2014

Improving Anesthesia Professional Adherence to Hand Hygiene

Martha E. Seneca
University of North Florida, martha.seneca@unf.edu

IMPROVING ANESTHESIA PROFESSIONAL ADHERENCE TO HAND HYGIENE

by

Martha E. Seneca

A project submitted to the School of Nursing

in partial fulfillment of the requirements for the degree of

Doctor of Nursing Practice

UNIVERSITY OF NORTH FLORIDA

BROOKS COLLEGE OF HEALTH

April 2014

Certificate of Approval

The project of Martha E. Seneca is approved: Date _____

_____ Date _____
Gerard T. Hogan, DNSc, CRNA, APRN
Committee Member

_____ Date _____
Katherine M. Robinson, Ph.D., RN
Committee Member

_____ Date _____
W. Patrick Monaghan,
Committee Chairperson, Ph.D., CLS, SBB

Accepted for the School of Nursing

_____ Date _____
Lillia Loriz, PhD, GNP, BC
Director, School of Nursing

Accepted for the College

_____ Date _____
Pamela S. Chally, PhD, RN
Dean, Brooks College of Health

Accepted for the University

_____ Date _____
Len Roberson, PhD
Dean of the Graduate School

Dedication & Acknowledgements

I wish to thank Dr. W. Patrick Monaghan, my committee chairperson, for providing guidance and encouragement throughout the completion of this project. I also would like to thank Dr. Gerard T. Hogan and Dr. Katherine M. Robinson for their participation and input as committee members. Finally, I'd like to thank my husband, Michael Seneca, for the unconditional support and patience as we completed our graduate studies together.

Table of Contents

Appendices

List of Tables

List of Figures

Abstract

Performance of hand hygiene is among the most effective means of preventing healthcare associated infections (HAI) among patients. Deaths resulting from HAIs are one of the top ten leading causes of death in the United States. Any improvement in the frequency of hand hygiene among healthcare professionals may have a direct impact on patient mortality and associated costs. While anesthesia professionals have been found to have low rates of hand hygiene adherence, few targeted studies seeking to improve hand hygiene adherence among this group exist. Studies conducted to improve hand hygiene among health care professionals have reported limited improvement, with overall inconclusive recommendations for improving prolonged hand hygiene adherence rates. The purpose of this project was to improve anesthesia professionals' hand hygiene through encouragement of performance and education on the current state of research in the area of anesthesia associated HAIs. Hand hygiene rates were evaluated through measuring the amount of hand sanitizer used at eleven anesthesia workstations in the main operating room of a hospital. Measurements were taken at baseline and continued for three months after the educational program was implemented.

Keywords: anesthesia, hand hygiene, quality improvement

Chapter One: Introduction

Healthcare associated infections (HAIs) are a major source of concern for public health in the United States. Estimated to occur in one out of every 20 patients, the direct costs associated with HAIs are approximately $20,000 per person per infection, with aggregate costs of approximately $40 billion annually in the United States alone (Scott, 2009). Deaths resulting from HAIs are one of the top ten leading cases of death in the United States (U.S. Department of Health and Human Services [USDHS], 2013). Causes of HAIs are as diverse as the healthcare settings in which they are acquired, and prevention is aimed at researching and implementing systems and guidelines to curb the transmission of deleterious causative organisms. This chapter will discuss the current state of research and policy on infection control practices in the anesthesia setting. Additionally, a discussion of the purpose of this project as well as a review of terms important to the project will be presented.

Background

The anesthesia setting is a unique environment in which the provider-patient interaction consists of a concentrated set of interventions during which there is a high risk of microorganism spread. Standards of practice for anesthesia professionals require implementing techniques to minimize the risk of infections during the provision of anesthetic care (AANA, 2007). Despite this, a study measuring infection control practices in ambulatory surgery centers (ASCs) found that 67.6% had at least one lapse in infection control, and 17.6% had three or more lapses (Schaefer et al., 2010). Common lapses included reuse of single dose medication vials between

patients, inadequate hand hygiene and inadequate decontamination of equipment used between episodes of patient care.

An important source of contaminating microorganisms in the anesthesia setting is from the hands of anesthesia professionals (Loftus et al., 2011). These microorganisms are transferred to the surfaces of intravenous stopcock sets and high traffic anesthesia workstation surfaces such as adjustable pressure limiting valves and volatile agent dials. Contamination of stopcock sets may be associated with an increased risk of patient mortality (Loftus et al., 2008). Unfortunately, hand hygiene practices by anesthesia professionals are poor, with hygiene opportunity failures ranging between 64% and 93% (Biddle & Shah, 2012). This confluence of factors may result in patient care conditions that may be below the standard of care regarding infection control.

Policy Influences

Infection control issues in the anesthesia setting have largely entered the public consciousness within the last 10 years. Most notable have been several publicized cases from Oklahoma, Nevada, Indiana, and New York of anesthesia professionals reusing syringes, needles, or single dose medication vials for multiple patients, placing these patients at risk for contracting blood borne infections (Wilson, 2008). These tragic events placed thousands of patients at risk of contracting illnesses such as HIV and Hepatitis C. As a result, the outdated (and previously accepted by anesthesia professionals) practice of syringe reuse was reevaluated, and has subsequently brought attention to infection control practices in the anesthesia setting (Biddle, 2009; Lessard et al., 1988).

In response to the discovery of these unacceptable syringe/needle/vial practices, professional anesthesia organizations released statements and bulletins to their members reminding all anesthesia professionals of the infection control guidelines emphasized by their

organization. Additionally, the Centers for Disease Control (CDC) issued updated guidelines for preventing transmission of infectious diseases in the healthcare setting (Siegel et al., 2007). Considerable attention was given to these lapses of infection control practice in the anesthesia setting, resulting in a significant decrease in the prevalence of unacceptable injection practices by anesthesia professionals. While the problem has not been fully eliminated, the vast improvement may potentially reflect a successful dissemination of campaigns to reduce these practices (Pugliese, Gosnell, Bartley, & Robinson, 2010; Schaefer et al., 2010).

While advances have been made in the area of injection practices in the anesthesia setting, very little progress has been made in the improvement of hand hygiene practices of anesthesia professionals (Biddle, 2009). This may potentially reflect a larger problem, as it could undermine even the progress made in advancements of safe syringe practices (Stucki, Sautter, Favet, & Bonnabry, 2009). Poor aseptic techniques, including lack of attention to hand hygiene, have long been implicated in incidents of extrinsic contamination of medications commonly administered in the anesthesia setting (Bennett et al., 1995).

Barriers to hand hygiene performance in the anesthesia work place may result from production pressure, lack of access to hand sanitizers, intensity of patient care, or even lack of awareness of risk to patient or provider. Studies have shown that interventions aimed at improving anesthesia professional hand hygiene can have significant impact, though due to the direct observational nature of compliance evaluation, it is unclear whether this is a result of the Hawthorne effect (Bellaard-Smith & Gillespie, 2012; Koff et al., 2009)

Purpose

The purpose of this project was to improve anesthesia professionals' hand hygiene through encouragement of performance and education on the current state of research in the area

of anesthesia associated HAIs. A baseline evaluation of hand hygiene adherence was conducted through monitoring the rate of use of hand sanitizers available to anesthesia professionals in the operating rooms of a tertiary care facility for one week. Subsequently, a presentation describing current research on anesthesia professional hand hygiene was provided to the anesthesia team. Hand sanitizer use was monitored monthly for a three-month period to determine the impact of education and awareness on the rate of hand sanitizer usage.

Definition of Terms

Anesthesia Professional

The term anesthesia professional refers to any individual in the perioperative setting directly involved in implementing an anesthetic plan. This may refer to a nurse anesthetist, a student nurse anesthetist, an anesthesiologist, a physician resident specializing in anesthesia, or an anesthesiologist assistant.

Hand Hygiene

The term hand hygiene refers to the practice of engaging in activities to disinfect the hands with antiseptic hand wash, antiseptic hand rub, hand washing, or hygienic hand rubs before or after moments in which the transmission of pathogenic organisms is likely. In the healthcare settings, these moments have been defined by the World Health Organization's Guidelines on Hand Hygiene in Healthcare (2009). These include before touching a patient, before a clean or aseptic procedure, after a body fluid exposure risk, after touching a patient, and after touching patient surroundings.

Healthcare Associated Infection

The term healthcare-associated infection refers to any infection (bacterial, viral, or fungal) occurring during the course of receiving health care services (CDC, 2012). These

infections can occur in any healthcare facility including hospitals and ambulatory surgery centers.

Chapter Two: Review of Literature

This chapter will provide an overview of hand hygiene topics in the healthcare setting, with particular attention to those relating to the anesthesia setting. Additionally, the current state of hand hygiene campaigns in the healthcare setting and evidence supporting their stance will be presented. Previously conducted studies on improvement of hand hygiene in anesthesia setting will be presented and critiqued in order to determine an approach for this study. Prior to discussion of the overview, a description of the literature search strategy will be presented.

Sources and Search Process

A review of literature on improvement of hand hygiene practices for anesthesia professionals was guided by the following PICO question: After an (I) educational program on hand hygiene in the anesthesia setting, will anesthesia providers (P) alter their (C) hand hygiene (O) adherence? CINAHL, PubMed, Science Direct, and the Cochrane Library were databases used for the literature search. Search terms included hand hygiene, anesthesia, improvement, hand hygiene adherence, and barriers to hand hygiene. Articles were selected based on relevance to the topic, and further articles were obtained by reviewing the reference list of articles found using databases. Due to limited availability of articles focusing on anesthesia professionals, hand hygiene articles pertaining to other HCPs was included in this literature review. Additionally, a review of the Centers for Disease Control position on hand hygiene was reviewed, which resulted in inclusion of a document released by the World Health Organization establishing hand hygiene guidelines.

Hand Hygiene in Healthcare Settings

The connection between hand hygiene and prevention of HAIs has been an important issue in health care settings since the late 1800s when Semmelweis made an observational association between maternal morbidity and contaminants on HCPs' hands. While techniques to improve this matter have been attempted since then, no formal guidance was available to HCPs until 1981 (World Health Organization [WHO], 2009). In 2009, the WHO released their most recent hand hygiene guidelines, providing a review of the science behind hand hygiene, consensus recommendations based on varying clinical and research evidence, suggestions for how to monitor hand hygiene processes and outcomes in health care settings, comparison of various hand hygiene strategies, and insight into various techniques used for hand hygiene improvement. Key among the recommendations was the identification of "five moments" requiring hand hygiene. These moments are identified as the following: before patient contact, after patient contact, before a clean or aseptic procedure, after potential exposure to body fluids, and after contact with patient surroundings. Establishing these minimal expectations for hand hygiene opportunities allows quantification rates of hand hygiene compliance among HCPs.

According to the Agency for Healthcare Research and Quality (AHRQ), hand hygiene is particularly important in the health care setting due to situational increases in susceptibility for patient infection with microorganisms (Hughes, 2008). For example, organisms are potentially more virulent due to increased antibiotic resistance among HAIs. Additionally, patients are at increased risk for an infection due to the invasive nature of procedures in operating rooms (Hughes, 2008). This combination places patients in the perianesthesia setting at an increased risk of developing HAIs that could increase morbidity and mortality.

Hand Hygiene in Anesthesia Settings

While adherence to strict hand hygiene routines is an undisputed requirement for the provision of safe patient care, it is unlikely that any clinical setting in the world has developed and implemented a technique without flaws (WHO, 2009). Studies describing gaps and barriers to hand hygiene are plentiful in research literature, yet information specific to anesthesia care remains limited.

Early research linking HAIs to anesthesia settings was not specific to hand hygiene. Among the early studies, Tait and Tuttle (1995) conducted a survey to determine anesthesiologist compliance with infection control measures (including hand hygiene) in the anesthesia care. In this study, only 58% of respondents reported performing hand hygiene after any patient contact. In a 2002 study by Askarian and Ghavanini evaluating anesthesia personnel adherence to infection control practices, the use of gloves was reported at 17.4%, with 28.4% of individuals reporting hand hygiene before donning gloves. As early as 2000, Hajjar and Girard described the existence of anesthesia related bacterial HAIs, though very limited research was conducted to evaluate factors contributing to these occurrences.

Due to the exposure of anesthesia related transmission of blood borne viral infections (Hepatitis, HIV) starting in the early 2000s, infection control topics in anesthesia literature primarily focused on prevention of blood borne illness through safe injection practices (Wilson, 2008). It was not until the late 2000s that hand hygiene and anesthesia workstation practices were evaluated to determine their contribution to the development of bacterial HAIs. Contamination of anesthesia workstations and stopcock sets were determined to place patients at increased patient mortality rates, with the source of contamination hypothesized to be the

anesthesia professionals' hands (Loftus et al., 2008). In 2011, the same researchers tested this hypothesis and determined that while not responsible for all HAIs in the anesthesia setting, the hands of anesthesia professionals were a significant source of bacterial contamination. Armed with this information, one of the first studies quantifying hand hygiene among anesthesia professionals was conducted (Biddle & Shah, 2012). In this study, the researchers determined through observation that hand hygiene opportunities for anesthesia professionals was approximately 40 times per hour, and that the aggregate failure rate for hand hygiene performance was 82%.

Barriers to Hand Hygiene Adherence in Anesthesia Settings

Barriers to implementation of hand hygiene improvement are varied and include professional, individual, and institutional factors. These different factors require exploration in order to determine the extent to which they are modifiable. Additionally, these factors may affect the duration of improvement from campaigns implemented to improve hand hygiene.

Professional barriers.

While anesthesia is unique in that the patient provider relationship is limited to a single patient paired with one or more anesthesia professionals, hand hygiene continues to be a relevant and difficult to tackle subject from a professional standpoint. Chief among the barriers to hand hygiene among anesthesia professionals is found within the nature of the tasks required to provide a safe anesthetic. For example, during the induction of an anesthetic, the anesthetist must perform a series of time sensitive actions to secure a patient's airway and promptly ensure an adequate level of anesthesia. These actions result in high exposure to mucous membranes, patient skin, and surroundings, with a high risk of cross contamination from the environment to the patient and vice versa (Loftus et al., 2011). The promptness required for these activities does

not allow for a full hand hygiene cycle between each task, as this would place the patient in danger, even in the most ideal conditions. In less than ideal conditions (e.g., difficult airway, cardiovascular compromise), the deftness with which these tasks must be performed is amplified, resulting in even less time for adequate hand hygiene.

In 2008, the American Society of Anesthesiologists (ASA) released the third revision of their recommendations for infection control in the practice of anesthesia. Within these recommendations, the ASA listed indications for hand hygiene within the anesthesia setting. These included the following: before and after contact with patients, before using sterile gloves, after contact with body fluids, broken skin, or mucous membranes, after contact with a contaminated body site, after contact with high touch surfaces in the vicinity of the patient, after removal of gloves, before eating, and after using the restroom. Similar to the WHO recommendations issued the following year, the ASA recommendations included key moments during which the risk of contamination and cross contamination were the greatest. Beyond these indications for hand hygiene, the ASA acknowledged the time constraints within anesthesia practice by including a Hand Hygiene Algorithm in their 2008 recommendations. In the algorithm, a key decision moment for appropriate hand hygiene is made when considering if there is enough time to perform hand hygiene before another task must be completed. If there is enough time, the algorithm recommends using a hand sanitizer upon removing gloves after a task. If there is not enough time, the algorithm recommends changing gloves and repeating the algorithm until there is enough time to adequately perform hand hygiene using a hand sanitizer. As an alternative to changing gloves, the ASA suggests double gloving in order to remove the outer contaminated glove prior to touching environmental surfaces. While the 2008 ASA recommendations acknowledge that changing gloves does not replace the need for performing

hand hygiene, they serve to provide a realistic set of recommendations for individuals involved in anesthesia practice.

Individual barriers.

Individual barriers to performance of hand hygiene are among the most potentially modifiable. In a survey of various HCPs, the reported reasons for not performing hand hygiene from most reported to least reported included forgetting, not believing hands were dirty, not planning on touching anyone or anything, believing that touching anything was dirtier than not washing hands, and not believing that hand washing prevents the spread of disease (McLaughlin & Walsh, 2012). Through proper education, these reported reasons can all be addressed by modification of beliefs leading to these reasons. But evidence exists that education alone may not result in a long-term improvement of hand hygiene compliance (Duggan, Hensley, Khuder, & Papadimos, 2008; Martino et al., 2011; Mortell, 2012). One hint of this problem is the frequent reporting of research studies showing an inverse correlation between professional level of education and hand hygiene frequency and sustainability after an intervention aimed at increasing hand hygiene adherence.

Another major barrier to hand hygiene at the individual level is the preference of individual HCPs in accepting a particular hand sanitizer. Reasons reported for not wanting to use a particular hand sanitizer include skin sensitivity, drying time, fragrance, “stickiness” of hands after use, and color of product (McLaughlin & Walsh, 2012; WHO, 2009). Manufacturers of hand hygiene products have addressed these reasons by developing newer products, but oftentimes cost savings decisions limit the availability of products within an institution (Cantrell, 2012; WHO). The decision for selecting a hand sanitizer requires significant consideration in order to achieve high levels of compliance for a campaign to encourage hand hygiene. The WHO

recommends that in addition to antimicrobial profile and cost, user acceptance be a major determinant for selection of a particular product.

Institutional barriers.

Barriers at the institutional level are primarily considered to be situational and therefore modifiable by proper planning and ergonomic design. Among the reasons reported by HCPs for not performing hand hygiene attributable to institutional barriers, availability and proximity to a hand sanitizer were the most common reasons reported (McLaughlin & Walsh, 2012). The constant vigilance required of an anesthetist does not allow for the anesthetist to leave the operating room to wash the hands with soap and water at a sink. Hand sanitizers, therefore, are necessary, but limitations on the availability of hand sanitizers continue to be a barrier. Fears of hand sanitizers presenting a fire hazard in the operating room due to their high alcohol content are occasionally cited as reasons for limiting selections of hand sanitizers (WHO, 2009). All alcohol based hand sanitizers are potentially flammable, and users are instructed to follow manufacturer instructions on preventing exposure to ignition sources, including static electricity. For this reason, the placement of hand sanitizers was at one time banned from corridors of egress for fear of building up static electricity (WHO). Due to the structure of the operating room, this limited the locations in which hand sanitizer could be located, limiting access by anesthetists and other operating room personnel. Despite these bans being reversed, the lack of sufficient availability of hand sanitizers in operating rooms continue.

Hand Hygiene Improvement Strategies

Improvement of hand hygiene adherence is the goal of campaigns aimed at promoting hand hygiene among HCPs. While many organizations and researchers have employed and promoted a plethora of varied and individualized strategies to improve hand hygiene adherence,

there is very little evidence of any long-term improvement after any intervention. An evaluation of different strategies described by researchers and organizations will serve to identify common techniques employed. This will enable a critique of the current state of evidence in this area of research.

Researcher Based Interventions

Strategies intended to improve hand hygiene adherence among HCPs from various settings were evaluated. While some researchers employed single interventions, a majority of interventions were multi-modal. Follow up periods varied among the different studies, and often reflected some degree of recidivism. A majority of studies were quasi-experimental in design. Only one systematic review was found describing strategies employed to improve hand hygiene.

Single interventions described by researchers included the introduction of a particular device intended to increase hand hygiene frequency and the employment of a single behavioral process. Koff et al. (2009) described the use of a hand held device attachable to a pocket and capable of counting the number of times it is used. Compared to the standard placement of hand sanitizer on anesthesia workstations, the study reported that use of the new device was associated with improved hand hygiene rates among the group selected to use the device, with a significant reduction in the number of HAIs subsequently developed by patients at follow up. No information is available about the long-term adherence using this technique.

Marra et al. (2011) evaluated the introduction of a single behavioral process for improvement of hand hygiene among HCPs. These researchers used the *positive deviance* behavioral technique to promote hand hygiene among their study group. Individuals identified as willing to champion and problem solve unit specific barriers to hand hygiene, while encouraging their peers to do so. In effect, the motivation to “buy in” was encouraged by a respected peer,

allowing a more sustainable improvement in hand hygiene compliance. A follow up period of 20 months was included in the analysis, showing that sustained improvement resulted in less HAIs in the units employing positive deviance techniques.

Among the studies employing multimodal techniques, common elements included the presence of an educational component, reinforcement of education periodically, as well as visual cues to perform hand hygiene. Results of multimodal interventions were mixed. In one study, an improvement in hand hygiene over a one year period was reported, yet the data indicating an improvement was limited to particular variables measured, and not significant overall (Eveillard et al., 2011). In a study limited to operating room staff, progressive improvement and overall improvement was demonstrated at four years after intervention (Bellard-Smith & Gillespie, 2012). Another study showed that after a multimodal intervention, improvement in hand hygiene practices was demonstrated initially and at one year following the intervention (Martino et al., 2011). Interestingly, the degree of sustained improvement varied according to profession, with physicians showing poorly sustained improvement.

Unfortunately, most studies conducted by researchers to improve hand hygiene have failed to meet methodological tests of rigor. In a systematic review of studies on hand hygiene improvement (Gould, Moralejo, Drey, & Chudleigh, 2011), 49 studies were identified, with only four studies meeting criteria for inclusion. One randomized controlled trial and three quasi-experimental design studies were included in the review. The results of this review indicated that there continue to be significant sources of bias in data collection (e.g. direct observation, self-reported behaviors) in study designs, and that while multimodal interventions appear to hold promise, there is insufficient evidence to recommend any type of intervention for hand hygiene

improvement. The authors recommended that further research was needed in this area, with more focus on developing robust study designs.

Organizational Based Interventions

The WHO Multimodal Hand Hygiene Improvement Strategy is similar to what is seen conducted by individual researchers (WHO 2009). The WHO recommends a baseline measurement of hand hygiene compliance rates, a post intervention measurement, and a follow up measurement. This program has been pilot tested in several facilities around the world, with a review of the positive and negative aspects of implementing this program. This particular strategy emphasizes five key changes that must occur for successful implementation. The key changes are education, access to hand hygiene supplies, hand hygiene monitoring and feedback, workplace reminders, and development of a culture valuing hand hygiene. The positive aspect of this strategy reported by facilities in which it was implemented was that it was very detailed and comprehensive. Limitations were based on requests for a simplified version, a version suitable for implementation in resource poor countries, and applicability to non-hospital healthcare facilities (WHO, 2009). Results reported on implementation of the WHO strategy were based on quasi-experimental study designs. A majority of the studies implementing the WHO strategy reported improvement in rates of HAIs. Regardless, the WHO acknowledged that no definitive causal link could be established because of uncontrolled studies, presence of confounding factors, and poor statistical significance. Similar to the recommendations issued by the systematic review conducted by Gould et al. (2010), further studies are required in order to definitively recommend any particular intervention, including the WHO strategy.

Summary

The current state of research in strategies for improving hand hygiene among HCPs is limited in quantity and quality. Interventions aimed at anesthetists in particular are even more limited. There is no question that proper hand hygiene is essential in preventing HAIs. Hand hygiene practices in anesthesia settings are in need of improvement. While limited definitive guidance exists on which methods are superior for improving hand hygiene among HCPs, this is an area that is in need of change. Devising an intervention and implementing it using a well-designed study will potentially improve the practice of anesthesia and patient outcomes.

Chapter Three: Methods

A prospective quasi-experimental design was used to fulfill the purpose of this quality improvement doctorate of nursing practice project. Data was collected at four distinct points between May of 2013 and November of 2013. This chapter includes a description of the setting and sample for this quality improvement project, followed by a discussion of the methods and procedures for the study, including the protection of human subjects.

Setting and Sample

Setting

Data collection for this project took place in the main operating room setting of a 335 bed, not-for-profit general acute care community hospital in northeast Florida. The anesthesia department consists of approximately 40 anesthesia professionals including physician anesthesiologists, certified registered nurse anesthetists, student registered nurse anesthetists, and anesthesiologist assistants. Within the operating room are anesthesia workstations and supply carts stocked for use by anesthesia professionals from which data was specifically collected for this project. Only data collected from operating rooms were included in this study (i.e., data not collected from rooms used solely for endoscopy or cystoscopy). A total of eleven workstations were used to collect data.

Sample

The sample consisted of measurements of amounts of hand sanitizer used in the anesthesia workstation and supply cart in the main operating room setting. At the hospital, hand sanitizer provided on the anesthesia supply cart is provided in the form of a gel in a bottle placed

on a visible surface at eye level. In order to limit bias potentially introduced by the project, neither the existing hand sanitizer used by the anesthesia department nor the placement on the anesthesia supply cart were altered.

Intervention

For this project, the intervention consisted of education on the most current information regarding hand hygiene research in the anesthesia setting. This method was selected as there is no conclusive evidence to support one type of intervention over another in the area of hand hygiene improvement, and education had previously been used to successfully improve poor infection control syringe practices among anesthesia professionals. Since many anesthesia professionals may be unaware that hand hygiene adherence rates among the profession are low, this was intended to highlight the need for improvement in this area. The information was presented in a format typically used within the anesthesia department for presentation of anesthesia related research and information to staff. This consisted of a poster presentation and an educational flyer. The poster (Appendix A) was placed in a prominent location within the anesthesia department office, where anesthesia staff typically clock in and takes breaks. This is presented in figure 3.1. The educational flyer (Appendix B) consisted of key information presented in the poster, and placed on the anesthesia workstation under a plastic surface protector, a location typically used to reinforce important information to staff in an easy to access location. This is presented in figure 3.2. After baseline data was collected, both formats were deployed simultaneously and maintained throughout the duration of the project.

Data Collection

Information collected for this project was limited to the amount of hand sanitizer used at anesthesia workstations within the hospital's main operating room setting. The amounts of hand

sanitizer were obtained through measuring the amount used during a seven-day period, referred to as a *measurement period*. For this study there were four separate measurement periods: a baseline measurement period prior to any intervention, and three separate measurement periods one month apart beginning immediately after deployment of the intervention.

Data for amounts of hand sanitizer used was collected using a consistent technique throughout the project. The same weight scale was used throughout the project, and tared to zero prior to each measurement. Hand sanitizer bottles were discreetly labeled to ensure that the same bottle was measured both before and after each measurement period. Weights for each bottle were recorded both before and after each measurement period. Differences between these values represented the amount of hand sanitizer used during the measurement period for each particular anesthesia workstation.

Figure 3.1. Poster Presentation Location

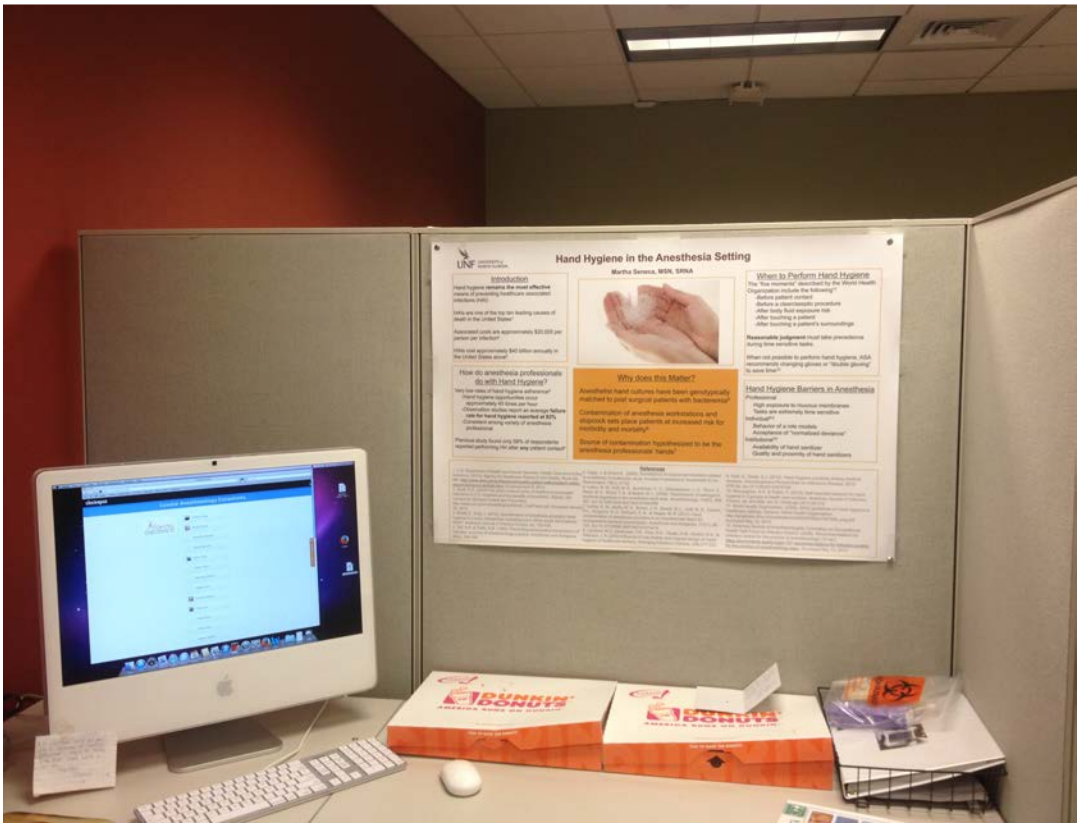


Figure 3.2. Educational Flyer Location on Anesthesia Workstation

Protection of Human Subjects

The Institutional Review Boards (IRB) for a state university and the community hospital were contacted and a research proposal was provided. Due to the project being considered as not including human subjects, exemptions were obtained from both facilities. IRB exemption letters can be found in Appendix C and Appendix D.

Chapter Four: Results

In this section, data collected from the study is presented. Tables will be presented to illustrate the data collected for all measurement periods. Baseline data represent the measurement period prior to the intervention. Subsequent numbered measurement periods represent data collected after deployment of the intervention at monthly intervals. Differences between the various measurement periods will be presented in graphical form.

Data Presentation

Each measurement period consisted of hand sanitizer bottle weights at both the beginning and the end of the seven-day cycle. This was used to determine the amount of hand sanitizer used for each measurement period per anesthesia workstation. Amounts of hand sanitizer used are presented in table 4.1. The change over time for the average amount of hand sanitizer used per measurement period is presented in figure 4.1.

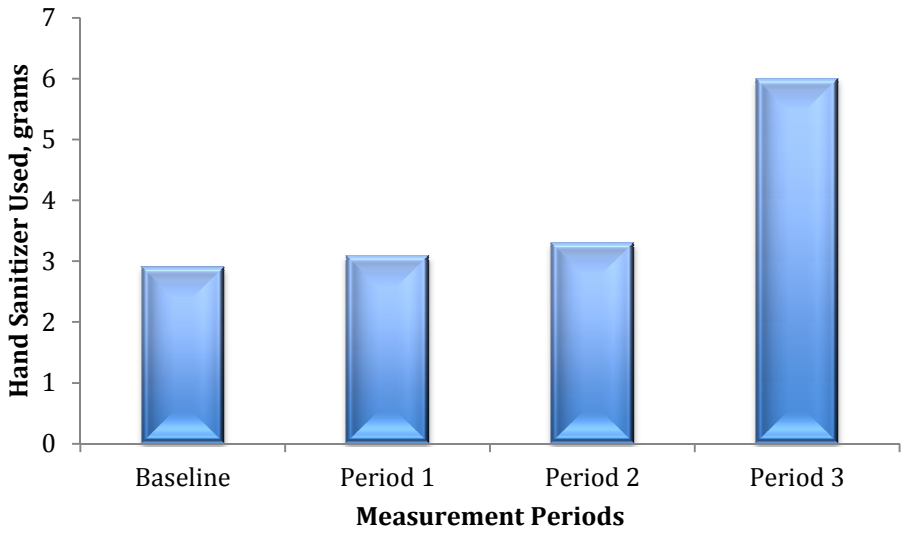
Table 4.1

Amount of Hand Sanitizer Used per Workstation per Measurement Period in Grams

Station	Baseline	Period 1	Period 2	Period 3
1	1	1	7	7
2	1	3	1	1
3	2	5	2	2
4	4	1	2	1
5	2	7	8	16
6	3	7	2	9
7	-[a]	4	1	9
8	7	1	3	6
9	3	1	6	14
10	4	0	1	1
11	2	4	-[a]	0
Average	2.9	3.09	3.3	6

[a] Indicates data collection unsuccessful due to loss of pre measured bottle after initial measurement.

Figure 4.1. Average Amount of Hand Sanitizer Used per Measurement Period



Outcome

Based on the data presented, during the study period, the average amount of hand sanitizer used per anesthesia workstation doubled from the baseline measurement taken prior to the intervention used in this study.

Chapter Five: Discussion

In this chapter, results found in this project are interpreted. This will be followed by a discussion of the significance of the results. The limitations encountered during this project will then be discussed, along with future recommendations and a conclusion.

Result Interpretation

Interpretation of the data in this project is an important step in evaluating the significance of the information collected. At first glance, the results show that the average amount of hand sanitizer used doubled from baseline to the conclusion of the project. Typically, this would be considered an encouraging finding, but further interpretation of the data reveals a less than ideal result.

The manufacturer of the hand sanitizer used in the setting of this project states that a two-ounce bottle should yield approximately 30 uses per bottle if used as directed (GOJO Industries, 2014). This amounts to approximately 2 grams per use if the product is used appropriately. An average increase from 2.9 grams to 6 grams used per week indicates that on average, appropriate hand sanitation occurrence increased from 1.5 times to 3 times per workstation per week. Even if the amount of hand sanitizer used per occurrence is reduced to 0.5 grams per use (as may typically occur if using a dime sized portion), the average occurrence of hand hygiene per workstation per week went from 6 times to 12 times. Prior studies have indicated that on average, there are 40 hand hygiene opportunities per hour in the anesthesia setting (Biddle & Shah, 2012). In this context, a doubling of the amount of hand sanitizer used per week continues to indicate that hand hygiene is a relatively rare occurrence at the anesthesia workstation.

Significance of Results

While the aim of this project was to improve anesthesia professional adherence to hand hygiene, the results indicate that though some improvement occurred after the intervention, in context of the overall low frequency of hand sanitizer use, the most significant finding was the extremely low rate of hand sanitizer use. This indicates that hand hygiene is occurring at very low rates, and at times, perhaps not occurring. This finding is not atypical, and is consistent with the findings of prior studies describing poor hand hygiene performance rates (Biddle & Shah, 2012; Tait & Tuttle, 1995).

While the average amount of hand sanitizer used increased minimally throughout the project, evaluating the individual workstations reveals a potentially more complicated finding. Some workstations showed no increase or even a decrease in hand sanitizer use. Others revealed up to an eightfold increase in the amount of hand sanitizer used at those workstations. While it is not possible to determine why this is the case, it is possible that individual professionals were differently affected by the educational intervention. This can only be determined through direct observation of practices by individual anesthesia professionals at different points in time.

Limitations and Future Recommendations

The most significant limitation of this project was due to the nature of maintaining complete anonymity as well as limitations in feasibility to carry out the project. As a result, the amount of hand sanitizer used was calculated based on a difference between measurements in a seven-day period. This does not account for spills, differences among providers, hours of anesthesia provided per workstation per week, or even the use of other hand sanitizers available to anesthesia professionals. To improve on errors introduced due to spills, variations in active

workstation time, and determining differences between anesthesia providers, a direct observation technique would need to be employed. Additionally, while foam sanitizers are available in the perioperative setting, throughout the measurement period, none were observed on anesthesia workstations. As anesthesia professionals typically do not veer far from the anesthesia workstation, the use of other hand sanitizers during direct anesthesia care is unlikely, but remains unaccounted for in this project.

For future projects of this kind, a direct and anonymous observation technique would allow a researcher to more accurately determine the quality and frequency of hand hygiene. Additionally, the presence of a stationary and easily accessible hand sanitizer dispenser with uniform amounts of hand sanitizer dispensed would help improve on determining the frequency of hand hygiene, regardless of whether a direct observation or indirect measurement technique was used. A project of longer duration would also allow a researcher to determine if changes in amount of hand sanitizer used was caused by seasonal differences, changes in hand hygiene habits, or even to determine if a regression to prior hand hygiene habits occurred after some improvement.

Implications for Practice

Patient safety is a culmination of multiple factors, of which infection control practices represent one, albeit interconnected, facet. Infection control issues in the anesthesia setting are unique in that while there are areas that receive a high degree of attention (i.e. syringe, needle, and singe-use vial reuse), other areas receive very little attention (i.e. hand hygiene and workstation sanitation). It is not uncommon for anesthesia professionals to scoff at bringing attention to hand hygiene practices within the profession, yet hand hygiene remains one of the most effective tools for preventing potentially life threatening and costly HAIs (CDC, 2012).

Published studies evaluating rates of hand hygiene performance among anesthesia professionals consistently indicate very poor adherence to the WHO recommendations for hand hygiene performance moments (Biddle & Shah, 2012; Munoz-Price et al., 2013; Scheithauer et al., 2013; WHO, 2009). With evidence indicating that anesthesia professionals' hands are a source of infection transmission to patients, it is unacceptable (both ethically and financially) to continue to accept this degree of non-adherence (Loftus et al., 2011). While this project aimed to improve hand hygiene adherence among anesthesia professionals, it succeeded in reinforcing the dire need for evaluating and creating a change in the culture of anesthesia professionals regarding hand hygiene practices.

Key to changing hand hygiene practices within the anesthesia profession is to understand why current practices exist. While workflow and task density have been cited as reasons for low rates of hand hygiene among anesthesia professionals, rates remain low during periods of low task density (Munoz-Price et al., 2013). Instead, essential to understanding current hand hygiene practices is the concept of *normalization of deviance*.

Coined by a sociologist in describing conditions leading up to the National Aeronautics and Space Administration (NASA) Challenger tragedy, normalization of deviance is the process of gradually accepting situations or conditions previously considered unusual or unacceptable to the point where they are accepted as normal conditions (Vaughan, 1996). This concept is applicable in the anesthesia setting, and is most evident when patient safety is potentially compromised for the sake of cost savings and efficiency. The pressure of production and the insular nature of anesthesia in operating room culture can both contribute to a compromise in patient safety (Kirsner & Biddle, 2012). Procedures and processes in anesthesia may be rushed in order to accommodate schedules and room turnovers, with many patient safety measures ignored

or even not performed. Lack of adequate equipment or supplies in response to cost savings can compromise the performance of standard safety precautions. Examples of these types of normalized deviance in anesthesia include removal of monitors prematurely to facilitate room turnover, lack of neuromuscular blockade monitoring, non-sterile performance of invasive procedures, and failure to perform hand hygiene at appropriate times (Prielipp, Magro, Morell, & Brull, 2013). With the anesthesia workstation often managed by a sole provider, otherwise unacceptable practices can develop with little accountability and remain until scrutinized in response to a significant event as occurred in publicized cases of blood borne infection transmission due to unacceptable practices (Kirsner & Biddle, 2012).

In light of these factors, a successful change in hand hygiene habits among anesthesia professionals requires the development of interventions specifically tailored to anesthesia workflow and culture. In a recent study by Scheithauer et al. (2013) aiming to improve hand hygiene among anesthesia professionals, three major changes were implemented resulting in improvement of adherence rates. Aside from improvement in access to hand sanitizers and teaching programs, a change in the frequency of hand disinfection was implemented. This occurred by observing existing practices and developing standardized ways to perform main processes in anesthesia practice in a way minimizing the occurrence of hand contamination requiring hand hygiene. These processes were then taught to anesthesia professionals, and feedback provided on an individual basis for appropriately performing these standardized procedures. Perhaps it is this type of innovative and profession specific intervention that is required for any significant improvement in this area.

Conclusion

Improving hand hygiene practices of anesthesia professionals remains a significant infection control challenge. Poor practices have been shown to exist in published literature as well as anecdotally among professionals. The normalization of less than ideal anesthesia professional practices is among the biggest obstacles in improving adherence to proper hand hygiene. While change in this area may be slow, opportunity exists for a significant shift in behavior as existing professionals enter retirement age (Munoz-Price & Birnbach, 2013). Programs designed to optimize task workflows conducive to hand hygiene in anesthesia may be a key to effect change in this area, especially as newer providers enter the profession.

Appendix A: Poster Presentation

UNF UNIVERSITY of NORTH FLORIDA

Hand Hygiene in the Anesthesia Setting

Martha Seneca, MSN, SRNA

Introduction

Hand hygiene **remains the most effective** means of preventing healthcare associated infections (HAI)

HAIs are one of the top ten leading causes of death in the United States[1]

Associated costs are approximately $20,000 per person per infection[2]

HAIs cost approximately $40 billion annually in the United States alone[2]

When to Perform Hand Hygiene

The "five moments" described by the World Health Organization include the following[11]

- -Before patient contact
- -Before a clean/aseptic procedure
- -After body fluid exposure risk
- -After touching a patient
- -After touching a patient's surroundings

Reasonable judgment must take precedence during time sensitive tasks.

When not possible to perform hand hygiene, ASA recommends changing gloves or "double gloving" to save time[12]

How do anesthesia professionals do with Hand Hygiene?

Very low rates of hand hygiene adherence[3]

- -Hand hygiene opportunities occur approximately 40 times per hour
- -Observation studies report an average **failure rate for hand hygiene reported at 82%**
- -Consistent among variety of anesthesia professional

Previous study found only 58% of respondents reported performing HH after **any** patient contact[4]

Why does this Matter?

Anesthetist hand cultures have been genotypically matched to post surgical patients with bacteremia[5]

Contamination of anesthesia workstations and stopcock sets place patients at increased risk for morbidity and mortality[6]

Source of contamination hypothesized to be the anesthesia professionals' hands[7]

Hand Hygiene Barriers in Anesthesia

Professional

- High exposure to mucous membranes
- Tasks are extremely time sensitive

Individual[8,9]

- Behavior of a role models
- Acceptance of 'normalized deviance'

Institutional[10]

- Availability of hand sanitizer
- Quality and proximity of hand sanitizers

References

U.S. Department of Health and Human Services. *Health Care-Associated Infections*. (2013). Agency for Healthcare Research and Quality. Rockville, MD. http://www.ahrq.gov/professionals/quality-patient-safety/patient-safety-resources/resources/hais.html. Accessed April 9, 2013.

Scott, R.D. (2009) The direct medical costs of healthcare-associated infections in U.S. hospitals and the benefits of prevention. Atlanta, GA: Centers for Disease Control and Prevention. http://www.cdc.gov/ncidod/dhqp/pdf/Scott_CostPaper.pdf. Accessed January 30, 2013.

Biddle C, Shah J. (2012). Quantification of anesthesia providers' hand hygiene in a busy metropolitan operating room: What would Semmelweis do? *American Journal of Infection Control*, 40, 756-759.

Tait, A.R. & Tuttle, D.B. (1995). Preventing perioperative transmission of infection: a survey of anesthesiology practice. *Anesthesia and Analgesia*, 81(4), 764-769.

Hajjar, J. & Grant, R. (2000). Surveillance of nosocomial infections related to anesthesia: A multicenter study. *Annales Francaises D'Anesthesie Et De Reanimation*, 19(1), 47-53.

Loftus, R. W., Koff, M. D., Burchman, C. C., Schwartzman, J. D., Thorp, V., Read, M. E., Wood, T. A., & Beach, M. L. (2008). Transmission of pathogenic bacterial organisms in the anesthesia work area. *Anesthesiology*, 109(3), 399-407. doi: 10.1097/ALN.0b013e3181822856

Loftus, R. W., Muffly, M. K., Brown, J. R., Beach, M. L., Koff, M. D., Corwin, H. L., Surgenor, S. D., Kirkland, K. B., & Yeager, M. P. (2011). Hand contamination of anesthesia providers is an important risk factor for intraoperative bacterial transmission. *Anesthesia and Analgesia*, 112(1), 98-105. doi:10.1213/ANE.0b013e318fef7ce18

Lankford, M.G, Zamow, R., Trick, W.E., Hacek, D.M., Noskin, G.A., & Peterson, L.R.(2003). Influence of role models and hospital design on hand hygiene of healthcare workers. *Emerging Infectious Disease*, 9(2), 217-223.

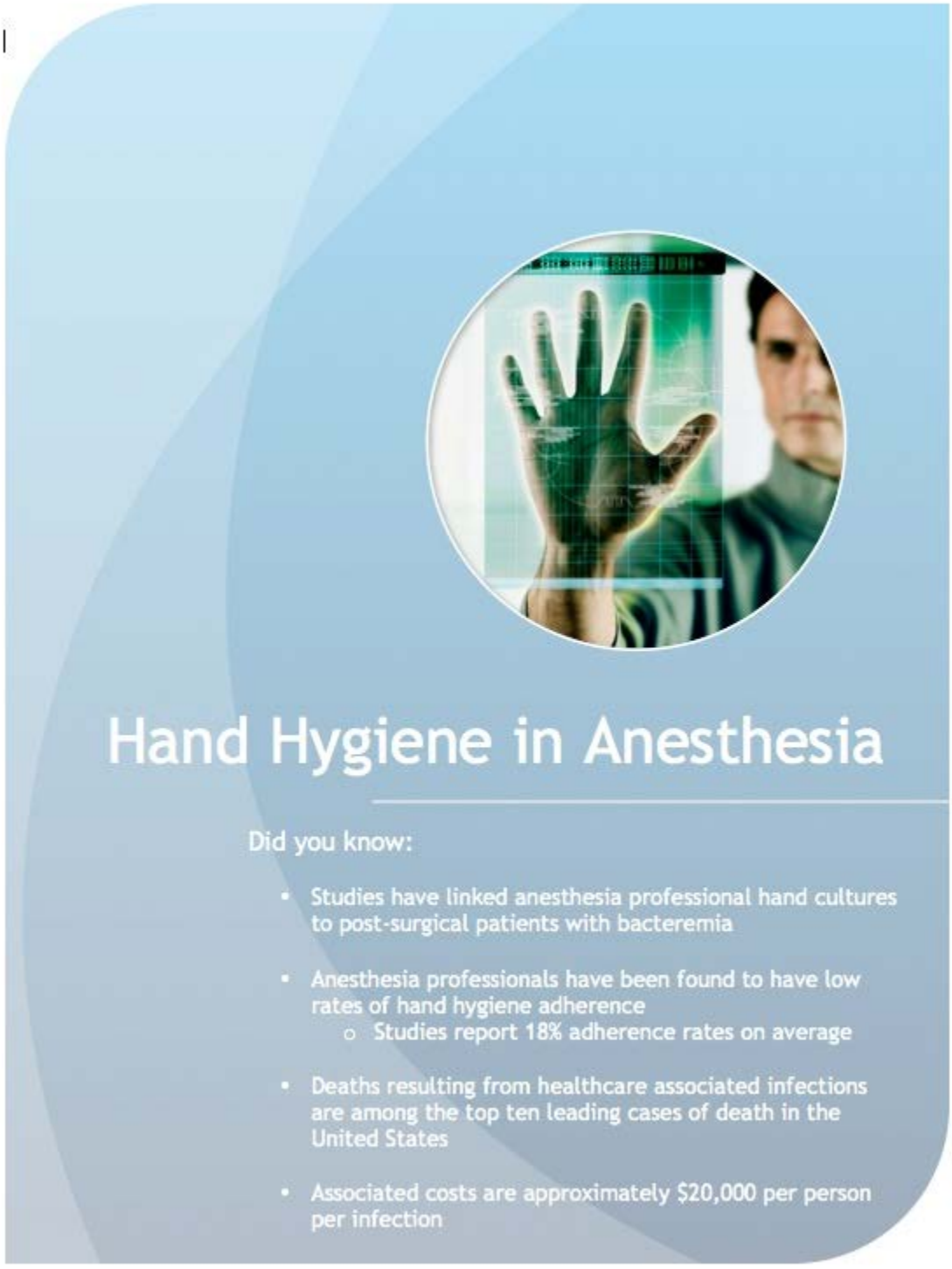
Kadi, A., Salati, S.J. (2012). Hand hygiene practices among medical students. *Interdisciplinary Perspectives on Infectious Disease*, 2012: 679129. doi 10.1155/2012/679129

McLaughlan, A.C. & Walsh, F.(2012). Self-reported reasons for hand hygiene in 3 groups of health care workers. *American Journal of Infection Control*, 40: 653-658. doi 10.1016/j.ajic.2011.08.014

World Health Organization. (2009). WHO guidelines on hand hygiene in healthcare settings. Geneva: World Health Organization. http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf Accessed May 13, 2013

American Society of Anesthesiologists Committee on Occupational Health Task Force on Infection Control. (2008). *Recommendations for infection control for the practice of anesthesiology* (3rd ed.). https://recommend.asahq.org/o-127-recommendations-for-infection-control-for-the-practice-of-anesthesiology.aspx. Accessed May 13, 2013

Appendix B: Educational Flyer



Appendix C: University of North Florida IRB Exemption

UNF
UNIVERSITY of NORTH FLORIDA.

Office of Research and Sponsored Programs
1 UNF Drive
Jacksonville, FL 32224-2665
904-620-2455 FAX 904-620-2457
Equal Opportunity/Equal Access/Affirmative Action Institution

MEMORANDUM

DATE: April 2, 2013

TO: Dr. Patrick W. Monaghan
NAP

FROM: Dr. Krista Paulsen, Chairperson
On behalf of the UNF Institutional Review Board

RE: Review by the UNF Institutional Review Board IRB#440064-1:
"IMPROVING ANESTHESIA PROVIDER ADHERENCE TO HAND HYGIENE"

This is to advise you that your project, "IMPROVING ANESTHESIA PROVIDER ADHERENCE TO HAND HYGIENE," was reviewed on behalf of the UNF Institutional Review Board. Although your project will be a systematic investigation designed to develop or contribute to generalizable knowledge, your reviewer determined that the research does not involve obtaining information about living individuals because the educational intervention would take place regardless of the research and no identifiable information will be collected from or about participants. Based on the above information, this project was declared "not research involving human subjects" based on the federal definition of "Human Subject" as stated in the U.S. Department of Health and Human Services Code of Federal Regulations 46.102.

Therefore, it is not necessary for this project to be reviewed and approved by the UNF IRB prior to initiation. This waiver should be kept for your records and applies to your project in the form and content as submitted to the IRB for review. Any variations or modifications to this waived project as related to dealing with human subjects must be cleared with the IRB prior to implementing such changes.

Thank you for submitting your work for IRB review. We appreciate that you understand the value of IRB review of research and projects conducted at UNF. Should you have any questions or if we can be of further service, please contact Kayla Champaigne

Appendix D: Flagler Hospital IRB Exemption

FLAGLER HOSPITAL
ST. AUGUSTINE
400 Health Park Boulevard
St. Augustine, Florida 32086
(904) 819-5155
www.flaglerhospital.org

Flagler Hospital
Institutional Review Board (IRB)
IRB# 00006886
Initial Review

Date: 7/2/12

To: Martha Seneca, MSN, RN (Principal Investigator)

Signature Deleted

From: Joseph Gordy, FACHE (Chairman, IRB)
Name

Protocol: Improving Anesthesia Professional Adherence to Hand Hygiene

Please be advised, your progress report was reviewed by the IRB and determined to be **Exempt** on 7/29/2013. The IRB is recommending the following:

☒ Approved - Exempt

☐ Approved, contingent upon: _____
- Once the contingency is met, the IRB will issue a letter of approval, noting you have met the standards outlined above, under the approved section.

☐ Not Approved, based on the following: _____

If you have any questions or comments, please contact Kari Bates

References

American Association of Nurse Anesthetists (2007). *Scope and standards for nurse anesthesia practice*. Retrieved from http://www.aana.com/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=26675

American Society of Anesthesiologists Committee on Occupational Health Task Force on Infection Control. (2008). *Recommendations for infection control for the practice of anesthesiology (3rd ed.).* Retrieved from https://ecommerce.asahq.org/p-137-recommendations-for-infection-control-for-the-practice-of-anesthesiology.aspx

Askarian M. & Ghavanini A.A. (2002). Survey on adoption of measures to prevent nosocomial infection by anaesthesia personnel. *Eastern Mediterranean Health Journal, 8*(2-3), 416-421.

Bellaard-Smith, E. R., & Gillespie, E. (2012). Implementing hand hygiene strategies in the operating suite. *Healthcare Infection, 17*(1), 33-37. doi:10.1071/hi12002

Bennett, S. N., McNeil, M. M., Bland, L. A., Arduino, M. J., Villarino, M. E., Perrotta, D. M., Burwen, D. R., Welbel, S. F., Pegues, D. A., Stroud, L., Zeitz, P. S., & Jarvis, W. (1995). Postoperative infections traced to contamination of an intravenous anesthetic, propofol. *The New England Journal of Medicine, 333*(3), 147-154. doi: 10.1056/NEJM199507203330303

Biddle, C. (2009). Semmelweis revisited: Hand hygiene and nosocomial disease transmission in the anesthesia workstation. *AANA Journal, 77*(3), 229-237.

Biddle, C., & Shah, J. (2012). Quantification of anesthesia providers' hand hygiene in a busy metropolitan operating room: What would Semmelweis think? *American Journal of Infection Control, 40*, 756-759. doi:10.1016/j.ajic.2011.10.008

Cantrell, S. (2012, October). Healthcare facilities strive to hand infections defeat. *Healthcare Purchasing News,* pp. 22, 24, 26, 28, 30.

Centers for Disease Control and Prevention (2012). Healthcare-associated infections. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Retrieved from http://www.cdc.gov/hai/

Duggan, J. M., Hensley, S., Khuder, S., Papadimos, T. J. (2008). Inverse correlation between level of professional education and rate of handwashing compliance in a teaching hospital. *Infection Control and Hospital Epidemiology, 29*(6), 534-538. doi:10.1086/588164

Eveillard, M., Raymond, F., Guilloteau, V., Pradelle, M.T., Kempf, M., Zilli-Dewaele, M., . . . Brunel, P. (2011). Impact of a multi-faceted training intervention on the improvement of hand hygiene and gloving practices in four healthcare settings including nursing homes,

acute-care geriatric wards and physical rehabilitation units. *Journal of Clinical Nursing, 20,* 2744-2751. doi:10.1111/j.1365.2702.2011.03704.x

GOJO Industries. (2014). Purell: Frequently asked questions. Retrieved from http://www.purell.com/customer-support/faq.aspx

Gould, D.J., Moralejo, D., Drey, N., & Chudleigh, J.H. (2010). Interventions to improve hand hygiene compliance in patient care. *Cochrane Database of Systematic Reviews, 9*, Article no.: CD005186. doi:10.1002/14651858.CD005186.pub3

Hajjar, J. & Girard R. (2000). Surveillance of nosocomial infections related to anesthesia: A multicenter study. *Annales Francaises D' Anesthesie Et De Reanimation, 19*(1), 47-53.

Hughes, R. G. (ed). (2008) Patient safety and quality: An evidence-based handbook for nurses. Rockville (MD): Agency for Healthcare Research and Quality, US

Kirsner, K. & Biddle, C. (2012). Production pressure and a culture of deviance in the insular operating room and the consequences of their "normalization": Have we reached a Hooper moment? *The Internet Journal of Law, Healthcare, and Ethics, 8*(1).

Koff, M. D., Loftus, R. W., Burchman, C. C. Schwartzman, J. D., Read, M. E., Henry, E. S., & Beach, M. L. (2009). Reduction in intraoperative bacterial contamination of peripheral intravenous tubing through the use of a novel device. *Anesthesiology, 110*(5), 978-985. doi:10.1097/01.anes.0000350854.83021.ec

Lessard, M. R. Trepsnier, C. A., Gourdeau, M., & Denault, P. H. (1988). A microbiological study of the contamination of syringes used in anesthesia practice. *Canadian Journal of Anaesthesia, 35*(6), 567-569.

Loftus, R. W., Koff, M. D., Burchman, C. C., Schwartzman, J. D., Thorum, V., Read, M. E., Wood, T. A., & Beach, M. L. (2008). Transmission of pathogenic bacterial organisms in the anesthesia work area. *Anesthesiology, 109*(3), 399-407. doi:10.1097/ALN.0b013e318182c855

Loftus, R. W., Muffly, M. K., Brown, J. R., Beach, M. L., Koff, M. D., Corwin, H L., Surgenor, S. D., Kirkland, K. B., & Yeager, M. P. (2011). Hand contamination of anesthesia providers is an important risk factor for intraoperative bacterial transmission. *Anesthesia and Analgesia, 112*(1), 98-105. doi:10.1213/ANE.0b013e3181e7ce18

Marra, A.R., Guastelli, L.R., Araujo, C.M., Saravia dos Santos, J.L., Filho, M.A., Silva, C.V., . . . Edmond, M.B. (2011). Positive deviance: A program for sustained improvement in hand hygiene compliance. *American Journal of Infection Control, 39*, 1-5. doi:10.1016/j.ajic.2010.05.024

Martino, P., Ban, K.M., Bartoloni, A., Fowler, K.E., Saint, S., and Mannelli, F. (2011). Assessing the sustainability of hand hygiene adherence prior to patient contact in the

emergency department: A 1-year post intervention evaluation. *American Journal of Infection Control, 39*, 14-18. doi:10.1016/j/ajic.2010.06.015

McLaughlan, A.C. & Walsh, F. (2012). Self-reported reasons for hand hygiene in 3 groups of health care workers. *American Journal of Infection Control, 40*, 653-658. doi:10.1016/j.ajic.2011.08.014

Mortell, M. (2012). Hand hygiene compliance: Is there a theory-practice-ethics gap? *British Journal of Nursing, 21*(17), 1011-1014.

Munoz-Price, L.S. & Birnbach, D.J. (2013). Hand hygiene and anesthesiology. *International Anesthesiology Clinics, 51*(1), 79-92.

Munoz-Price, L.S., Lubarsky, D.A., Arheart, K.L., Prado, G., Cleary, T., Fajardo-Aquino, Y., . . . Birnbach, D.J. (2013). Interactions between anesthesiologists and the environment while providing anesthesia care in the operating room. *American Journal of Infection Control, 41*, 922-924.

Prielipp, R.C., Magro, M., Morell, R.C., & Brull, S.J. (2010). The normalization of deviance: Do we (un)knowingly accept doing the wrong thing? *Anesthesia & Analgesia, 110*(5), 1499-1502.

Pugliese, G., Gosnell, C., Bartley, J. M., &Robinson, S. (2010). Injection practices among clinicians in United States health care settings. *American Journal of Infection Control, 38*, 789-798. doi:10.1016/j.ajic.2010.09.003

Schaefer, M. K., Jhung, M., Dahl, M., Schillie, S., Simpson, C., Llata, E., Link-Gelles, R., Sinkowitz-Cochran, R., Patel, P., Bolyard, E., Sehulster, L., Srinivasan, A., Perz, J.F. (2010). Infection control assessment of ambulatory surgical centers. *Journal of the American Medical Association, 303*(22), 2273-2279. doi:10.1001/jama.2010.744

Scheithauer, S., Rosarius, A., Rex, S., Post, P., Heisel, H., Krizanovic, V., . . . Lemmen, S. (2013). *American Journal of Infection Control, 41*, 1001-1006.

Scott, R. D. (2009). The direct medical costs of healthcare-associated infection in U.S. hospitals and the benefits of prevention. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Retrieved from http://www.cdc.gov/HAI/pdfs/hai/Scott_CostPaper.pdf

Siegel, J. D., Rhinehart, E., Jackson, M., Chiarello, L., & the Healthcare Infection Control Practices Advisory Committee (2007). 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings. Retrieved from http://www.cdc.gov/hicpac/pdf/isolation/Isolation2007.pdf

Stucki, C., Sautter, A., Favet, J., & Bonnabry, P. (2009). Microbial contamination of syringes during preparation: The direct influence of environmental cleanliness and risk manipulations on end-product quality. *The American Journal of Health-System Pharmacy,* 66, 2032-2036. doi:10.2146/ajhp070681

Tait, A.R. & Tuttle, D.B. (1995). Preventing perioperative transmission of infection: a survey of anesthesiology practice. *Anesthesia and Analgesia, 80*(4), 764-769.

U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality. (2013). *Health-care associated infections. Retrieved from* http://www.ahrq.gov/professionals/quality-patient-safety/patient-safety-resources/resources/hais.html

Vaughan, D. (1996). *The Challenger launch decision: risky technology, culture, and deviance at NASA*. Chicago, IL: The University of Chicago Press.

Wilson, W. (2008). Public at risk: Addressing the syringe reuse problem in healthcare. Parkridge, IL: American Association of Nurse Anesthetists. Retrieved from http://www.aana.com/newsandjournal/News/Pages/031808-Addressing-the-Syringe-Reuse-Problem-in-Healthcare.aspx

World Health Organization. (2009). WHO guidelines on hand hygiene in healthcare settings. Geneva: World Health Organization. Retrieved from http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf

VITA

Martha Seneca completed her Doctorate of Nursing Practice program in 2014. After graduating from nursing school in 2004, Martha worked in the pediatric oncology unit at Wolfson Children's Hospital. She obtained master's degrees in nursing in 2008 and 2013, specializing in primary care and nurse anesthesia. She currently lives in Jacksonville, Florida with her husband Michael Seneca, also a nurse anesthetist.