CERTIFIED REGISTERED NURSE ANESTHETISTS' DISPOSAL PRACTICES OF RECYCLABLE SOLID WASTE IN THE OPERATING ROOM: AN EXPLORATION OF PRACTICE

A Scholarly Project
submitted to the Faculty of the
Graduate School of Arts and Sciences
of Georgetown University
in partial fulfillment of the requirements for the
degree of
Doctor of Nurse Anesthesia Practice

By

Tina Kushnir, B.S.N.

Washington, DC
April 4th, 2020

CERTIFIED REGISTERED NURSE ANESTHETISTS' DISPOSAL PRACTICES OF RECYCLABLE SOLID WASTE IN THE OPERATING ROOM: AN EXPLORATION OF PRACTICE

Tina Kushnir, B.S.N.

Thesis Advisor: Crystal O'Guin, DNAP

ABSTRACT

Over the past 30 years excess hospital waste has turned into a significant environmental problem. U.S. hospitals generate over 5.9 million tons of waste annually[5,9,12] with operating rooms contributing to 20-33% of all hospital waste.[1,12] Although some operating rooms recycle plastic bottles, paper, and 'blue wrap;' U.S. hospitals are not obligated to recycle by law, thus, recycling is not standard practice in the U.S. Recycling programs have been shown to be both environmentally and financially beneficial for hospitals.

Studies have been conducted that explored recycling practices of physician anesthesiologists in the U.S and abroad. However, no study to date has explored recycling practices of Certified Registered Nurse Anesthetists – the largest anesthesia provider workforce in the United States. This survey study was emailed to a random sample of 3,000 members of the American Association of Nurse Anesthetists. A total of 292 Certified Registered Nurse Anesthetists of 3,000 responses were analyzed, a 9% response rate. Of the survey respondents, 40% recycled in their operating room. Of the survey respondents that had a formal recycling protocol at their medical facility, 83% did not recycle in their operating room and over 80% disposed of various plastic potentially recyclable items in the trash bin. Questions about the availability of recycling bins found limited amenities available in operating rooms. Of survey respondents, 16% had a recycling bin in their operating room. Conclusions from the study

include that limited recycling amenities are available in operating rooms, and there is limited information provided to staff about intraoperative recycling.

The research and writing of this thesis
is dedicated to everyone who helped along the way.

Many thanks,
Tina Kushnir

TABLE OF CONTENTS

Chapter 1 Introduction 1

Problem Statement 2

Purpose of Study 2

Research Questions 2

Definitions 3

Chapter 2 Review of the Literature 5

Municipal Solid Waste 6

Incineration and Landfills 8

The Case for Recycling 10

Potential Recyclables 12

Barriers to Recycling 12

Summary 16

Chapter 3 Methodology 17

Research Design 17

Sample 18

Instrumentation 19

Procedure 20

Data Analysis 22

Protection of Human Subjects 22

Chapter 4 Findings 24

Sample 24

Research Question 1 26

Research Question 2 31
Summary 35
Chapter 5 Discussion 37
Limitations 40
Implications 41
Future Recommendations 42
Appendix A: Citi Program: A Collaborative Institutional Training Initiative 43
Appendix B: Raosoft Sample Size Calculator 44
Appendix C: Informed Consent Script 45
Appendix D: Recycling in the Operating Room (OR) Assessment Tool 47
Appendix E: Institutional Review Board Permission Letters 51
References 54

LIST OF FIGURES

Figure 1. Items Recycled by CRNAs in the Operating Room 28

Figure 2. Types of Plastic Items Recycled by CRNAs in the Operating Room 29

Figure 3. Items Disposed of in Trash Bins 29

Figure 4. Perceived Barriers to Recycling in the Operating Room 34

LIST OF TABLES

Table 1. Demographics of CRNA Research Participants 25

Table 2. CRNA Recycling Practices vs. Presence of Hospital-Wide Recycling Protocols.....27

Table 3. CRNA Recycling Practices vs. Presence of Recycling Amenities 30

CHAPTER 1

Introduction

Hospitals generate over 5.9 million tons of waste annually, with operating rooms (ORs) producing 20-30% of a medical facility's total waste.[1] The literature available states that over 70% of hospital waste may be recyclable and is often improperly incinerated or buried in landfills.[1,2,3] Studies have shown that operating rooms are a top generator of hospital waste and that over 40% of operating room waste may be recyclable.[4] The recent spotlight on climate change and environmental sustainability has shifted hospital focus to curbing waste production. Studies have shown that anesthesia providers may play a significant role in the disposal of recyclable waste in the operating room – a method of improving hospital environmental sustainability and reducing hospital costs.[4,15,17,36]

This study will contribute to the body of evidence-based research that supports recycling initiatives in operating rooms and helps foster environmentally sustainable hospital practices. It will advance the Certified Registered Nurse Anesthetist (CRNA) profession by positioning CRNAs as leaders in their field. CRNAs will have the opportunity to lead the development of environmentally sustainable hospital initiatives and reduce the negative environmental impacts of their anesthesia practice.

Problem Statement

Operating rooms are a major source of hospital waste and the majority of operating room waste may be recyclable. As part of the operating room team, anesthesia providers may play a significant role in the disposal of recyclable solid waste in the operating room – a method for improving hospital environmental sustainability and reducing hospital costs. Studies have been conducted that analyze recycling views and practices of physician anesthesiologists. However, no research studies have been conducted that examines the disposal practices of CRNAs' in the operating room and what barriers may prevent CRNAs from recycling in the operating room.

Purpose of Study

The purpose of this study is to examine Certified Registered Nurse Anesthetists' (CRNA) current disposal practices of recyclable solid waste in the operating room. This study will also identify barriers that exists that prevent CRNAs from recycling in the operating room.

Research Questions

The research questions for this study are:

1. What are CRNAs' current disposal practices of recyclable solid waste in the operating room?
2. What barriers exist that prevent CRNAs from recycling in the operating room?

Definitions

For the purpose of this study, the following terms and definitions were used.

Conceptual/Theoretical Definitions

1. Certified Registered Nurse Anesthetists' disposal practices of recyclable solid waste: The actions and habits of Certified Registered Nurse Anesthetists in sorting recyclable solid waste items into various, specific, recycling amenities such as plastic, paper, cardboard, and glass bags or bins. Recyclable solid waste includes disposable solid waste that has the ability to be recycled such as plastic, paper, cardboard, and glass. Recyclable solid waste in the operating room may include plastic wrapping and packaging materials from medical equipment, plastic syringes, plastic IV bags, plastic oxygen tubing, 'blue wrap,' 'Tyvek – a plastic fiber,' plastic basins, plastic anesthesia drug trays, glass bottles, cardboard, and paper. Disposal practices may include instructions on how to sort recyclable solid waste into recycling amenities. Recycling amenities in the operating room include specific bags or bins used to sort and dispose of various types of recyclable solid waste such as plastics, paper, cardboard, and glass. Disposal practices may also include 'sustainable effort' initiatives or 'green taskforce' programs to incentivize and encourage employees to recycle.
2. Barriers to recycling: Barriers to recycling are defined as obstacles that prevent Certified Registered Nurse Anesthetists from recycling. These may include a lack of recycling amenities, costs incurred by recycling, inadequate information about recycling policies, lackadaisical attitudes about recycling practices by staff, a lack of

time to recycle, a lack of education about recycling practices, and negative attitudes by hospital administrators.

Operational Definitions

1. Certified Registered Nurse Anesthetists' disposal practices of recyclable solid waste: Certified Registered Nurse Anesthetists' disposal practices of recyclable solid waste will be assessed through select all that apply, yes/no/don't know and Likert scale questions on the Recycling in the Operating Room (OR) Assessment Tool.
2. Barriers to recycling: Barriers to recycling will be assessed through five yes/no/don't know, and select all that apply questions to the Recycling in the Operating Room (OR) Assessment Tool to determine what prevents Certified Registered Nurse Anesthetists from perioperatively recycling.

CHAPTER 2

Review of Literature

In 2001, the United Nations Intergovernmental Panel on Climate Change (IPCC) declared that the Earth's warming temperatures over the past 50 years were caused by human activities.[5-6] Various organizations such as the IPCC, the World Health Organization (WHO), and the U.S. Environmental Protection Agency (EPA) have pointed to greenhouse gas emissions as a key contributor to global warming and to climate change.[6-8] More recently, climate change has been linked to various public health disasters such as large wildfires, draughts, famine, and the spread of infectious disease.[1,6-8]

Although meant to be a place of healing, hospitals are a major source of greenhouse gas emissions and environmental degradation. Hospitals overconsume energy and water; they use vast amounts of disposable medical products that contribute to waste production; and they also dispose of their waste in landfills and incinerators emitting toxins into the air, soil and water.[9-11] The U.S. is the 2nd largest emitter of greenhouse gases globally[8] with its healthcare sector accounting for over 8% of the total greenhouse gas emissions in North America.[1] U.S. hospitals generate 5.9 million tons of waste annually[5,9,12] with operating rooms (ORs) contributing to 20-33% of this hospital waste.[1,12] Over the past 30 years, excess hospital waste production has turned into a significant problem.[9] Over 70% of hospital waste is incinerated or sent to landfill, contributing to greenhouse gas emissions.[1-2,9] Most of this waste includes food packaging, glass, plastic, and paper – many items that are potentially recyclable.[9] Likewise, most waste generated

in the operating room (OR) includes plastic and paper packaging that maintains the sterility of medical supplies. Over 40% of OR waste is potentially recyclable.[7]

In 1992, a historic, quantitative and qualitative study was conducted assessing surgical waste in the operating room. Researchers found that 75% of operating room waste was potentially recyclable.[13] Similarly, a 2009 waste audit of 6 operating rooms at a university affiliated hospital in Melbourne, Australia found over 60% of general waste was recyclable.[15] Researchers noted approximately 50% of OR waste was plastic products generated by anesthesia providers.[15] Finally, a 2012 analysis on decreasing waste in Canadian hospital operating rooms found the major contributor to OR waste was plastic packaging as most surgical and anesthesia products are packaged in paper and/or plastic.[16]

Although some operating rooms recycle plastic saline bottles, paper, plastic trays and 'blue wrap' (material used to wrap sterilized equipment), the U.S. Department of Health and Human Services offers little guidance for ecologically sustainable waste disposal practices[1]. U.S. hospitals are not obligated to recycle by law thus, recycling is not standard practice in the U.S.[17]

This literature review examines current CRNA recycling practices in the operating room and the barriers that exist that prevent CRNAs from recycling.

Municipal Solid Waste

Municipal solid waste (MSW), otherwise termed garbage, is defined as unusable or unwanted material that is discarded after use. MSW includes food, packaging, furniture, yard trimmings, and electronics.[18] Sources of municipal solid waste includes businesses, schools, and hospitals (EPA). In 2017 approximately 268 million tons of MSW was generated in the U.S. Of

this, 67 million tons (25%) was recycled, 33 million tons (12%) was incinerated, and 137 million tons (51%) was buried in landfills.[18-19] Of the recycled MSW, paper and cardboard accounted for the majority (65.7%) of MSW. Glass followed with 4.5% of MSW and plastics with 4.4% of MSW. Of the MSW buried in landfills, food accounted for 22%, plastics for 19.2%, and glass for 4.9%.[18-19]

MSW collected from hospitals is typically divided into two categories: general waste, otherwise known as non-regulated medical waste; and clinical waste, referred to as regulated medical waste (RMW). [21-22] General waste does not require special processing prior to burial in landfill. Regulated medical waste (RMW) on the other hand, is potentially infectious due to contamination by blood or bodily fluids, sharps, radioactive material and/or pharmaceuticals. RMW requires special processing prior to burial in landfill that may include incineration, autoclaving, chemical processing or sterilization.[21-22]

The majority of RMW generated in the operating room often consists of disposable surgical supplies. In a 2017 case report that audited segregated RMW in operating rooms at the Iha University College of Medicine in Incheon, South Korea, researchers found that many items incinerated along with RMW included plastic, paper and cardboard – items that were recyclable.[21] According to the Center of Disease Control and Prevention, only 2-3% of total hospital waste should be disposed of as clinical waste or RMW.[1] This is a significantly smaller figure than the amount of RMW that is normally generated in hospitals.[1] Unfortunately, many facilities inappropriately dispose of recyclables and general waste in 'red bags,' otherwise termed, clinical waste.

The average cost of incinerating RMW is approximately 6-10 times more than processing RMW.[2,23] A 2011 prospective study of RMW in operating rooms demonstrated the cost of

processing clinical waste in an academic medical center was 24.5 cents/pound as opposed to 4 cents/pound for general waste.[23] After implementing of a segregation program to separate recyclable waste from RMW, researchers decreased their disposal costs from $151,442 per month to $105,930, saving a total of $45,512 for the hospital.[23]

Incineration and Landfills

Incineration of RMW destroys biohazardous or infectious waste through burning. Although incineration remains a popular waste disposal method, it emits greenhouse gases such as CO2, mercury, dioxins and furans into the atmosphere.[16,18,24] The EPA once considered RMW incineration to be the second largest source of dioxins, a known carcinogen into the environment.[21] Today, incineration is used to manage 7-19% of MSW generated in the U.S. at 'waste-to energy' facilities where energy is extracted from the burning of MSW.[18-19,24] In 1998 the EPA published a report exposing medical waste incineration as a major source of toxic air emission in the U.S.[9] Today, the incineration of waste is the fourth largest releaser of mercury into the atmosphere.[24] CO2 and mercury emissions from the incineration of waste has risen 34% since 1990.[24] Mercury emissions from the incineration of waste are carried by winds into soil and water systems. Mercury then enters the food chain and becomes concentrated in fish. Mercury has been shown to damage the nervous system,[24-26] while exposure to dioxins and furans, also released from the incineration of waste, has been linked to hormonal alterations, infertility, and decreased fetal weight.[16]

Aside from incineration, the most popular waste disposal method in the U.S. is the burial of MSW in landfills. Every year, approximately 220 million tons of MSW is buried in landfills.[19]

Decomposing garbage in landfills releases methane and CO2 – potent greenhouse gases into the atmosphere. In 2016, landfills accounted for 16.4% of methane emissions, the third largest emitter of methane in the U.S.[24] Methane (CH_4) is 25 times as effective as CO2 at trapping heat in the atmosphere contributing to greenhouse gas emissions and warming Earth's temperatures.[18,24]

According to the EPA, greenhouse gases such as CO2, methane, nitrous oxide, fluoride, chlorine and bromine, are byproducts of human industrial activities.[7,18-19] When released into the air these gases absorb the energy radiating from Earth, trapping heat in the atmosphere and warming Earth's temperatures.[7] The last 30 years have each been the warmest decades on Earth since 1850.[6-7] Average temperatures in the U.S. are expected to increase about 2.5 degrees F over the next few decades regardless of future greenhouse gas emissions.[7] The warming of Earth's temperatures is consistent with the recent extreme weather events humans are seeing around the world. Heavy floods, draughts, and large wildfires are increasing in frequency; glaciers, rivers and lakes are disappearing; and there have been vast disruptions of wildlife habitats.[1,6-8]

The financial cost of sending waste to landfill has been steadily increasing an average of 1% per year since 2004.[18] The difference in monetary fees correlates with landfill capacity and fluctuates between various regions of the U.S. For example, areas with vast space for landfills such as Texas, Montana or Nevada charge an average of $48.27/ton of MSW; while areas in the northeast charge double at $74.75/ton.[18]

The Case for Recycling

Currently, hospitals are increasingly utilizing disposable medical supplies, thus generating more waste which eventually ends up in landfills or incinerators.[5] Landfill sites are reaching capacity and as of January 2018 China stopped importing recycling from foreign nations.[14] Legislation such as the landfill tax in the UK are making it more expensive to dispose of waste in landfill.[27] As burying and incinerating waste becomes increasingly more expensive and citizens become more environmentally conscious, hospitals are seeking environmentally sustainable and cost- effective means of waste disposal. Recycling programs have been shown to be both environmentally and financially beneficial for hospitals.

Recycling cuts down on waste that's sent to landfill and incinerators. It conserves natural resources such as water, and wood.[29,30] Likewise, recycling saves energy by creating new commodities from reprocessed materials. This process requires less energy input than making new products from scratch.[28-30] In 2001, the EPA conducted a national recycling 'life-cycle' assessments calculating the energy consumed from the time a potentially recyclable product was picked up until it was manufactured into a new product.[28] Recycled plastic bottles use 76% less energy to manufacture from recycled materials than to produce from scratch.[28-29] Newspapers use approximately 45% less energy and can be remanufactured into new products four to six times over.[20] Recycling minimizes the need to manufacture new products and reduces the volume of waste that ends up in landfills and incinerators. According to the EPA, the amount of waste that was recycled and composted in 2017 is equal to the amount of emissions reduced by taking 39 million cars off the road for one year.[18] A 2013 study that implemented a green committee to reduce OR waste at the Carolinas Medical Center in Charlotte, demonstrated a 65%

reduction in OR waste by converting to reusable products.[2] Researchers noted that switching to reusable materials in the operating room could potentially divert 25 tons of medical waste from landfills annually, saving thousands of dollars by reducing the volume of waste produced.[2]

Aside from helping conserve natural resources, recycling is also an important driver of the U.S. economy.[28] In the 2019 the EPA found that in a single year recycling accounted for the addition of 757,000 jobs, $36.6 billion in wages, and $6.7 billion in tax revenues.[28] Recycling programs are financially beneficial for hospitals because they decrease the volume of waste disposed and thus, the cost of waste disposal. A 2012 case study on sustainability initiatives in the operating room cited the cost of recycling operating room plastic was approximately half of that of disposing of general waste ($68/ton for plastic vs $12/ton for general waste).[16] Likewise, a 2018 implementation of a sharps recycling program at a surgery center in Paradise Valley, yielded a 10% cost savings for waste disposal. According to researchers, extrapolating these savings over 1 year would result in $820 savings for 3 operating rooms while instituting such an initiative at a large facility such as the Mayo Clinic could potentially result in $33,000 savings per year.[31] Similarly, a study by Reidel and colleagues, demonstrated that implementing a recycling program at Mercy Mt Airy Hospital in Cincinnati, Ohio saved the hospital $4,672.[30] Finally, a 2016 quality improvement project introducing a recycling program at the Princess Alexandria Hospital in Queensland, Australia reduced waste disposal costs by 60% and saving the facility $7,600 AUD ($5,790 USD).[20] The data reflects a financial incentive for increasing recycling initiatives in operating rooms. As the cost of burial in landfill increases and the healthcare industry moves toward decreasing its environmental impacts, alternate sources of waste disposal such as recycling will become essential.[27]

Potential Recyclables

The operating room is rife with recyclables. Recyclable waste generated in the operating room that can be recycled includes plastic (IV fluid bags, bottles, oxygen masks and tubing), paper, linen, glass, metal, cardboard, and surgical 'blue wrap.' Plastics form approximately 50% of operating room waste generated by anesthesia providers[15]. Equipment used by anesthesia are typically wrapped in plastic or paper packaging that maintains the sterility of medical supplies. The majority of this waste is potentially recyclable.[16] The operating room also generates a plethora of cardboard from packaging, glove boxes, and equipment boxes.[8] Cardboard is fully recyclable as long as it remains dry.[8] Operating room generated plastics often end up in landfills rather than recycling due to poor waste segregation.[33]

Multiple studies corroborate that over 50% of waste generated in the operating room is potentially recyclable.[14-15,34,35] A 2009 audit of potentially recyclable operating room waste demonstrated that 60% of waste generated by anesthesia providers was potentially recyclable[15]. Likewise, a 2017 audit of operating room recycling showed 67% of OR waste was recyclable paper and cardboard[27]. A paper by Tieszen and Gruenberg, found that operating room waste could be reduced by 93% by segregating linen, paper and plastic by recycling[13].

Barriers to Recycling

The literature addresses various barriers that prevent hospital staff from recycling in the operating room. Numerous surveys across the U.S., United Kingdom, New Zealand and Australia show that staff attitudes towards recycling in the operating room depend on the

individual's interest and practice of recycling at home.[17,23,36] In a 2018 survey of recycling perceptions on four Mayo Clinic campuses, researchers reported that participants were concerned about the amount of garbage that was produced at their medical facilities and had positive attitudes towards recycling.[31] Although over 89% of survey respondents reported recycling at home, they indicated that they recycle less than 25% of waste generated in the operating room.[31] Likewise, in a 2012 survey of anesthesiologists (n=780) in Melbourne, Australia, over 90% of respondents reported recycling at home, and over 90% expressed desire to recycle in the operating room.[4] However, only 11% of respondents reported recycling programs were implemented at their medical facilities.[15] Similarly, in a 2016 survey of American anesthesiologists (n=2036), 81.4% of respondents reported recycling at home, 80.1% stated they wished to recycle in the operating room, and 27.7% responded they recycled at their workplace.[36] Although these studies show a desire to recycle in the workplace, the data is at odds with the low rates of recycling practices in operating rooms.

Another barrier to recycling addressed in the literature was the limited information and education provided about recycling and environmental sustainability efforts. In a 2015 random sample survey emailed to members of the American Society of Anesthesiologists (ASA) (n=2036), the majority of respondents (67%) surveyed reported there was insufficient information about how to recycle in the operating room.[36] Likewise, in a 2012 survey of anesthesiologists' attitudes towards operating room recycling in Australia, New Zealand, and England (n=780), researchers reported that the greatest barrier to recycling was staff education and motivation.[4,14] Similarly, in a 2015 study conducted in operating rooms at the University of Pittsburgh Medical Center (n=53), researchers cited a general lack of knowledge surrounding waste disposal policies and environmental initiatives by hospital staff[37]. A survey of hospital

staff in Saudi Arabia also pointed to a broad lack of awareness about generated waste and waste disposal policies.[38] Likewise, in 2018 Azous & colleagues conducted a survey and cost- savings analysis program that was implemented on 4 Mayo Clinic campuses. It showed that 56.7% of respondents were unclear about which OR items to recycle and 47.7% thought the greatest barrier to recycling was a lack of knowledge.[31]

The handling of infectious or contaminated materials and the concern for cross-contamination of waste also permeates in the literature. One of the biggest barriers to recycling remains a concern about infectious cross contamination in the recycled bins.[15] In a 2012 qualitative survey of anesthesiologists from Australia, New Zealand, and England (n=780), researchers reported that only 43.8% of anesthesiologists answered correctly when asked what items were appropriate to place in the red clinical waste bin or RMW bin.[3-4] The authors' audit of OR recycling showed similar results when the majority of survey respondents incorrectly (56.2%) assumed that anything that had come into contact with a patient or had a drop of blood on it was to be placed in red waste bags.[15] Likewise, a 2015 audit of operating rooms at the University of Pittsburgh Medical Center (n=53), indicated that staff wrongly placed recyclable materials such as IV fluid bags into RMW or 'red bag' waste due to concern for infection.[37] Although these assumptions are unfounded, they prevail in the literature. Over 90% of red bag or RMW waste doesn't meet criteria for red bag waste.[39] Common items mistakenly disposed of in red bags include IV fluid bags, vent tubing, and urinary catheter foleys.[39] According to McGain and colleagues, in actuality there is minimal cross contamination of infectious material and over 60% of RMW waste can be recycled with proper education.[15]

Another barrier to recycling cited in the literature was the challenge of instituting hospital wide 'environmental sustainability' or 'green initiative' programs.[2,36,40] Hubbard et al. identified

a lack of hospital environmental initiatives as a significant barrier to waste reduction.[37] In a 2010 article on environmental sustainability, authors cited difficulty in changing hospital culture without directed leadership from hospital administration.[40] Similarly, in a 2015 random sample survey of the ASA (n=2036), anesthesiologists specifically noted inadequate hospital leadership concerning environmental initiatives.[36] Only 12.6% of the anesthesiologists surveyed in the study indicated that hospital administrators encouraged recycling initiatives and only 18% of respondents reported there were 'green initiative' or environmental sustainability programs implemented at their medical facilities. According to authors, the biggest barrier to recycling was not attitudes held by staff, but hospital administrators reluctant to change facility culture.[36]

Prior studies have also suggested that the success of environmental hospital programs depend on committees composed of a diverse staff – a combination of physicians, nurses, techs, and administrators.[2,9,40] In 2013 researchers at the Carolinas Medical Center in Charlotte, NC formed a 'Green OR Committee' aimed to reduce operating room waste through a recycling program.[2] They composed their committee of surgical staff, residents, research personnel, nursing, and environmental services personnel.[2] Results from the study found that involving multiple stakeholders from various hospital sectors fostered an environmentally conscious culture which translated into practice.[2,40] According to researchers, changes in hospital culture must occur at both the administrative and organizational levels to translate into widely accepted hospital practice.[40] Patients are quickly becoming better informed about environmental issues and hospitals are becoming aware of the benefits of marketing themselves as 'green' or ecologically conscious.

Other barriers to recycling noted in the literature included a lack of recycling amenities, lackadaisical attitudes about recycling by staff, a lack of time to recycle, and negative attitudes

by hospital administrators.[15] In the 2015 random sample survey of the ASA (n=2036), only 18% of anesthesiologists reported there was a 'green task force' in their hospital[36]. Authors discussed the need for greater attention to environmental issues in anesthesia literature and a need to incorporate environmental education into medical education[36]. The lack of education in medical and nursing school curriculums is also discussed in Kaiser's 'Solutions to healthcare waste: life-cycle thinking and green purchasing' analysis and points to medical providers lacking environmental health knowledge when choosing health care products for their patients.[41]

Despite the barriers to recycling noted in the literature, numerous successful environmentally sustainable and cost-effective recycling programs have been implemented in medical facilities around the world. Successful operating room recycling programs in the U.S., Australia, New Zealand, and U.K. have been shown to be both environmentally and financially beneficial for hospitals.

Summary

Numerous studies cite the environmental and financial benefits of recycling in operating rooms. Although data exists reflecting the views and recycling practices of anesthesiologists in the operating room, the literature is void of data about Certified Registered Nurse Anesthetists (CRNA's) recycling practices. CRNA's annually administer 43 million anesthetics in operating rooms across the U.S., however there is no research to date that analyzes their recycling practices, and the barriers that exist which prevent them from recycling in the operating room.

CHAPTER 3

Methodology

This chapter outlines the methodology that was used to answer the following research questions: (1) What are CRNAs' current disposal practices of recyclable solid waste in the operating room? (2) What barriers exist prevent CRNAs from recycling in the operating room? The methodology outlined in this chapter discuss the instrumentation, procedure, data analysis, and protection of human subjects used to conduct this study. The study hypothesized that CRNAs have limited access to recycling amenities in the operating room, thus, CRNAs often dispose of all anesthesia waste in one single trash bin close to their workstation. It is also hypothesized that facility culture, education, and a facility wide environmental sustainability program plays a significant role in OR recycling practices.

Research Design

This study was conducted using an exploratory, descriptive quantitative research design which will evaluate CRNAs' disposal of recyclable waste. This methodology examined CRNAs' disposal practices of recyclable waste in operating rooms and barriers that prevented CRNAs from recycling in operating rooms.

Sample

The population for this study was active CRNA members of the AANA, the professional organization for nurse anesthetists. Currently there are 44,611 active CRNA members in the American Association of Nurse Anesthetists (AANA). From this population, the AANA Research Surveys Services and Assistance Department carries out a systematic randomized sample of CRNA participants from their database of 44,611 active CRNA members. This selection was based on computer generated numbers with a uniform distribution. There was equal probability of getting any one randomly selected member as another. The inclusion criteria for this study was active, board certified or recertified CRNA members of the AANA. The exclusion criteria for this study was currently non-practicing CRNAs or Student Registered Nurse Anesthetists (SRNAs). Also excluded were members who opted out of mass email communication from the AANA.

Using the Raosoft Inc. software to obtain a power analysis, the recommended sample size for this study was 377 subjects. The power analysis was obtained using a 5% margin of error, a 95% confidence level, a population size of 44,611, and a response distribution of 50%. According to the AANA, typical email surveys generate a response rate of 3-7%. Thus, to ensure a sample size of 377 subjects with a 5% response rate, the survey data tool would have been sent to 7,540 members. The maximum number of mailings by the AANA was 3,000, which was a limitation to the study.

Instrumentation

Data collection for this study was conducted using the 'Recycling in the Operating Room (OR) Assessment Tool,' developed by the study's researchers (See Appendix D). The survey tool contained 20 questions divided into two sections. The first section contained five questions about study participants' demographics. The second section contained fifteen questions about study participants disposal practices of recyclable solid waste in their medical facility's operating room and barriers to recycling in the operating room. The survey questions ranged in format and included multiple choice, yes/no/I don't know, and select all that apply questions. There were ten questions that addressed study participants disposal practices and five questions that addressed barriers to recycling. The instructions for the survey were outlined in the beginning of the data tool and the survey took approximately five minutes to complete.

Five content experts evaluated this data tool for content and validity. Experts included were two CRNA professors of the Doctorate of Nurse Anesthesia Practice program at Georgetown University, each with over ten years of clinical and teaching experience. The third expert was a PhD professor at Georgetown University's School of Nursing who is a scholar and researcher in environmental health and public health. The fourth expert was a biomedical science expert and researcher at the U.S. Department of Defense. The fifth expert was a statistician and researcher at Georgetown University's Department of Human Sciences.

Procedure

After IRB approval, the researchers applied to the AANA Research Surveys, Services and Assistance Department to send the survey tool to its members. Documents in the application included a cover letter with a consent script (see Appendix C), the official IRB approval letter (see Appendix E), and the research methodology including the data collection tool 'Recycling in the Operating Room (OR) Assessment Tool' (see Appendix D). The data collection tool was formatted by the AANA using *SurveyMonkey,* a secure data platform tool and survey link. This hyperlink was electronically emailed to randomly selected survey participants which were members of the AANA. These randomly selected participants received an email with the cover letter and consent script. If they chose to participate, they clicked a hyperlink to the secure online data survey tool.

The cover letter (see Appendix C) contained the purpose of the study, instructions on how to complete the survey, and the consent manuscript ensuring informed consent of the study participants. Clicking the hyperlink to access the survey implied consent. Study participants were informed there were no risks or benefits associated with participating in the study and they would not be penalized if they chose to opt out of the study. Study participants were informed that they could withdraw from the study at any time prior to submission of the data collection survey tool. However, once the data was submitted through *SurveyMonkey* the data could not be withdrawn from the study. The cover letter also notified participants that the data collection survey tool was accessible for up to two weeks through *SurveyMonkey* and that the survey would take approximately five minutes to complete. A reminder email was sent to study participants

after seven days before the survey closed to all non-respondents and respondents who did not finish the survey.

The survey was accessible for two weeks. A reminder email was sent to study participants seven days before the survey closed. The AANA emailed an electronic reminder to study participants approximately seven days prior to the survey deadline. This reminder was sent through the same secure, encrypted hosting network that provided encryption for the original email, cover letter, and data collection survey tool. After completion of the data collection survey through SurveyMonkey, study participants clicked submit to verify completion. An automated thank you note was generated on the screen to inform participants that they had completed the survey. After submission of this data collection survey, study participants did not have access to the survey again. Study participants could not change answers once the survey was submitted since no participant identifiers were recorded. Partially completed surveys were not counted towards the data analysis. All data gathered for the study was taken from completed surveys only.

Neither Georgetown University, nor the AANA, had access to study participant information. The AANA formatted the survey data results in Excel spreadsheets and delivered these to researchers electronically. These Excel spreadsheets contained no identifying study participant information. Excel files were secured on a password protected personal computer only the principle researchers could access. Data will be stored for 3 years per IRB guidelines.

Data Analysis

This section contains information regarding the statistical tests performed. Statistical tests performed included Chi square, and Fisher's Exact tests.

Protection of Human Rights

Permission to conduct this study was granted by Georgetown University's Institutional Review Board (see Appendix E). The Georgetown University IRB required all researchers to be certified in the Collaborative Institutional Training Initiative (CITI) Human Resources Curriculum (see Appendix A). The AANA's research department, who deployed the survey to participants in this study reviewed and approved the data tool, the cover letter, survey agreement, survey order form for protection of participants, and authentication that research participant's email addresses was kept confidential. All participants' contact information was kept confidential by the AANA. The survey tool was emailed to a randomly selected, computer generated sample of AANA members. Members that opted out of mass e-mail communication from the AANA were not included. Their responses remained anonymous. The AANA achieved this anonymity by periodically reviewing and updating the survey site with security measures to ensure protection for personal data. The survey site stores personal information of AANA members in secure databases protected by passwords and network firewalls to prevent the loss, misuse, or alteration of personal or survey information. The network operations staff perform regular security audits on the servers and the hosting facility conducts regular and ongoing independent security audits. Survey data is stored at a secure hosting facility with both physical

and software-based security systems. The survey site also provides SSL encryption for survey participation. At no time did the researchers have access to AANA member e-mail addresses or any members' identifying information. Only authorized personnel from the AANA in charge of the survey have access to these files. All responses and surveys will be destroyed 12 months after the survey launch. No hard copies of electronic surveys are kept by the AANA.

Participants in the survey were allowed to withdraw from the survey at any time prior to submission by closing their internet browser window or tab where they survey was displayed. However, once submitted, there was no mechanism to withdraw the survey since no identifying information was collected. If a participant chose not to participate, the choice to withdraw from the survey was not recorded.

CHAPTER 4

Findings

This chapter presents the collected and analyzed results of the Recycling in the Operating Room (OR) Assessment Tool. The study surveyed randomly selected CRNAs through the American Association of Nurse Anesthetists (AANA) to examine disposal practices of recyclable solid waste and to identify barriers to recycling in the operating room. Results of the statistical analyses are summarized below along with relevant figures and tables.

Sample

The Recycling in the Operating Room (OR) Assessment Tool was emailed to a total of 2,866 randomly selected AANA CRNAs. A total of 315 responses were received, resulting in a 9% survey response rate. Of the 315 responses, 292 surveys were returned to the researchers fully completed, while 23 were returned partially completed. Out of the 315 surveys returned, 23 were disqualified from the data analysis for omitting the essential survey question of whether the survey participant recycled in the operating room. A total of 292 surveys were analyzed using descriptive, quantitative statistics.

Table 1. Demographics of CRNA Research Participants.

Demographics	# of Responses (%)
Gender	
Male	192 (65.8)
Female	97 (33.2)
Prefer not to say	3 (1.0)
Practice Experience	
0-5 years	74 (25.4)
6-10 years	53 (18.2)
11-20 years	81 (27.8)
> 20 years	83 (28.5)
Primary Work Facility U.S. Region	
Northeast	60 (20.8)
Midwest	74 (25.6)
Southeast	93 (32.3)
Southwest	22 (7.6)
West	39 (13.5)
Primary Facility Type	
Community hospital	173 (0.59)
University hospital	4 (0.01)
Outpatient surgery facility	11 (0.03)
Military facility	43 (0.14)
Pain Clinic	1 (0.003)
Other	60 (0.21)

The first five questions of the Recycling in the Operating Room (OR) Assessment Tool addressed participant demographics which included gender, work facility type, facility location, years providing anesthesia services, and number of anesthetic cases per week. The majority of participants were female (65.8%) with over 20 years of CRNA work experience (28.5%). Respondents practiced in all 50 states with the majority of surveyed CRNAs employed in medical facilities in the southeastern United States (32.3%).

The study found no statistically significant difference between the percentage of male CRNAs who recycle (37.2%) and the percentage of female CRNAs who recycle (42.1%) in the operating room, $X^2(1) = 0.619$, $p = 0.431$. The percentage of CRNAs who reported recycling in

their operating room ranged from 28.6% in the southwest to 45.8% in the midwest. The differences by region were not statistically significant, $X^2(4) = 2.390$, $p = 0.664$. By facility type, pain clinics had the lowest percentage of recycling in the OR at 0.003%, followed by university hospitals at 1% and then outpatient surgery facilities at 3%. Community hospitals had the highest percentage of recycling at 59.2%. percentage of recycling in the operating room at 37.9%, followed by university hospitals at 40.7%. These differences by facility type were not statistically significant, $X^2(3) = 2.151$, $p = 0.542$.

Research Question 1

After demographics information, survey items 6-10 of the data collection tool addressed Research Question 1: what are CRNAs' current disposal practices of recyclable solid waste in the operating room?

Of the 289 analyzed CRNA responses, 40% reported recycling in their operating room, while 59% denied recycling in their operating room. Survey participants were further questioned about the presence of a recycling protocol at their medical facility. Out of 289 respondents, 33% indicated that their medical facilities had formal facility wide recycling protocols, while 43% reported a lack of facility wide recycling protocols. Twenty-three percent of CRNAs said they 'did not know' whether they had recycling protocols at their facilities. Chi Square analysis of independence found a statistically significant association between having a formal facility wide recycling protocol and recycling at that medical facility, $X^2(2) = 70.533$, $p < .001$. Of the survey respondents that indicated they had a recycling protocol at their medical facility (n=96), 71.9%

also recycled in their operating room. Of those CRNAs that did not have a recycling protocol at their facility, 16.1% still reported recycling while 83% said they did not recycle.

Table 2. CRNA Recycling Practices Vs. Presence of Hospital Wide Recycling Protocols.

	Have protocol %	Don't have protocol %	Don't know whether protocol exists %
Recycle	69 (71)	21 (16)	24 (36)
Don't Recycle	27 (28)	104 (83)	41 (63)

This table examines CRNA survey participants that reported both recycling and not recycling in the operating room and compares their responses to whether their medical facility had instituted hospital-wide recycling protocols.

A statistically significant association was found using a chi square analysis between years in practice as a CRNA and having an awareness of a formal hospital-wide recycling protocol at the medical facility, $X^2(3)=14.337$, $p=0.002$. Survey results indicated that 36% of CRNAs practicing 0-5 years reported that they were unaware of whether their medical facility had a recycling protocol. Comparatively, 11% of CRNAs practicing over 20 years reported not knowing whether their medical facility had a recycling protocol. No statistical significance was found, however, between years in practice and whether CRNAs recycled in their operating room at, $X^2(3)=1.239$, $p=0.744$.

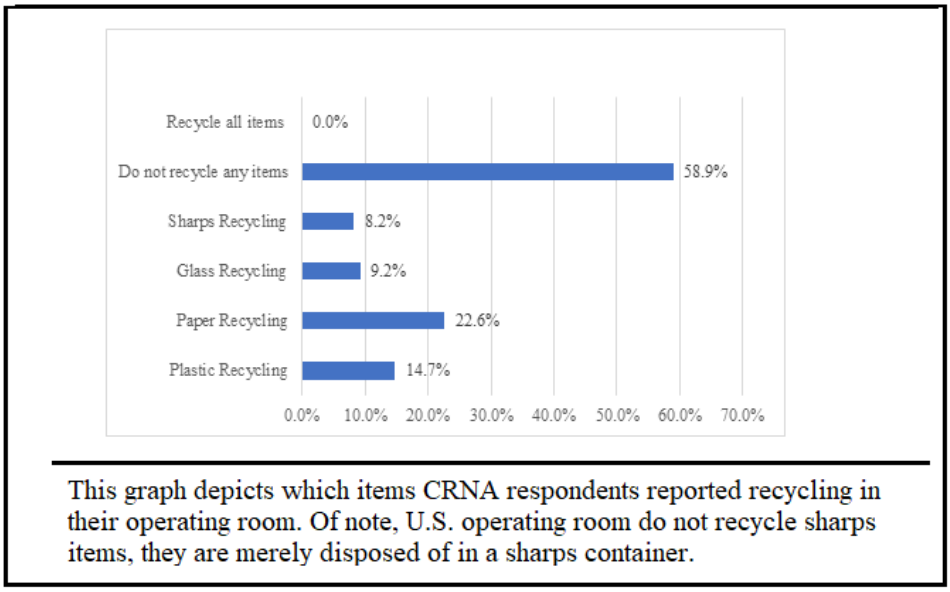
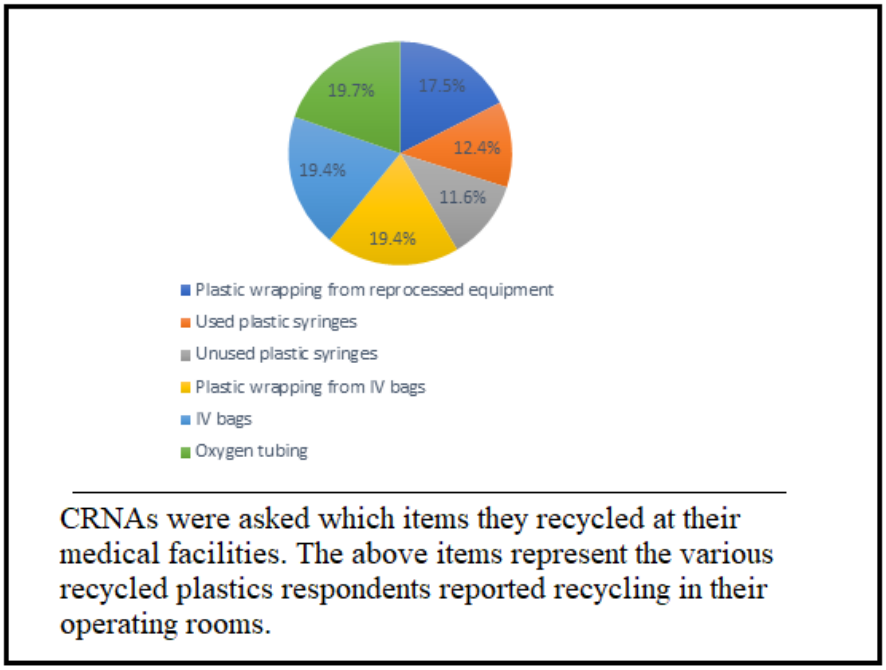


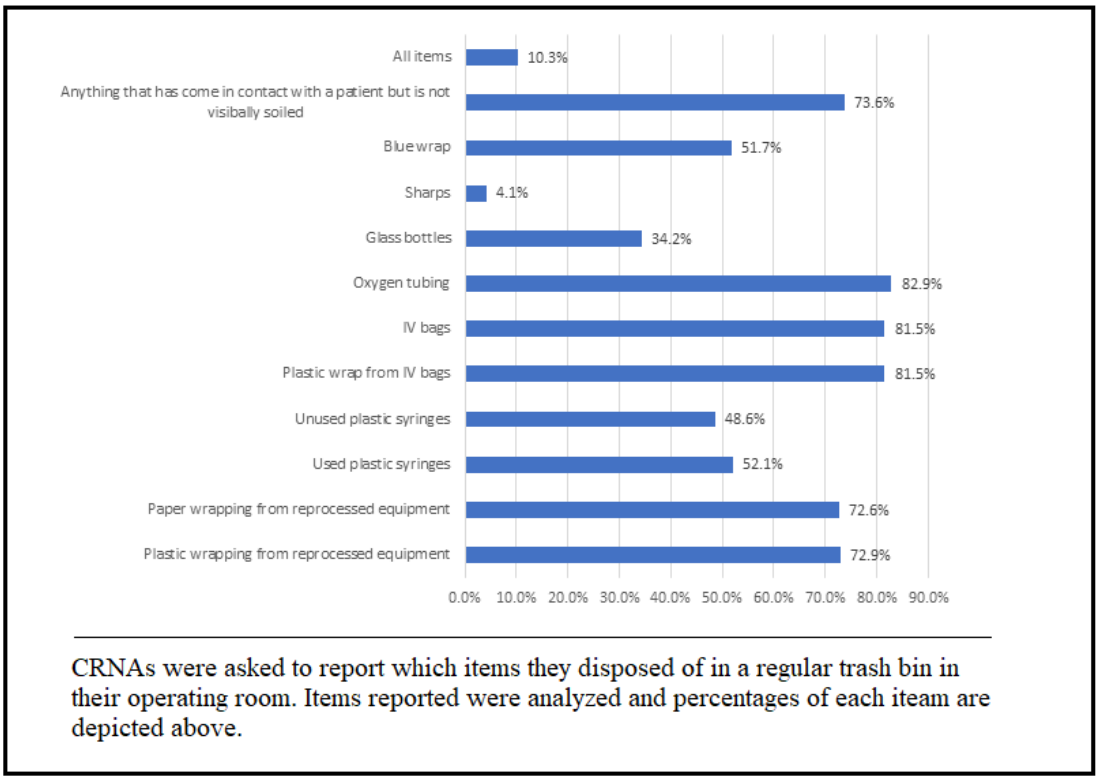
Figure 1. Items Recycled By CRNAs in the Operating Room.

The study also surveyed CRNAs to determine which medical supplies they recycled in the operating room. **Figure 1** depicts all items survey respondents reported recycling. Items were grouped into plastic, paper, glass and sharps recyclables. Various plastic recyclables such as plastic wrapping, plastic syringes, and IV bags were grouped into one plastics category. Similarly, items such as paper, cardboard, and Tyvek materials were grouped together into one paper recyclables category. None of the respondents surveyed indicated that they recycled all of the potentially recyclable items used by anesthesia providers in the operating room. The majority of the respondents (58.9%) indicated that they did not recycle any items in the operating room. Study analyses attempted to further distinguish between types of plastics recycled by CRNAs. See **Figure 2** for the various types of plastics recycled.



CRNAs were asked which items they recycled at their medical facilities. The above items represent the various recycled plastics respondents reported recycling in their operating rooms.

Figure 2. Types of Plastic Items Recycled by CRNAs in the Operating Room.



CRNAs were asked to report which items they disposed of in a regular trash bin in their operating room. Items reported were analyzed and percentages of each iteam are depicted above.

Figure 3. Items Disposed of in Trash Bins.

Figure 3 depicts items CRNAs reported throwing away in the trash bin in their operating room. Of note, 73.6% percent of CRNAs (n=216) disposed of 'anything that had come in contact with the patient but was not visibly soiled' in the regular trash bin. Of survey respondents, 10.3% of CRNAs disposed of everything in the trash bin and the majority of CRNAs (over 80%) disposed of various plastic items in the trash bin. These items included oxygen tubing, IV bags, plastic wrap from IV bags, plastic syringes and wrapping from reprocessed equipment. All of the items listed are in fact potentially recyclable.

Table 3. CRNA Recycling Practices Vs. Presence of Recycling Amenities.

	Presence of recycling bins	Lack of recycling bins
Recycle	42 (35)	75 (64)
Don't Recycle	5 (2)	167 (97)

Chi Square analysis found a significant association between CRNA recycling and a presence of a recycling bin ($p<0.01$).

In evaluating CRNAs with recycling bins in the operating room, chi square analysis revealed an association between the presence of a recycling bin and the practice of recycling, $X^2(2) = 54.9$, $p<0.001$. **Table 3** shows the majority of CRNAs (97%) that reported they did not have recycling bins available in their operating rooms also did not recycle in the OR. Likewise, only 2% of those that did not recycle had recycling bins in their operating room. However, the data also showed that even if recycling amenities were provided, only 35% of CRNAs reported recycling.

Another statistically significant association that was found using Chi Square analysis was between having a facility wide recycling protocol and having recycling bins available in the operating room, $X^2(2) = 65.3$, $p<0.001$. In facilities with a recycling protocol, 40.6% of CRNAs had recycling bins in the operating room compared. Comparatively, 3.2% of CRNAs had a recycling bin in their OR in facilities without a protocol. Nevertheless, the majority of facilities with protocols (59.4%) still did not have recycling bins in the operating room.

This survey also assessed the types of waste disposal bins available for CRNAs to utilize in their operating room. Out of 292 responses to this section, 85% of CRNAs reported having red bins for clinical waste in their operating rooms; however, only 16% (n=46) of CRNAs reported having recycling amenities to use.

The data tool also asked survey respondents whether recycling amenities were available specifically for anesthesia providers, placed at their anesthesia workstations. Ninety-four percent of CRNAs that reported having recycling amenities at their anesthesia workstation also reported recycling in their operating room. Inversely, 36.1% of those without anesthesia-specific recycling amenities reported recycling. Over 63% of survey participants that denied having anesthesia-specific recycling amenities available in their operating room also did not recycle at their workplace. The relationship between having anesthesia-specific amenities and recycling in the operating room was statistically significant, $X^2(2) = 23.8$, $p<0.001$.

Research Question 2

Survey items 11-20 addressed Research Question 2: what barriers exist that prevent CRNAs from recycling in the operating room?

The study hypothesized that education of recycling may be a barrier to recycling practices. Results revealed 72.8% of CRNAs were not provided with any education about intraoperative recycling and 19.3% did not know if they had been provided with education. Only 7.9% of CRNAs surveyed indicated receiving any education on recycling in the operating room. Those who had received education were significantly more likely to recycle than those without education or those who did not remember being educated on recycling. Additionally, 36.4% of those who did not have education or could not remember having education indicated that they recycled in the operating room, compared to 82.6% of those who had received recycling education, $X^2(1) = 18.84$, $p<0.001$.

Survey participants were questioned about recycling amenities in the operating rooms. The study found a statistically significant association between having recycling amenities in the operating room and CRNA recycling, $X^2(1) = 54.91$, $p<0.001$. Of the CRNAs surveyed, 89.1% that reported having a recycling bin also reported recycling. Only 30.7% of those who did not have recycling bins in the operating room reported recycling.

The study found limited recycling amenities available for CRNA use in operating rooms. Only 15.9% of the CRNAs surveyed reported having a recycling bin in their operating room. Meanwhile, 85% of the CRNAs surveyed indicated they had access to a red clinical waste bin. A finding discussed earlier suggests that the lack of recycling amenities may be a barrier to recycling practices. Also, the majority of CRNAs that had facility wide recycling protocols (59.4%), also reported not having recycling bins available in their operating room. Likewise, out of 290 respondents, 91.4% responded they would recycle if proper amenities were available in their operating room, while 1.7% answered they would not recycle; 6.5% of respondents

answered that they did not know whether they would recycle if proper amenities were available to them.

CRNAs also answered questions on the availability of recycling amenities specifically for anesthesia provider use. Only 6.2% reported having anesthesia specific recycling amenities. Those with amenities specifically for anesthesia providers were significantly more likely to recycle than those without such amenities or who did not know if they had such amenities, $X^2(1) = 23.65$, $p<0.001$. Nearly all (94.4%) of those with anesthesia specific recycling amenities reported recycling compared with 36.4% of those without such amenities.

The presence of facility wide recycling protocols or 'environmental sustainability' initiatives had a statistically significant association with recycling in the operating room, $X^2(1) = 15.47$, $p<0.001$. The majority of survey respondents (92.3%) that reported having a facility wide recycling protocol or sustainability program also reported they recycled in the operating room, compared to only 37.6% of those who did not have such programs. Only 4.5% of respondents, however reported that their hospital had 'green' or 'sustainability' initiatives, 52.1% did not have such initiatives, and 43.4% did not know.

Survey respondents in our study ranked their biggest barriers to recycling in the operating room as (1) a lack of recycling amenities (84.9%), (2) inadequate information about/ how to recycle (57.9%), and (3) a lack of education about recycling (54%), shown in **Figure 4**. In assessing CRNAs perception of barriers to recycling in the operating room, majority of respondents (84%) indicated a lack of recycling amenities in the operating room as the biggest barrier that prevented them from recycling in their workplace. Inadequate information was cited as the second largest barrier (57%) to recycling in the operating room. Finally, a lack of education was indicated as the third largest factor (54%) that contributed to the lack of recycling

in the operating room. Another barrier to recycling noted in the study was perceived infection risk by CRNAs. Over 73% of CRNAs surveyed in this study reported disposing of anything that had come into contact with a patient but was not visibly soiled in the regular trash bin.

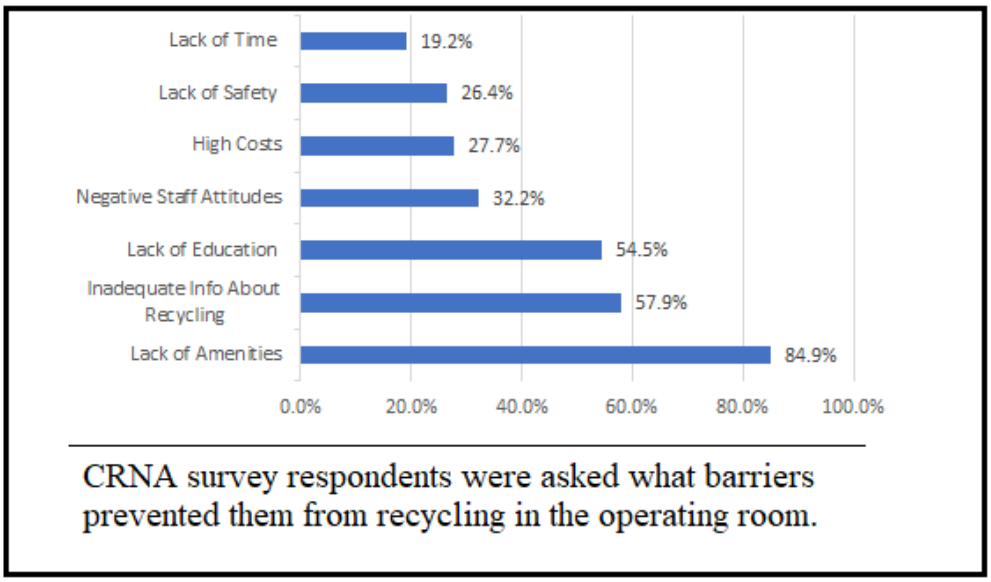


Figure 4. Perceived Barriers to Recycling in the Operating Room.

The final question of our survey asked respondents to add additional comments about recycling in the operating room. Of 289 survey respondents, 108 people left comments on the survey which were grouped into three categories. The first category included comments supportive of recycling practices in the operating room. Examples included: "I wish we did more to recycle and eliminate waste," " …this is a good study and [I] hope you guys have a way to help hospitals implement recycling efforts in the OR…" The second type of comment was not supportive of recycling in the operating room. Examples included: "it is becoming expensive to dispose of recycled waste." The third type of comment described problems faced by CRNAs in attempts to recycle in the operating room. Examples included: "I have asked our administration

about recycling and have not heard anything regarding a program for our institution." Other problems described were costs of recycling, concern for cross contamination, and the questionable effectiveness of recycling. The most common answer provided to the question of 'to increase recycling in operating rooms, I am willing to do the following' was to advocate for more recycling amenities in their workplace (37%).

Summary

The majority of CRNAs in this study (59%) indicated that they did not recycle any items in the operating room at their medical facility. A significant association was found between having a formal hospital-wide recycling protocol and recycling in the operating room, $X^2(2) = 70.533$, $p < 0.001$. Of the survey respondents that indicated they had a recycling protocol at their medical facility (n=96), 71.9% also reported recycling in their operating room.

Survey respondents in our study ranked their biggest barriers to recycling in the operating room as (1) a lack of recycling amenities (84%), (2) inadequate information about recycling (57%), and (3) a lack of education about recycling (54%). A statistically significant association was found between having recycling amenities in the operating room and CRNA recycling, $X^2(1) = 54.91$, $p<0.001$. In the survey, 15.9% of the CRNAs reported having a recycling bin in their operating room and 7.9% of CRNAs reported education on recycling in the operating room. Participants were given the option to write additional comments about intraoperative recycling on their survey, resulting in 108 discrete qualitative responses. Twenty-eight of the 108 (25%) responses described various barriers to recycling faced by CRNAs at their medical facilities. As one participant wrote, "…so many materials used in the OR have the potential to be

recycled…having enough receptacles and room for them would be tricky in some ORs due to size and available space…also having staff on board to comply would be difficult seeing the demands placed on them already for productivity, efficient turnover, etc."

CHAPTER 5

Discussion

This study explored the utilization of recycling among CRNAs and then examined the potential barriers that may prevent implementation within the sample population. To the authors knowledge, this is the first study that specifically explores CRNA recycling practices. The results of this study showed that 40% of CRNAs reported recycling in their operating room. This number was double the amount cited in prior surveys of anesthesiologists. However, the majority of CRNAs (58.9%) continue to abstain from recycling any materials in the operating room. These findings reflect the limited recycling practices published in the literature. For example, 2012 survey of anesthesiologists in Australia, New Zealand, and England (n=780), found that only 11% of surveyed anesthesiologists reported recycling in the operating room.[4] Likewise, a 2016 random sample survey emailed to ASA (n=2189) indicated that 27.7% recycled.[36] Recycling behavior in the U.K.'s National Health Service was also noted to be relatively low in comparison to the amount of recyclable waste found in its clinical waste stream.[42] In all of these studies, staff expressed high desire to recycle in the workplace yet actual recycling levels were considerably low. This current study continues to reflect these findings. Surveyed CRNAs expressed consistent desire to recycle in numerous questions of our survey, however, study results point to various barriers that prevent actual recycling from occurring in the operating room.

Although hospital-wide recycling programs as well as other environmental sustainability programs are growing across the country, the CRNAs surveyed through this study were unaware

of whether their facility had any facility wide recycling protocols, hospital environmental sustainability programs, and/or 'green initiatives.' These findings are consistent with the literature. The 2016 survey of ASA members (American Society of Anesthesiologists) reported that the majority of physicians answered "I don't know" to questions relating to the presence of hospital sustainability programs.[36] Their survey cited only 18% of respondents as having an environmental initiative in their facility[36]. Similarly, a hospital audit in Saudi Arabia reported a generalized lack of knowledge from hospital staff about waste disposal policies and procedures.[38] CRNA responses from this study do not differ from anesthesiologist responses published eight years ago which may reflect various barriers to recycling.

Survey respondents in our study ranked their biggest barriers to recycling in the operating room as (1) a lack of recycling amenities (84%), (2) inadequate information about recycling (57%), and (3) a lack of education about recycling (54%). These findings differed from the barriers identified in the first survey of American anesthesiologists (n=2189),[36] but mirrored those reported by the 2012 survey of international anesthesiologists (n=780). Ard cited the biggest barriers to recycling as (1) insufficient information about how to recycle (67%), (2) negative staff attitudes (47.5%) and, (3) a lack of time (47.4%).[36] The perception that there was a lack of sufficient information and/or education about intraoperative recycling continues to permeate this study and may continue to contribute to low perioperative recycling by anesthesia providers.

This study found limited recycling amenities available for CRNA use in the operating room which correlated with limited recycling. Only 16% of the CRNAs surveyed reported having a recycling bin in their operating room, while 85% of the CRNAs surveyed indicated they had access to a red clinical waste bin. This may indicate that disposing of clinical waste is more

widely accepted and is also expected of staff, unlike intra-operative recycling. The lack of available recycling amenities in the operating room was also perceived as the greatest barrier to recycling by CRNAs. When CRNAs were asked if they would be more likely to recycle if proper amenities were provided, the majority (91%) responded yes, while 6% responded they did not know whether they would recycle. This ambivalence about recycling may be due to inadequate information about recycling in the operating room and/or a lack of education about recycling as both problems were identified as the second and third largest barriers to recycling in our survey. Moreover, the most common answer provided by CRNAs to the question of 'to increase recycling in operating rooms, I am willing to do the following' was to advocate for more recycling amenities in their workplace (37%).

The lack of education about recycling reflected in this study has already been established in the literature. A 2012 survey administered through the ASA (n=2189) found the majority of anesthesiologists lacked basic information on how to recycle in the operating room[4]. Similar findings in a 2002 survey study administered to a waste management hospital committee in Saudi Arabia showed a lack of awareness from hospital staff of generated waste and of policies and procedures about recycling and proper waste disposal.[38] A 2002 anesthesia related waste disposal report also mirrored these findings, concluding that the biggest barrier to recycling was a lack of knowledge by medical staff about waste disposal policies and hospital environmental initiatives.[37]

Many anesthesia providers continue to believe that an item cannot be recycled if it has come in contact with a patient, although it may not be visibly soiled.[4,36] Likewise, the majority of CRNAs surveyed in this study reported disposing of anything that had come in contact with a patient but was not visibly soiled in the regular trash bin. This misconception is prevalent in the

literature. McGain et al attributed it to perceived infection risk; their study concluded that staff often err on the side of caution when disposing of materials that they believe may be infectious.[4,15] However, only 7% of general waste, 25% of anesthesia waste, and 16% of red bin clinical waste was found to have cross-contamination with infectious materials.[15] Authors of this study emphasized that proper education and a motivated staff were unlikely to dispose of contaminated waste into a recycling bin. Likewise, a 2019 study emphasized a need for improved education surrounding proper waste disposal and recycling[31]. Over 56% of survey respondents indicated it was unclear which items were recyclable.[31] Thus, multiple studies corroborate this study's findings, which call for further education surrounding intra-operative recycling.[15,16,26,36]

Limitations

A limitation of this study included its sample size. The recommended sample size to meet a 95% confidence interval and a 5% margin of error was 381, thus this study was underpowered since we did not meet the minimum sample size. Another potential limitation of this study was whether survey respondents were representative of AANA membership. Because our survey was a convenience sample, our respondents may have been more enthusiastic about recycling and environmental sustainability issues. Thus, there may have been biases in those who opted to fill out our data survey. Other limitations to the study surrounded several questions on the survey data tool. Questions that included select all that apply answers were limited in their statistical analyses and thus, were not adequately analyzed.

Implications

Current operating room recycling practices continue to need improvement. Sustainable behavior changes are needed to promote environmentally sustainable operating room waste disposal. Barriers to operating room recycling can be curbed through forced compliance with green initiatives by hospital administration, improved sustainability education programs, and mandating recycling bin use in operating rooms. Currently, hospital sustainability initiatives are on the rise.

Another point to consider is that recycling is influenced by the current political and economic climate. When a nation's political agenda does not support environmental initiatives, it is difficult to influence corporations to act in an environmentally sustainable manner. Currently, American manufacturing companies do not bear the cost of waste disposal, thus there is no incentive to manufacture products out of environmentally sustainable materials.

Consider also that in January of 2018 China banned its import of foreign recycling, specifically most plastic recycling. Prior to this policy, China had handled most of the world's recyclable waste for over the last 25 years. Thus, current U.S. recycling is being sent to landfills and incinerators as recycling companies scramble for new markets for their recyclable waste. If the U.S. healthcare system is committed to doing no harm, it is time to improve current hospital waste disposal processes and put pressure on manufacturing companies to make recyclable and environmentally sustainable products.

Future Recommendations

Future studies of operating room recycling should address hospital waste reduction programs, purchasing practices of hospital materials management departments, and the lack of environmental sustainability education found in both medical and nursing education. Furthermore, despite the public's increased awareness of recycling and environmentally sustainable waste disposal, the volume of waste Americans produce continues to increase. Future studies should further analyze hospital programs that implement waste minimization programs and healthcare companies that produce environmentally sustainable materials.

APPENDIX A

Citi Program: Collaborative Institutional Training Initiative

CITI PROGRAM

Completion Date 09-Sep-2018
Expiration Date 08-Sep-2021
Record ID 28586711

This is to certify that:

Tina Kushnir

Has completed the following CITI Program course:

Human Research (Curriculum Group)
Group 2.Social and behavioral research investigators and key personnel. (Course Learner Group)
1 - Basic Course (Stage)

Under requirements set by:

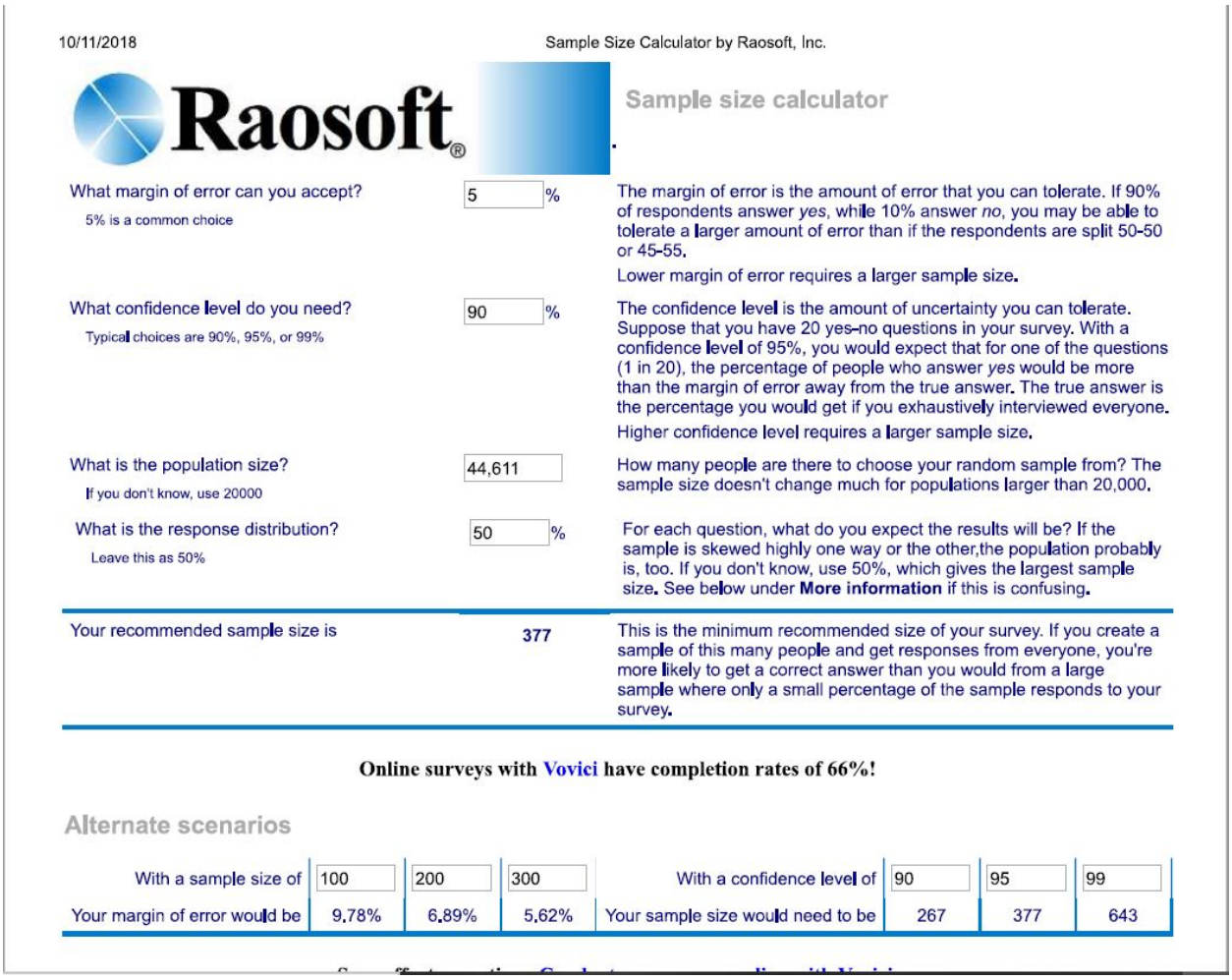
Georgetown University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?we378dd85-889a-46be-b421-d60fdf1e27fa-28586711

APPENDIX B

Raosoft Sample Size Calculator



10/11/2018 Sample Size Calculator by Raosoft, Inc.

Raosoft®

Sample size calculator

What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	90 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	44,611	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other,the population probably is, too. If you don't know, use 50%, which gives the largest sample size. See below under **More information** if this is confusing.
Your recommended sample size is	**377**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

Online surveys with Vovici have completion rates of 66%!

Alternate scenarios

With a sample size of	100	200	300	With a confidence level of	90	95	99
Your margin of error would be	9.78%	6.89%	5.62%	Your sample size would need to be	267	377	643

APPENDIX C

CERTIFIED REGISTERED NURSE ANESTHETISTS' DISPOSAL PRACTICES OF RECYCLABLE SOLID WASTE IN THE OPERATING ROOM: AN EXPLORATION OF PRACTICE
Number: IRB # STUDY00000078

INFORMED CONSENT SCRIPT
ANONYMOUS SURVEY

You are invited to participate in a research study titled **"**Certified Registered Nurse Anesthetists' Handling of Recyclable Waste in the Operating Room: An Exploration of Practice**"**. This study is being conducted by Tina Kushnir, Principal Investigator and Doctorate of Nurse Anesthesia Candidate at Georgetown University. Co-Investigators are Dr. Catherine Horvath, DNAP and Dr. Carrie Bowman-Dalley, Professors at the School of Nursing and Health Studies, Georgetown University. The purpose of the study is to examine Certified Registered Nurse Anesthetists' recycling practices, analyze Certified Registered Nurse Anesthetists' views of recycling, and identify barriers that exist to recycling in the operating room.

Participation in this study is entirely voluntary at all times. You can choose not to participate at all or to leave the study at any time. Regardless of your decision, there will be no effect on your relationship with the researcher(s) or any other consequences.

You are being asked to take part in this study because you are an active board certified or recertified Certified Registered Nurse Anesthetist member of the American Association of Nurse Anesthetists (AANA). If you agree to participate, you will be asked to answer questions on one electronic survey that you will access online through *SurveyMonkey* – the link to the survey is provided below. The survey will include two sections: demographics (gender, years of practice as a Certified Registered Nurse Anesthetist, location of your medical facility); and your recycling practices in the operating room. This survey should take approximately 5 minutes to complete. Once completed, the survey questions and your responses will be submitted electronically through *SurveyMonkey* and be sent directly to the Georgetown Principal Investigator.

All of your responses to this survey will remain anonymous and cannot be linked to you in any way. No identifying information about you will be collected at any point during the study. The *SurveyMonkey* system has been determined to be sufficiently protected/secure to allow for its use by Georgetown University researchers. Once you submit your completed survey, there will be no way to withdraw your responses from the study because the survey contains no identifying information. Study data are returned to the researcher in a digital format that does not identify individual responses. The digital, nonidentifiable, encrypted data will be kept by the AANA on password protected computers. The aggregate, non-identifiable data will be shared with study researchers.

There are no risks associated with this study. While you will not experience any direct benefits from participation, information collected in this study may benefit others in the future by contributing to our knowledge and understanding of recycling practices in operating rooms. This

includes but is not limited to barriers faced by Certified Registered Nurse Anesthetists to recycling in the operating room.

If you have any questions regarding the survey or this research project in general, please contact the principal investigator, Tina Kushnir, at (443)-854-2771 or via email at tk780@georgetown.edu, or Dr. Catherine Horvath at (202)-538-1790 or via email at chh24@georgetown.edu. If you have any questions about your rights as a research participant, please contact the Georgetown University IRB at (202) 687-1506 or irboard@georgetown.edu.

By completing and submitting this survey, you are indicating your consent to participate in this study. There is no need for a signed consent to participate.

To start the survey, please follow this link:

We request that you submit the survey by:

Sincerely,

Tina Kushnir, BSN, RN
Doctorate of Nurse Anesthesia Candidate 2020
Georgetown University

Catherine Horvath, DNP, CRNA
Assistant Professor
Georgetown University

APPENDIX D

Recycling in the Operating Room (OR) Assessment Tool

This survey questionnaire is a data tool to assess the prevalence of recycling practices of Certified Registered Nurse Anesthetists in the operating room. Please answer the questions below regarding recycling of disposable solid waste in your medical facility. The survey must be completed in its entirety to be included the study and should take approximately 5 minutes to complete. Please note no personal information will be collected.

1. What is your gender?
    a. Female
    b. Male
    c. Prefer not to say

2. What type of facility do you primarily work?
    a. Community Hospital
    b. University hospital
    c. Outpatient surgery facility
    d. Military facility
    e. Pain clinic
    f. Other

3. In what state is your facility located?
    [Drop down selection of all states]

4. How many years have you been providing anesthesia services as a Certified Registered Nurse Anesthetist?
    a. 0-5 years
    b. 6-10 years
    c. 11-20 years
    d. >20 years

5. On average, how many cases per week do you provide anesthesia services in your medical facility?
    a. 0-20 cases/week
    b. 21-40 cases/week
    c. 41-60 cases/week
    d. 61-80 cases/week
    e. >81 cases/week

Recycling Practices of Certified Registered Nurse Anesthetists

For questions 6 through 20, please select the answer choice(s) that apply to your personal recycling practices in the medical facility at which you are primarily employed.

6. Does your facility currently have recycling protocols?
    a. Yes
    b. No
    c. Don't know

7. Do you currently recycle any of the disposable solid waste items listed below in the operating room? Please select all that apply.
    a. Plastic wrapping from reprocessed equipment
    b. Paper wrapping from reprocessed materials
    c. Used plastic syringes
    d. Unused plastic syringes
    e. Plastic wrap from IV bags
    f. Plastic containers
    g. IV bags
    h. Oxygen tubing
    i. Glass bottles
    j. Sharps needles
    k. 'Blue wrap'
    l. 'Tyvek'
    m. Paper
    n. Cardboard
    o. All of the above
    p. Do not recycle any items
    q. Other, please list

8. What type of trash bin(s)/bag(s) are currently located in your operating room? Please select all that apply.
    a. Black bin(s)/bag(s)
    b. Red bin(s)/bags(s)
    c. Clear bin(s)/bag(s)
    d. Trash chute
    e. Recycling bin(s)/bag(s)
    f. All of the above

9. What types of specific recycling amenities does your operating room provide? Please select all that apply.
    a. One recycling bin/bag for all recyclable items
    b. Recycling bin(s)/bag(s) for plastic
    c. Recycling bin(s)/bag(s) for paper
    d. Recycling bin(s)/bag(s) for glass
    e. Recycling bin(s)/bag(s) for cardboard

f. There are no recycling bin(s)/bag(s) available in my operating room
g. Other (fill in the blank)

10. Which item(s) do you place in the regular trash bin in the operating room? Please select all that apply.
    a. Plastic wrapping from reprocessed equipment
    b. Paper wrapping from reprocessed materials
    c. Used plastic syringes
    d. Unused plastic syringes
    e. Plastic wrap from IV bags
    f. IV bags
    g. Oxygen tubing
    h. Glass bottles
    i. Sharps needles
    j. 'Blue wrap'
    k. Anything that has come in contact with a patient but has no visible blood or bodily fluids
    l. All of the above
    m. None of the above

11. Would you recycle if the proper recycling amenities were available in your operating room?
    a. Yes
    b. No
    c. Don't know

12. Is education about recycling practices or protocols provided in your facility to operating room staff?
    a. Yes
    b. No
    c. Don't know

13. Does your facility or department use financial incentives to encourage recycling?
    a. Yes
    b. No
    c. Don't know

14. Does your operating room have specific recycling amenities for anesthesia providers to use?
    a. Yes
    b. No
    c. Don't Know

15. Does your department or hospital have a sustainability or 'green' task force or committee?
    a. Yes
    b. No
    c. Don't know

16. I recycle at home
    a. Always
    b. Frequently
    c. Sometimes
    d. Rarely
    e. Never
    f. Don't know

17. According to my observations, my Certified Registered Nurse Anesthetist colleagues recycle in the operating room
    a. Always
    b. Frequently
    c. Sometimes
    d. Rarely
    e. Never
    f. Don't know

18. What do you perceive as barriers to recycling in the operating room? Please select all that apply.
    a. Staff attitudes
    b. Costs
    c. Inadequate information about how to recycle
    d. Potential infectious contamination/safety
    e. Lack of time to recycle
    f. Lack of education about recycling
    g. Lack of recycling amenities
    h. Other (fill in the blank)

19. To increase recycling in operating rooms, I am willing to do the following
    a. Provide education to my co-workers on recycling
    b. Become a member on a committee that promotes hospital recycling
    c. Advocate for more readily available recycling amenities in the operating room from hospital administrators
    d. None of the above
    e. Other (fill in the blank)

20. Do you have any additional comments about recycling in operating rooms (fill in the blank)?

APPENDIX E

Institutional Review Board Permission Letters

GEORGETOWN UNIVERSITY

APPROVAL

February 4, 2019

Tina Kushnir
tk780@georgetown.edu

Dear Tina Kushnir:

On 2/4/2019, the IRB reviewed the following submission:

Type of Review:	STUDY
Title:	Certified Registered Nurse Anesthetists' Disposal Practices of Recyclable Solid Waste in the Operating Room: An Exploration of Practice
Investigator:	Tina Kushnir
IRB ID:	STUDY00000078
Review Type:	Non-Committee
Review Level:	Expedited
Review Category:	(7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
IND, IDE, or HDE:	None
Documents Reviewed:	• Informed Consent, Category: Consent Form;

The IRB has approved the submission. You can begin research activities. **The approval is valid from 1/29/2019 through 1/28/2020**. Any modifications to the IRB-approved protocol and other supporting documents must be reviewed and approved by the IRB prior to implementation.

If the study will continue beyond 1/28/2020, please submit a continuation request form at least thirty (30) days prior to 1/28/2020 to allow the IRB sufficient time to review and approve the request.

In conducting this protocol, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

Sincerely,

Page 1 of 2

GEORGETOWN UNIVERSITY

Michael Orquiza

GEORGETOWN UNIVERSITY
School of Nursing & Health Studies

Dear AANA Research Department:

A graduate student in the Georgetown University Doctor of Nurse Anesthesia Practice program, Christopher Parrish, has developed a research project titled " CRNAs Disposal Practices of Recyclable Solid Waste in the OR: An Exploration of Practice". This has been approved by the Georgetown University IRB #__STUDY 00000078_.

I support this application to the AANA to conduct this study via electronic survey. Thank you for processing their application.

Sincerely,

Catherine Horvath

Catherine H Horvath, CRNA
Assistant Professor and Research Director Class 2020
Doctor of Nurse Anesthesia Program
Georgetown University School of Nursing and Health Studies
202-687-8122
chh24@georgetown.edu

REFERENCES

1. Sherman JD, Ryan S. Ecological responsibility in anesthesia practice. *International anesthesiology clinics*. 2010;48(3):139-151.

2. Wormer BA, Augenstein VA, Carpenter CL, et al. The green operating room: Simple changes to reduce cost and our carbon footprint. *The American Surgeon*. 2013;79(7):666-671.

3. McGain F, Story D, Hendel S. An audit of intensive care unit recyclable waste. *Anaesthesia.* 2009;62:1299-302.

4. McGain F, White S, Mossenson S, Kayak E, Story D. A survey of anesthesiologists' views of operating room recycling. *Anesthesia & Analgesia.* 2012;114(5):1049-1054. http://www.ncbi.nlm.nih.gov/pubmed/22415530. doi: 10.1213/ANE.0b013e31824d273d.

5. Chung JW, Meltzer DO. Estimate of the carbon footprint of the US health care sector. *JAMA*. 2009;302(18):1970-1972. doi: 10.1001/jama.2009.1610.

6. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2001: The Scientific Basis*. Cambridge: Cambridge University press; 2001. https://www.ipcc.ch/site/assets/uploads/2018/07/WG1_TAR_FM.pdf. Accessed March 11, 2020.

7. U.S. Global Change Research Program (USGRP). *The Climate Science Special Report: Fourth National Climate Assessment (NCA4), Volume I.* U.S. Global Change Research Program (USGRP); 2017:470. https://nca2018.globalchange.gov/. Accessed November 8, 2020.

8. World Health Organization (WHO). *World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva: WHO; 2020. https://apps.who.int/iris/bitstream/handle/10665/42510/WHR_2002.pdf?sequence=1. Accessed December 14, 2019.

9. Cotton R, Cohen A. Eco-conservation and healthcare ethics: A call to action. *The Laryngoscope*. 2009:120. doi: 10.1002/lary.20663.

10. Wyssusek K, Keys M, van Zundert A. Operating room greening initiatives – the old, the new, and the way forward: A narrative review. *Waste Management & Research*. 2018;37(1):3-19. doi: 10.1177/0734242X18793937.

11. Eckelman MJ, Sherman J. Environmental impacts of the U.S. health care system and effects on public health. *PLoS One*. 2016;11(6):e0157014. doi: 10.1371/journal.pone.0157014.

12. Lee B, Ellenbecker MJ, Moure-Eraso R. Analyses of the recycling potential of medical plastic wastes. *Waste Management*. 2002;22(5):461-470. doi: 10.1016/S0956-053X(02)00006-5.

13. Tieszen ME, Gruenberg JC. A quantitative, qualitative, and critical assessment of surgical waste: surgeons venture through the trash can. *JAMA*. 1992;267(20):2765-2768.

14. Hutchins D, White S. Coming round to recycling. *BMJ*. 2009;338(7697):746-748.

15. McGain F, Hendel S, Story D. An audit of potentially recyclable waste from anaesthetic practice. *Anaesthesia and intensive care*. 2009;37(5):820-823. doi:10.1177/0310057x0903700521

16. Kagoma Y, Stall N, Rubinstein E, Naudie D. People, planet and profits: the case for greening operating rooms. *Canadian Medical Association Journal*. 2012;184(17):1905-1911. doi:10.1503/cmaj.112139

17. McGain F, Story D, Kayak E, Kashima Y, McAlister S. Workplace sustainability. *Anesthesia & Analgesia*. 2012;114(5):1134-1139. doi: 10.1213/ANE.0b013e31824ddfef.

18. U.S. Environmental Protection Agency (EPA). *Advancing sustainable materials management: 2017 fact sheet*. EPA; November 2019. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100Y4BP.PDF?Dockey=P100Y4BP.PDF. Accessed January 8, 2020.

19. Environmental Research & Education Foundation (EREF). *Municipal solid waste management in the U.S. 2010 & 2013*. EREF;2016. www.erefdn.org

20. Wyssusek K, Foong W, Steel C, Gillespie B. The Gold in Garbage: Implementing a Waste Segregation and Recycling Initiative. *AORN Journal*. 2016;103(3):316.e1-316.e8. doi:10.1016/j.aorn.2016.01.014.

21. Shinn HK, Hwang Y, Kim B, Yang C, Song J, Lim HK. Segregation for reduction of regulated medical waste in the operating room: A case report. *Korean Journal of Anesthesiology*. 2017;70(1):100. doi: 10.4097/kjae.2017.70.1.100.

22. Lee R, Mears S. Reducing and recycling in joint arthroplasty. *Journal of Arthroplasty*. 2012;(27):1757-60.

23. Stonemetz J, Pham J, Necochea A, McGready J, Hody R, Martinez E. Reduction of Regulated Medical Waste Using Lean Sigma Results in Financial Gains for Hospital. *Anesthesiology Clinics*. 2011;29(1):145-152. doi:10.1016/j.anclin.2010.11.007

24. U.S. Environmental Protection Agency (EPA*). Inventory of U.S. greenhouse gas emissions and sinks: 1990-2016*. EPA; 2018:524-541. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100TT0X.PDF?Dockey=P100TT0X.PDF. Accessed February 12, 2020.

25. Sattler, B. Environmental health in the health care setting. *American Nurse*. 2002;34:25-38.

26. Topf M. Psychological explanations and interventions for indifference to greening hospitals. *Health care management review*. 2005;30(1):2-8. doi: 10.1097/00004010-200501000-00002.

27. McKendrick D, Snedden L, Bunch R, McGregor H. Pragmatic recycling of paper and cardboard in the operating theatre: An audit. *Journal of Perioperative Practice*. 2017;27(3):43-49. doi: 10.1177/175045891702700302.

28. U.S. Environmental Protection Agency (EPA). *National framework for advancing the U.S. recycling system*. EPA; November 2019. https://www.epa.gov/sites/production/files/2019-11/documents/national_framework.pdf. Accessed March 2, 2020.

29. U.S. Environmental Protection Agency (EPA). *Recycling basics*. EPA; 2019. https://www.epa.gov/recycle/recycling-basics. Accessed March 2, 2020.

30. Riedel, Lisa M. CRNA, DNP, MS. Environmental and financial impact of a hospital recycling program. *AANA Journal*.2011;79(4):S8-S14.

31. Azouz S, Boyll P, Swanson M, Castel Nikki, Maffi T, Rebecca Alanna. Managing barriers to recycling in the operating room. *The American Journal of Surgery.* 2019(217):634-638.

32. Axelrod D, Bell C, Feldman J, et al. Greening the operating room and perioperative arena. *American Society of Anesthesiologists*. 2014.

33. McGain F et al. Recycling plastics from the operating suite. *Anaesthesia and intensive care*. 2008;36(6):913-914.

34. McGain F, Naylor C. Environmental sustainability in hospitals – a systematic review and research agenda. *Journal of Health Services Research & Policy*. 2014;19(4):245-252. doi: 10.1177/1355819614534836.

35. Shelton C, Abou-Samra M, Rothwell MP. Recycling glass and metal in the anaesthetic room. *Anaesthesia*. 2012;67(2):195-196. doi: 10.1111/j.1365-2044.2011.07041.x.

36. Ard J, Tobin K, Huncke T, Kline R, Ryan S, Bell C. A survey of the American society of anesthesiologists regarding environmental attitudes, knowledge, and organization. *International Anesthesia Research Society*. 2016; 6(7): 208-216. doi: 10.1213/XAA.0000000000000184.

37. Hubbard R, Hayanga J, Quinlan J, Soltez A, Hayanga H. Optimizing anesthesia-related waste disposal in the operating room: A brief report. *Anesthesia & Analgesia*. 2017;125(4):1289-1291. doi: 10.1213/ANE.0000000000001932.

38. Aljabre S, Hoffmann F, Almorzog BS, Mikiling L, Alabdulatif M, Al-Quorain AA. Hospital generated waste: An assessment of the awareness of hospital staff. *Journal of Family & Community Medicine*. 2002;9(1):47.

39. Kwakye G. Green surgical practices for health care. *Archives of Surgery*. 2011;146(2):131. doi:10.1001/archsurg.2010.343.

40. Porter-O'Grady T, Malloch K. Innovation: Driving the green culture in healthcare. *Nurse Administration Quarterly*. 2010;34(4):1-5.

41. Kaiser B, Patrick D. Eagan, Shaner H. Solutions to health care waste: Life-cycle thinking and "green" purchasing. *Environmental Health Perspectives*. 2001;109(3):205-207.

42. Tudor T, Noonan C, Jenkin L. Healthcare waste management: A case study from the national health service in Cornwall, United Kingdom. *Waste Management*. 2005;25(6):606-615. doi: S0956-053X(04)00177-1.