted by Goldberg et al (1996). The design included a two-part analysis: analysis of responses to a questionnaire regarding anesthesia providers' attitude toward recycling, and a cost-benefit analysis of a recycling program. The authors found that the recycling program is cost-effective and environmentally beneficial; however, most anesthesia providers would not participate in a recycling program unless mandated by law (Goldberg et al., 1996).

In a more recent survey of anesthesiologists' views of operating room recycling, McGain et al (2012) investigated attitudes toward and barriers to recycling. A survey was distributed to anesthesia providers in Australia, New Zealand and the UK. More than 90% of respondents reported that they would like to recycle at work. The greatest barriers to recycling most frequently reported by respondents were inadequate recycling facilities, staff attitudes, and inadequate information on how to recycle. Time, safety, inadequate recycling space, and cost were each thought to be the greatest barriers to recycling by less than 5% of respondents (McGain et al., 2012).

Identification of Suggested Solutions

Investigation into literature regarding recycling practices within the operating room setting would not be complete without review of proposed suggestions for change and development of successful recycling programs. Many articles found within the database searches included solutions for management of medical waste (namely plastics) and the methods through which a recycling initiative should be developed. Hospitals for a Healthy Environment

(H2E) is a national program that provides “hospitals across the nation with the framework, tools, and resources they need to change their waste-disposal practices” (Brannen, 2003, p. 25). The H2E program encourages institutions to consider their current waste disposal practice and as well as the potential impact simple, methodical change may have on the hospital and world environment (Brannen, 2003).

In 2011, Riedel published a study in the American Association of Nurse Anesthetists Journal regarding the multifaceted impacts of a hospital-wide recycling program (Riedel, 2011). In this study, financial and environmental incentives to recycle were discussed due to generation of “2.7 metric tons of waste per day” (Riedel, 2011, p. S9) by hospitals alone. Interventions created to address this problem were implemented in phases: Phase 1 included education of staff regarding environmental benefits of recycling and types of materials appropriate for the recycling receptacles; Phase 2 was placement of designated containers throughout the hospital with printed lists of acceptable items; Phase 3 meant collection of all bins into a designated area for weekly weight and disposal by a pre-determined company. After a year of waste collection, weight of materials was compared to the pre-intervention year to determine cost-effectiveness of an increased waste diversion from solid-waste to recycling receptacles. Riedel (2011) found that the “annual recycling increased 9.3metric tons (10.3 US tons) after single-stream recycling began” (p. S11). Significant financial benefits to this shift in waste separation were illustrated by the \$4,672.88 decrease in non-hazardous waste disposal cost (Riedel, 2011). Landfill waste was subsequently reduced by 40.2 metric tons, resulting in a cost-savings of \$4,114.75. Riedel suggested ease of use due to single-stream recycling and effective education of staff as major contributors to success of the program.

Practice Greenhealth, an online healthcare community, focused on efficiency and environmental friendliness within patient care and developed a template for creation of an operating room recycling initiative (Practice Greenhealth, 2011). Ten steps were outlined within the plan for improved operating room recycling compliance. ‘Step One: Enlist Allies’ stresses the importance of designating passionate, involved team of stakeholders to spearhead the new program. ‘Step Two: Identify Hauling Partner’ identifies the real challenge finding a reliable hauling company may pose for hospitals; clear communication lines between hauler and environmental services (EVS) director are necessary when establishing pick-up date, time and location, differentiation between nonhazardous/hazardous material, as well as single versus multi-stream capabilities. ‘Step Three: Have a Sense of What Can Be Recycled’ is critical in development of a coherent staff education program; without complete understanding of acceptable items within the spearhead committee, effective communication of items to participating staff members will be nearly impossible. ‘Step Four: Work with EVS to Define Containers and Collection Schedule’ suggests involvement of EVS in placement/replacement of designated receptacles and development of collection schedules for maximal effectiveness/cleanliness; use of a certain color receptacle specifically for recycled plastic waste may serve to facilitate workflow for EVS and anesthesia staff. This suggestion proved to be effective within the University of Chicago Medical Center operating rooms. According to Dr. Catherine Bachman, blue recycling containers were placed next to each anesthesia cart for the sole diversion of anesthesia related plastic materials such as syringe packaging, IV bag protectors, etc. Staff grew to recognize these blue containers as a reminder to recycle and ease of use/convenience of placement served to increase the amount of recycling products diverted from

solid waste disposal. The University of Chicago has since been nationally recognized for its efforts in environmental improvement and awareness (Bachman, 2010).

‘Step Five: Develop Signage to Highlight New Segregation Practices’ suggests implementation of pictures into signage placed near/above each receptacle to provide visual guidance for easy identification of acceptable plastic materials. ‘Step 6: Educate and Engage Staff on Appropriate Segregation Procedures’ stresses the crucial nature of a well-developed staff education plan; in-services regarding change to practice, color of receptacles and appropriate recyclable materials should be communicated in multiple staff meetings during times when majority of staff is available and receptive to information. ‘Step Seven: Divert Recyclable Waste Pre-Incision’ recommends starting recycling diversion during procedure set-up. ‘Step Eight: Segregate Recyclable Waste After Procedure’ is in place to maintain cleanliness of materials collected and prevent mixing of hazardous and non-hazardous waste between patients; a decision must be made regarding continuance of receptacle use between patients or if a new receptacle (bag) will be obtained for each patient. ‘Step Nine: Problem Identification and Resolution Plan’ encourages members of the planning committee to anticipate hiccups in implementation of the plan and brainstorm regarding how to prevent/troubleshoot those roadblocks. ‘Step Ten: Track Progress and Recognize Success’ realizes the need to recognize effective change within an institution and use the new-found success to implement policies to ensure continued success. These guidelines were established without bias or conflict of interest and were developed to aid hospitals in development of an effective recycling initiative (Practice Greenhealth, 2011).

The push for potential plastic reuse has also been recognized by the Healthcare Plastics Recycling Council (HPRC) as a significant potential contribution to the future health and

wellness of our society (Healthcare Plastics Recycling Council, 2013). Historically, recycling efforts within hospitals have been largely focused on administration and food service areas. However, the need to expand these efforts throughout an institution is anticipated by the HPRC and subsequent guidelines have been developed to aid hospitals in disposal of specific plastic waste. Links to appropriate resources regarding characterization to waste, commitment to sustainability, economic analysis, and clinical infrastructure are all provided within the pamphlet (Healthcare Plastics Recycling Council, 2013). Waste characterization tools such as “The Plastics Mapping Tool” are provided to help distinguish between types of plastics accepted by most hauling companies; the HPRC also suggests an in-depth conversation and detailed contract to be drawn up between hospital and recycling partner to prevent blurred lines regarding acceptable plastics. Guideline tools for best placement of receptacles, necessary equipment, training tools and posters, as well as tools for evaluation of program effectiveness are also provided in the HPRC pamphlet (Healthcare Plastics Recycling Council, 2013). Periodic review and audit of the program is recommended by the HPRC to ensure sustainability of the chosen program. Provision of useful resources such as these is advantageous in development of new plastic recycling initiatives.

Research Design

A single group post-intervention evaluation design was utilized for this study.

Sampling Approach

There are seventeen operating rooms at Evanston hospital with 125 anesthesia providers on staff including doctors, nurse anesthetists, and residents. Depending on the number of scheduled surgical cases, there were 40-50 anesthesia providers scheduled daily for patient care.

All anesthesia providers at Evanston Hospital were included in the sample as each of these providers had the opportunity to participate in recycling.

Recruitment Procedure

Recruitment activities were conducted by the primary investigators of this study. After a two-week, blind collection of materials used to measure baseline recycling participation, an email was distributed to all NorthShore anesthesia staff using a listserv via EasyCall software system. In the email, researchers notified anesthesia staff of the pilot program and emphasized the availability and location of conveniently-placed recycling receptacles in each OR. A list of recyclable materials was attached to the email. Laminated copies of this list of recyclable materials were posted above each new recycling receptacle.

Inclusion criteria for participation in the study were: Participants must have been current anesthesia providers (doctor, resident, CRNA, or SRNA) at NorthShore University HealthSystem, Evanston Hospital. Materials collected included all non-contaminated plastic waste except that identified as #6-type plastic (polystyrene), all non-contaminated paper waste except that covered in waxy film, and all glass waste except those medication vials containing greater than 3% of the original contents of the vial. Exclusion criteria for participants were operating room employees in non-anesthesia role (such as operating room nurses, surgeons, and technicians). Exclusion criteria for materials collected included biohazardous waste or solid waste collected in waste receptacles other than that provided by researchers. Participants did not receive a material incentive to participate in the study.

Ethical Considerations

This project obtained Institutional Review Board approval from NorthShore University HealthSystem and DePaul University. Protection of human subjects was upheld by the

anonymous nature of data collection for the study, with recycled material weighed daily in a single measurement separate from interaction with anesthesia providers. Participants were informed of the purpose of the study, protection of their privacy, their right not to participate without penalty, and the contact information of researchers. All data collected was stored on a password-protected computer that only the primary researchers could access. Permission to wave consent from eligible participants with support from the Director of Anesthesia at Northshore University HealthSystem, Dr. Joe Szokol, was approved by the Office of Research Services at DePaul University.

Methods

Data collection for this study was conducted in the 17 operating rooms at NorthShore University HealthSystem Evanston Hospital from February 15, 2016 to March 15, 2016, with a total of 20 days of data collection. Pre-intervention data collection consisted of 10 days of collection of recycled material from each operating room by a member of the research team between the hours of 3 and 4 pm. Collected material was weighed in kilograms (kg) daily using a Tariss JetSetter luggage scale, which was zeroed prior to each use. The daily number of cases was tracked using the operating room status board (OpTime, Epic Systems, Verona, Wisconsin), with cases starting prior to 6 am and at or after 3 pm each day excluded from the case count. Following completion of the pre-intervention 10-day period, an email describing the study and placement of receptacles was distributed to all anesthesia staff using the listserv provided on NorthShore's EasyCall server (see Appendix B). A paper copy of the email notification as well as an updated list of materials acceptable for recycling were posted above the anesthesia cart in each operating room. Each morning between 6 and 6:30 am, a recycling bag was placed on the left side of the anesthesia cart by a member of the research team (see Figure 1). The same bags,

later containing recyclable waste, were collected between the hours of 3 and 4 pm daily using the same collection protocol as in the pre-intervention period. The number of cases was again tracked using the operating room status board, with cases starting prior to 6 am and at or after 3pm each day excluded from the count. Microsoft Excel 2013 was used to record daily collection throughout.

Results

Pre-intervention collected waste totaled 6.5 kg over the 10-day collection period (for 346 cases) with an average of 0.65 kg per day and 0.0192 kg/case. Post-intervention collected waste totaled 34.5kg of recyclables (for 371 cases) with an average of 3.45 kg per day and 0.0978 kg/case. Kilograms per case of recycled waste increased by 409% after the intervention period. The highest collection day in the pre-intervention period resulted in 1.3 kg of waste; the highest collection in the post-intervention period resulted in 7.0 kg of waste. Statistical analysis was completed using IBM SPSS software to determine mean, standard of deviation, and significance ($p < 0.05$) of pre- and post-intervention measured values using a paired *t*-test (see Table A).

The difference between total recycled material collected pre-intervention (6.50 kg) and total recycled material post-intervention (34.50 kg) was statistically significant, with paired *t*-test yielding a p-value of 0.001. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant, with paired *t*-test yielding a p-value of 0.01. To ensure that the pre- and post-intervention arms are not systematically biased, a *t*-test was also performed to determine the statistical significance of the variation in the number of cases during the pre-intervention versus post-intervention periods (346 cases pre and 371 cases post). The *t*-test for this data set gave a p-value of 0.498, indicating that the two arms are not statistically significant in terms of the number of cases during the study period (see Table B).

Discussion

Results indicate that participation in recycling by anesthesia providers is largely dependent on the convenience of recycling. In our literature search, we identified a lack of convenience in the face of numerous other high-priority tasks as a barrier to operating room recycling by anesthesia providers. We addressed this barrier by placing recycling bags and a recycling guide at a convenient location next to each anesthesia cart. This allowed anesthesia providers to recycle appropriate waste without having to leave their patients and walk across crowded, often sterile-prepared operating rooms to the designated recycling bins used by scrub and circulating nurses. Recycled waste per case increased by 409% overall after the intervention.

Recycled material collected during the pre-intervention period reflected participation in recycling by anesthesia providers in Evanston Hospital at baseline. The amount of recycled material per case varied considerably from day to day. The lowest amount of recycled material collected in a day was 0.0056 kg per case and the most recycled material collected in a day was 0.0382 kg per case (see Chart 1).

Variation in recycling by day may be attributed to variation in recycling practices among anesthesia staff; in other words, some anesthesia providers participated more than others in recycling at baseline, and on the days those providers were working, more material was collected.

Another potential reason for daily variation in waste per case at baseline may be that on certain days or with certain surgeries, there is a higher prevalence of more complicated procedures requiring the use of more supplies and, therefore, increased yielded waste. For example, surgeries requiring general anesthesia include use of an airway circuit with heavy corrugated plastic tubing as well as packaging for: oral gastric tubes, at least six to ten medication syringes, eye protection, intravenous fluid bags and wrappers, etc. The increase in

demand for supplies during general anesthesia cases is much higher than for that of monitored anesthesia care cases, which may only require a nasal cannula, three to four syringes, and less intravenous fluid. Provider preference for supplies may also impact this disparity as some providers take a “less is more” approach and generally use less supplies than their peers.

Patient acuity may also explain variation in recycling practice. Anesthesia providers are trained to place patient safety as top priority. If a patient is critically ill or unstable, or the surgery is particularly high-risk, speed and efficiency on the part of the anesthesia provider are paramount to safety. In some cases it must be recognized that even when a receptacle for recycling is conveniently placed, the act of sorting materials may take time and attention away from the care of an unstable patient. The anesthesia provider must use his or her judgment to decide whether or not it is safe to prioritize recycling in high-acuity cases.

Another explanation for the variation in recycling from day to day is possible contamination of recyclable waste by hazardous material (i.e. blood or other bodily fluids), which renders waste inappropriate for recycling. Plastic material that has come into contact with blood, sputum, gastric contents, or urine/feces, must always be disposed of via biohazardous solid waste receptacles. Provider understanding of contamination by bodily fluids may not always be clear. For example, the plastic corrugated tubing used for breathing circuits contains condensation from the moisture in patients’ exhaled gases. This moisture is not considered contamination and therefore does not render the used circuit unsuitable for recycling. If, however, a patient’s sputum contaminates the tubing, the circuit must be disposed of with biohazardous waste.

The recycled material collected during the post-intervention period reflected participation in recycling at Evanston Hospital after bags were provided on the anesthesia cart in each operating room. Again, the amount of recycled material per case varied considerably from day to day and this was likely due to variation in recycling practices by different staff, the types of cases that were performed on different days, [the level of patient acuity](#), and the possibility of hazardous waste making some waste unsuitable for recycling. The lowest amount of recycled material that was collected in a day was 0.0229 kg per case and the most recycled material that was collected in a day was 0.1707 kg per case.

It was noted that during the post-intervention data collection phase, the amount of recycled material increased steadily over time. On day one, the total collected waste was 1.1 kg and on day ten the total collected waste was 4 kg (see Chart 2). This increase in participation over time may be attributed to increased awareness of the study among anesthesia providers over the 2-week period, as some providers may not have immediately read the email sent to them or noticed the sign and recycling bag. Additionally, momentum and support for the researchers' project may have built among anesthesia staff over the two-week period, causing them to increase their participation in recycling. [In their template for creation of an operating room recycling initiative, Practice Greenhealth stresses the importance of educating and engaging staff on recycling behaviors. They suggest that the plan for recycling should be communicated repeatedly in order to reach staff when they are most receptive to information \(Practice Greenhealth, 2011\). Increasing staff engagement during the data collection period explains why there was a dramatic increase in providers' participated in recycling efforts for this pilot study over time.](#)

The null hypothesis for this study was that there would be no statistically significant difference in the amount of recycled material collected pre-intervention versus post-intervention. Paired *t*-tests allowed us to examine the relationships between pre- and post-intervention data. The difference between total recycled material collected pre-intervention and total recycled material post-intervention was statistically significant. The difference between recycled materials per case between pre-and post-intervention data sets was also statistically significant. These findings suggest that participation in recycling by anesthesia providers, both overall and per case, increased significantly after signs and recycling bags were placed conveniently at the anesthesia cart in each operating room.

A *t*-test was also performed to determine the statistical significance of the difference in the number of cases during the pre-intervention versus post-intervention periods. The *t*-test for this data set gave a p-value of 0.498, which is not statistically significant (see Table B). This suggests that the overall caseload was not a confounding factor for recycling participation, and therefore it can be inferred that the difference in recycling practice pre- and post-intervention is attributable to the convenient placement of recycling bags rather the difference in caseload.

Strengths and Limitations

Strengths of the study include valid, statistically significant comparisons between baseline provider participation and participation following the implemented intervention. As stated, the difference in total cases performed during pre- and post-intervention data collection was not statistically significant and is, therefore, not a confounding factor in this study. Study approval from both the NorthShore University Health System and the DePaul University Institutional Review Board upheld participant anonymity throughout the data collection period. Increased recycling convenience improved participation by 409% in this institution's anesthesia

department; when extrapolated to one year of participation at the post-intervention rate, an estimated 900.45kg of waste could be diverted from municipal solid waste (see Appendix D) compared to the pre-intervention forecast of 169.65kg. The environmental implications of an increase in waste diversion of this magnitude are impressive and may serve as motivation for providers to continue recycling participation. It is believed that during the data collection period most of the enthusiasm demonstrated by anesthesia providers at Evanston Hospital was for recycling itself.

A limitation of the study is that it was not blinded; the study took place amongst anesthesia colleagues who were aware of the data collection taking place and whose support for the researchers may have influenced the outcomes of the study. Inability of researchers to control for the type of cases performed during the pre- and post-intervention collection period must also be identified as a limitation in this study as the type of case is suggested as having an impact on recycling practice. Inability to control for scheduling variation among anesthesia providers who work on different days of the week is also a potential limitation of the study, as some providers were more motivated than others to participate in recycling.

Implications for Further Research

Further studies could be conducted, perhaps by administering a post-intervention survey, to explore staff attitudes regarding the effect of convenience on recycling. As stated by McGain, et al. (2008), reluctance to change work practice or belief that recycling is not a priority may serve as major barriers to recycling participation. A study that examines staff attitudes regarding the recycling program might serve as the first of multiple, ongoing evaluations of the program. These evaluations can serve to identify areas for improvement that ultimately engage more participants and enhance recycling in the institution.

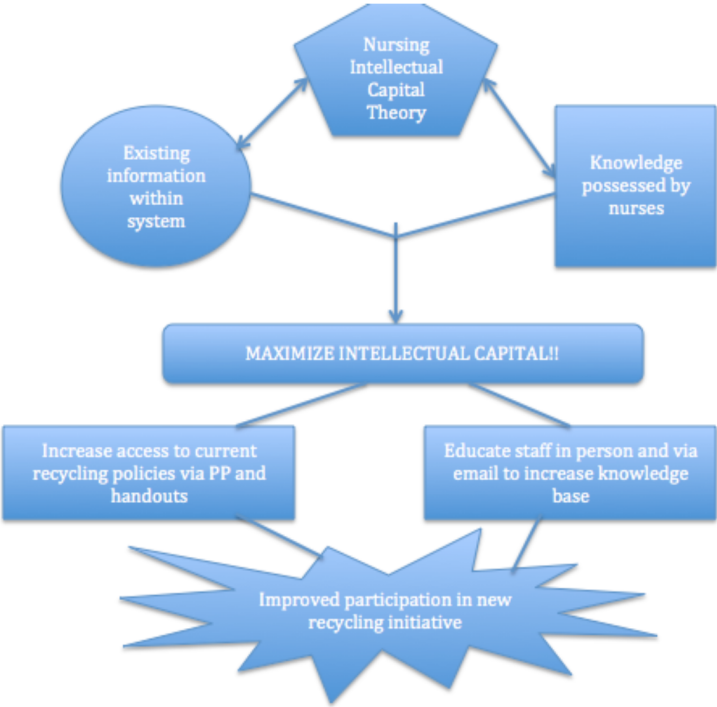
Additionally, further studies might emphasize the impact of education in recycling practice on staff participation. A thorough understanding of which materials are acceptable for recycling is crucial for the success of any recycling program. A study might examine the most effective ways to keep staff informed. For example, as supplies and equipment change over time, the list of approved materials will need revision and will, therefore, provide researchers with opportunities to re-educate staff on a regular basis. This repetition may enhance learning and reinforce participation.

Finally, a study focusing on cost analysis may provide insight as to the financial benefit of increased recycling to the hospital. NorthShore University HealthSystem reports a solid waste cost of \$0.03/lb and a recyclable waste cost of \$0.01/lb. An exhaustive cost-benefit analysis would highlight the financial gains that a recycling program can offer the institution. This could enhance support from administration and ultimately lead to changes in policy and practice.

Conclusion

Anesthesia providers are in a position to help their institution separate recyclable waste from municipal waste. The results of this study suggest that the provision of a conveniently-placed receptacle can greatly increase participation in recycling by anesthesia providers, as evidenced by a 409% increase in recycling after the intervention. The benefits of recycling are many and include reduced landfill waste and environmental pollution, institutional cost savings, improved staff morale and better public image for the institution.

Conceptual Map



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Appendix A: Research Article Review Table

Study Purpose	Research Design	Sampling	Human Subjects Issues	Extraneous Variables	Intervention Offered	Outcome Measures Used	Adverse Effects of Intervention	Study Variables	Statistical Analysis	Study Findings
"A Survey of Anesthesiologists' Views of Operating Room Recycling" - (McGain Forbes; White, 2012)										
To determine the importance of recycling operating room waste to anesthesia providers; To identify barriers preventing OR recycling	Qualitative ; Survey emailed to 500 randomly selected fellows via the ANZC Trials group and to approx..500 consultant anesthetists in English National Health Service; Survey developed using Survey Monkey	Survey of Anesthesiologists or anesthesia fellows ; No gender/age /ethnicity variables; -Total of 780 surveys received.	Study methodology approved by Human Research Ethics Committee at Western Health, Melbourne, Australia . Written informed consent was waived by ethics committee.	Survey included one open-ended question to attain additional potential information regarding barriers to recycling within the OR	No Intervention measured	Outcomes measured are the survey response s; Low rate of return on survey distribution serves as major limitation of the study.	None	- Questionnaire used could be comparable across other studies -Used an established study tool, Survey Monkey for easy distribution/access for survey participants	Statistical analysis completed via Wilson's Method to calculate the 95% confidence intervals for the proportions,	95% agreed that they would like to recycle anesthesia waste; 11% agreed that recycling does take place; 3 most influential barriers to recycling identified as: 1. Inadequate recycling facilities, 2. Staff attitudes, 3. Inadequate information on how to recycle; Time, safety, inadequate space, and cost were less influential barriers to recycling
"Analysis of an Organization's Waste Stream" – outlines how to complete a waste stream analysis - (Hayne, 1993)										
Development of thorough waste stream analysis for hospitals to utilize in order maintain safe, cost effective methods of waste disposal from beginning to end or to develop new	Review of a system – not study in sense of qualitative vs quantitative; More of an outline on how to perform a waste stream analysis	Explains how to perform this analysis within one institution	No human subjects involved in this article	- Individuals within the organization who are current with the local, state, and federal regulations may need to be included in the analysis	Analysis of the amount/type of waste disposal within an institution to provide suggestions for improvement and identify areas of need	None	None	None	None	Waste Stream Analysis worksheet provided as suggested format for analysis

policy regarding waste management in that institution				committ ee -Should include status of local landfills , waste management of other major community polluters						
The Green Operating room: simple changes to reduce cost and our carbon footprint - (Wormer, 2013)										
Assess improvement in waste reduction and recycling after implementation of a Green Operating Room Committee	GORC formed and Green OR initiative campaigns instituted throughout the ORs. Quarterly meetings held to discuss the impact of the initiatives and their effectiveness; Results of the 'score cards' were recorded and downstream effects on cost analyzed. Methods were effective in analyzing the potential for cost savings and identifying the areas for improvement within cost containment.	Study performed at one large Level-1 trauma institution in North Carolina; 100 consecutive MDs, Nurses, Scrub techs monitored during scrub patterns regarding water consumption; Education campaigns provided to all other OR staff in regard to solid reusable waste, Red Bag biohazardous waste, and Recyclables/ Reusables. -Population of this study well matches that of interest in our project. - Gender/age/ethnicity not pertinent variables -Sample size was not justified through use of statistical analysis.	Methodology approval not mentioned; GORC formed by Division of Gastrointestinal and Minimally Invasive Surgery and joined by Nursing, Environmental Services, and Anesthesia at Carolina's Medical Center in 2008.	Study did not control for confounding variables, but did take them into account in regard to outside cost of waste disposal ; involved multiple departments in the project as well.	Education campaigns for each recycling initiative was completed over the course of a year to evaluate the effectiveness of each campaign on cost/staff behavior change.	Effectiveness is measured through comparison of \$\$ before and after the initiatives were completed; through their studied initiatives, this institution saved approximately 158,000 annually .	None	Variables of interest: Solid Waste Reduction, OR Recyclables & Reusables, Energy & Water Reduction, Charitable Donations. Researchers performed their own data collection with the help of environmental services staff in which the weight of waste was measured and compared throughout the year.	None	-Avg cost of disposal of regulated medical trash is \$0.28/lb. -Annual cost savings after implementation of 4 different recycling/energy saving initiatives was \$158,000. -12,000lbs solid waste was diverted, 75% decrease in Red Bag waste, 500lbs alkaline waste diverted, Complete reduction of foam waste, 2.7million liters of water saved.
People, Planet, and profits: the case for greening operating rooms - (Kagoma, 2012)										
Purpose is to identify ORs as	Analysis/Literature Review;	138 article resulted, 65 of which	No IRB approval needed	No extraneous	Suggested interventions	No measure of	None	No study variables	None	-Hauling costs for recyclable

major contributors to waste and to identify waste-reduction strategies that “satisfy the ‘triple bottom line’ (people, planet, profits), by reducing health care costs and environmental effects without compromising patient care” (p. 1905).	predefined search strategy explained and total of 138 articles resulted, 65 of which were used in the analysis.	were used to complete the literature analysis.	b/c no human subjects were involved in this literature review.	variables	included for ways to reduce waste via segregation of waste products, fluid waste management, energy savings, and equipment packaging are all provided. -No direct intervention is evaluated in this review	effectiveness as this is just a lit review.					plastics are nearly half that of solid waste disposal; Institutions may negotiate rebates for recycled plastics.
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Reduce – Recycle – Reuse: Guidelines for Promoting Perioperative Waste Management (Lausten, 2007)

Literature review to promote greener waste management objectives	-“Green team” of nurses recruited voluntarily to explore the excessive waste generated in the perioperative setting. - Descriptive analysis of contents of one red bag completed. -	One red bag analyzed; may be a limitation that only one bag was analyzed.	No IRB approval mentioned; only human subjects at risk were the authors themselves during the removal of contents of potentially biohazardous material in the red bag. No mention of consent obtained from the members of the “Green Team”.	Did not control for extraneous variables such as type of procedure performed in red-bag associated OR; does state that limitations of study are that only one bag is analyzed results may vary institutionally.	Guidelines for greening of the operating room after realizing the mis-education demonstrated by the contents of a red bag	None	Benefits are worth the cost of implementing the recommended guidelines	Descriptive analysis was performed	None	-Majority of waste found in red bag is not actually biohazardous waste -Providers need to be more aware of what they place in the red bag and guidelines are recommended for future practice; time table should be included b/c will be a slow process to change the behavior and make all those involved feel that their actions matter.
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Greening critical Care - (Chapman, 2011)

Map ways	Review of	Population	No	No	No	No	Benefits	No study	None.	Recomm
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to green up an ICU and reduce negative environmental effects on patients with suggestions targeted at individuals as well as whole institutions.	methods used to increase green initiative awareness within an ICU/hospital. Four areas of focus are considered: consumption, waste, toxins, and personal footprint of staff.	targeted is ICU staff. → not our target population, but same idea to increase awareness within a smaller portion of the entire hospital organization.	approval was gained or warranted b/c no intervention was executed.	extraneous variables	intervention offered to be examined; only recommendations for practice.	outcomes measured.	of this review outweigh the potential risks.	variables b/c this is just a recommendation for practice within the ICU.		conditions for reducing waste, increasing reuse, and decreasing the carbon footprint of those working within the ICU in this institution evaluated.
Environmental and financial impact of a hospital recycling program (Rieder, 2011)										
Purpose: To determine the environmental and financial impact of recycling at 148-bed acute care hospital.	Current non-hazardous waste disposal practices were kept in place and single-stream recycling was added and measured over a year period. Staff was educated about environmental benefits of recycling and what to recycle via PP presentations and at nursing leadership meetings; Newsletters were published promoting the program. Recycle bins were placed in staff common areas with notification acceptable items for collection; Bins were collected by disposal company at	Entire hospital staff is the sample population. -Good match to our target population, although larger participant sample than anticipated for our study b/c we are focusing in OR only, not entire 148-bed facility.	Robert Morris University granted exempt IRB status. Mercy Foundation granted money for the purchase of recycling bins.	Confounding variables possible within the study include disposal of inappropriate material in the recycle bins; this was controlled as much as possible by prior education of staff as well as informational sheets placed on bins. Seasonal variation in waste generation was considered and eliminated as a confounding variable by considering an entire	- Intervention offered was placement of recycling bins in common areas for easy, single-stream recycling opportunities. -Control group subjects received education about recycling benefits and items before placement of bins in common area. -Study lasted a year.	Effectiveness of the study was measured via comparison of nonhazardous waste streams from 2008-2009 to those of 2007-2008. Environmental Protection Agency's Waste Reduction Model used to calculate the GHG emissions and energy savings of new practices compared with the baseline year;	Benefits of the study are work the potential harm. No cost was involved in this study due to money obtained from a grant to purchase the bins.	Variables include hospital operations during the control and study period → nullified by statistical correlation. -No questionnaires were used to complete the study. -Tools used were Environmental Protection Agency's Waste Reduction Model to calculate the GHG emissions and energy savings of new practices → reliable tool.	SPSS analysis of waste generation and facility operations was performed. Pearson Correlation was used to compare waste generation and facility operations for control and intervention periods. -Waste generation and facility operations between the two time periods noted to be very similar	- Nonhazardous waste disposal cost decreased \$4,672.88. -Revenue for the hospital increased by \$390 and overall landfill waste was reduced by 40.2 metric tons.

	the end of each week. Tonage of non-hazardous waste for this year time period was compared with previous year (control).			year time frame in the study and comparison group.						
Managing Medical Waste - (Brannen, 2003)										
Hospitals for a Healthy Environment (H2E) helps hospitals change waste-disposal practices; Article outlines ways in which this policy guideline can beneficially impact waste management and respond to demands of currently evolving environmental awareness.	Review of one policy → may be considered as type of case study? Case review? H2E provides healthcare organizations with the framework, tools, and resources needed to change their waste disposal practices.	Populations targeted are any and all healthcare organizations → either in the “partner” or “champion” classification depending on what type of institution it is.	No approval needed.	None	Interventions offered are just suggestions for resources regarding waste management start-ups.	No outcomes measured.	No adverse effects of intervention or procedure	NO study variables	No statistical analyses.	Organizations interested in beginning a new recycling initiative should utilize the framework and tools provided via H2E. Mercury assessments should be conducted. Recommendations for starting a waste management plan.
Wastage of Supplies and Drugs in the Operating Room (Esaki & Macario, 2009)										
Identification of anesthesia related waste in the OR including drugs, packaging, etc.; Explanation of Reduce-Reuse-Recycle-Restrict practice suggestions	Review of current RRRR practices within the OR and related to anesthesia	Populations targeted are anesthesia providers who have contact with waste associated with direct patient care and surgical set up	No approval needed.	None	Reduce, Reuse, Recycle, Restrict – suggestions for implementation of these principles within the OR; Restrict = Segregation of waste into classes for easier distribution to the proper waste	No outcomes measured	No adverse effects of intervention or procedure	No study variables	No statistical analyses	Identification of barriers to recycling include space for a recycling bin, potential infectious risk if providers don't follow the proper organization of waste

					stream.					
Medical Waste in the Environment: Do Anesthesia Personnel Have a Role to Play? (Goldberg et al,1996)										
To conduct a feasibility study of the mechanics of recycling single-use anesthesia breathing systems and practices of anesthesiologists and nurse anesthetists in a tri-state region.	Two-part, open, prospective analysis using pre-printed questionnaire and cost-time analysis of labor and materials	Anesthesia departments in PA, NJ, and Delaware	No approval discussed although questionnaire was completed by providers involved in the study	Cost-time analysis of breakdown of single-use breathing circuit only examines the effectiveness of breaking down this ONE type of circuit – many types exist and some are more complex than others with potential for non-recyclable components	Breathing circuits were collected and sent to a laundry facility where they were broken down to evaluate time/cost relationship or benefit. A survey was distributed to anesthesia providers to determine willingness to participate in a recycling program if one was offered.	Outcomes measured were cost of disassembly of the breathing circuits → showed a potential savings of over \$4,000 in a year's time. Survey outcomes were measured with a questionnaire.	No adverse effects of the interventions	Study variables were type of breathing circuit chosen for the study.	Anova and Kruskal-Wallis tests	The disassembly program proposed is economically feasible and has many cost benefits. The questionnaire found that many anesthesia providers are concerned about environmental benefits of recycling but wouldn't participate in a program unless legally mandated.
Recycling plastics from the operating suite (McGain, F., Clark, M., Williams, T. & Wardlaw, T., 2008)										
Identification of types of plastic to be recycled and contacted within patient care by an anesthesia provider as well as identification of barriers to recycling.	Pilot study to determine potential savings of increased recycling	OR "theatre" staff were targeted for one year in a small Melbourne Australia hospital.	No approval discussed	Extraneous variables were the different types of plastic considered within the study, potential for contamination of materials, etc.	Intervention: Agreement was reached with local plastics recycling company willing to accept used plastic materials from the OR and these were collected for one year	Cost and environmental savings over the study period of one year.	No adverse effects of the study. Staff did not experience delays between cases due to the new recycling initiative.	None	None discussed.	Good information about the prevalence of plastics capable of being recycled within the OR and identification of barriers to recycling such as different types of plastic, infection concerns, etc. Shows improvement in participation when staff is educated properly.

Medical Plastics Recycling in the OR (Practice Greenhealth, 2011).										
Purpose of this module is to list steps useful in designing a new recycling initiative for a hospital/operating room setting	Suggestion for practice, not a study.	Operating room staff are targeted as well as administrators interested in developing a system for recycling	No approval discussed.	None	Steps 1-10 of how to develop and evaluate the effectiveness of a new recycling program	No outcomes measured	No adverse effects of the study	None	None	Great tips to ensure success of a new program as well as things to look out for when putting a new program together.
Hospicycle: A plastics recycling guide for hospitals (HPRC, 2013)										
Purpose of this compilation is to serve as an outline for development of a new plastics recycling program – many links provided for administrators	Suggestion for practice, not a study.	Operating room staff and administrators who are involved in development of a new program.	No approval discussed.	None	Outlines steps to take before beginning, as well as links useful in determining commitment to sustainability, economic analysis, infrastructure of the program, waste characterization, the importance of choosing the right recycling partner, and how to run a successful program.	No outcomes were measured since this is a suggestion for practice	No adverse effects of the study	None	None	Good for outlining how to set up a new program
Analyses of the recycling potential of medical plastic wastes (Lee, B.K., Ellenbecker, M., Moure-Eraso, R., 2001)										
Purpose is to analyze the recycling potential of plastic wastes generated by health care facilities.	Collection of materials and evaluation of type of plastic, amount of each type,	Five Massachusetts hospitals – all areas of recycling were considered, not just ORs	No approval discussed	None	Collection of materials in the ambulances, ORs, cafeterias, etc to compare amount and type of plastics capable of being recycled.	Outcomes measured were waste characteristics, components of waste, cost of disposal of waste, and collection from the ORs compared with	No adverse effects of the study	Types of plastic collected 5 area hospitals involved -Unable to compare to other studies	Unknown	Identified the major risk of recycling as spread of infection

						ambulan ces, cafeteria s, and other areas of the hospital.				
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Appendix B: Email to Anesthesia Staff

Dear Anesthesia Colleagues,

Hello! We are sending this email to notify you of the recycling project we are working on as part of our graduation requirements at NorthShore. Our clinical time here has alerted us to inconsistencies in recycling practice at Evanston and we would like to know whether or not anesthesia providers are more willing to recycle when they are provided with a conveniently placed receptacle.

Over the next weeks we will provide plastic bags on the side of each anesthesia cart in the morning; these bags will be collected each afternoon at 4pm. **DO NOT DISPOSE OF THESE BAGS!! THEY ARE TO BE USED FOR DATA COLLECTION!!**

Please **DO** use these bags to recycle packaging and equipment. A comprehensive list of recyclable materials is attached and this list will also be available to use as a reference on anesthesia carts.

Here are some general guidelines for recycling:

DO recycle

- All plastics packaging, including syringe/ETT/IV fluid packaging, etc.? **YES!**
- IV tubing that is **NOT** contaminated with biohazardous materials (ie. blood)? **YES!**
- Any other plastic peel-back from materials packaging? **YES!**
- Paper without waxy film? **YES!**
- Used Anesthesia Circuit? **YES!**
- Paper **INSIDE** nasal cannula package? **YES!**
- Empty glass drug vials? **YES!**
- Empty IV Bags themselves? **YES!**

DO NOT recycle

- Paper with waxy film? **NO** -- if you can't tear the paper, you can't recycle it!
- Nasal Cannula plastic packaging? **NO**
- #6 plastic items (will have # on them)? **NO**
- Glass vials containing drugs? **NO**

Thank you in advance for your participation!

Sincerely,

Alaina Becker, SRNA, Class of 2016
Brittany Schuler, SRNA, Class of 2016

NorthShore Anesthesia Cart: Items by Drawer**1: MEDICATIONS**

YES	NO
Plastic back of black rubber syringe cap package	Paper portion of black rubber syringe cap package
Glass vials/ampules with <3% med remaining	Glass vials containing >3% of med

2: SYRINGES/IV CANNULAS

YES	NO
Plastic portion of syringe wrapper	Paper on syringe packaging
Plastic portion of needle wrapper	Paper on needle wrapper
Entire 20cc syringe wrapper	
Plastic portion of IV catheter package	Paper on IV catheter package

3: AIRWAY ACCESSORIES

YES	NO
Oral airway wrapper/package	Paper with waxy film
Plastic bags covering extra blades	
Plastic breathing circuit (not contaminated with blood)	

4: ETTs/STYLETS

YES	NO
Plastic portion of ETT package	Paper on ETT package
Plastic portion of Stylet wrapper	Paper portion of stylet wrapper

5: NGTs/BLUE TOWEL/TEMP PROBES

YES	NO
All plastic from NGT package	Contaminated NGT itself
Clear plastic from temp probe wrapper	Temp probe itself
Entire 60cc syringe wrapper	

6: IV FLUIDS

YES	NO
IV bag outer package	
IV bag itself (without fluid, non-contaminated)	
IV tubing, non-contaminated w/ blood	
Clear plastic from IV tubing packaging	

Appendix C: Figures & Tables

Figure 1:

Email to anesthesia staff posted
on wall above cart



Receptacle placed on left side of
cart for collection

