THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF HEALTH POLICY & ADMINISTRATION

THE EFFECTIVENESS OF HANDWASHING INTERVENTIONS

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SPRING 2012

A thesis submitted in partial fulfillment of the requirements for a baccalaureate degree in Health Policy & Administration with honors in Health Policy & Administration

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Abstract

PURPOSE: Healthcare providers do not always wash their hands after each patient interaction. The medical community does not definitively agree as to whether hand hygiene, in particular handwashing, is imperative for reducing the spread of illness and infection. This meta-analysis will compare the results from various handwashing interventional studies in order to determine the effectiveness of handwashing in reducing nosocomial infection rates.

METHODS: A literature search was performed to find hand hygiene interventional studies that met the inclusion criteria. After studies were selected that met such criteria, a statistics based meta-analysis was performed using the odds ratio effect-size statistic. The overall effect hand hygiene interventions had on nosocomial infection rates was determined using the odds-ratio statistic.

RESULTS: After performing the literature search, 7 studies were found that matched the inclusion criteria. A meta-analysis was then performed using the odds-ratio statistic to find the effect size. Using the odds-ratio statistic resulted in an effect size of 0.454.

CONCLUSIONS: The odds ratio statistic of 0.454 suggests that improved hand hygiene compliance results in lower rates of nosocomial infections. The improved state of hand hygiene has a significant overall effect on nosocomial infection rates at the facilities in the various studies selected. The overall effect was significant and positive. An increase in hand hygiene compliance on a large scale can dramatically reduce the number of nosocomial infections acquired affecting patients.

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Acknowledgements

I would like to thank the people who contributed to my thesis. I am incredibly appreciative of Dr. Rhonda BeLue for all of her insight and assistance during her supervision of my thesis. Dr. BeLue is my thesis advisor, and I am very grateful for her time, guidance, and support throughout the writing process. I would also like to thank her for the significant impact she has had on my education and college career.

I would also like to thank my faculty reader, Dr. Kyoungrae Jung, who provided me with valuable insight that improved my thesis very much.

Thank you to my parents, Suthan and Sumathy, who have never stopped believing in me. They bore me, raised me, supported me, taught me, and loved me. You will forever be my motivation and inspiration. And final thanks to my younger brother, Nealon, who assisted me with the formatting and always provides his support.

List of Visuals

CHAPTER 1

I. Introduction

Individuals are provided with medical care in order to better their health and quality of life. Unfortunately, while patients are receiving their necessary care, they are sometimes harmed during the process. It has been estimated that hospital-acquired infections killed 1.7 million in 2002 (Klevens et al., 2007). As hospital-acquired infections have resulted in such a significant number of annual deaths, as well as rising costs, a number of educational programs and prevention initiatives have been implemented (Scott, 2009).

A number of studies have proven that healthcare workers hands are common transmitters of pathogens associated with medical care (World Health Organization [WHO], 2006). Hand hygiene has been targeted as the leading action that can be taken to reduce cross contamination and hospital-acquired infections (Tietjen, Bossemayer, & McIntosh, 2003).

Although hand hygiene can be instrumental in reducing hospital-acquired infection rates, hand hygiene compliance is quite poor amongst healthcare professionals (Allegranzi and Pittet, 2009). Physicians and nursing assistants are associated with lower adherence when compared to nurses (Pittet & Boyce, 2002 and Pittet et al., 2004).

A study at the University of Geneva hospital observed an average of 57% of hand hygiene adherence among 163 physicians. Adherence varied depending on specialty: internists had an adherence of 87%, and anesthesiologists had an adherence of 23%. It was noted that physicians practicing in more technical

specialties, like surgery and anesthesiology, had lower adherence (Pittet et al., 2004).

Hand hygiene compliance is usually attributable to knowledge, workload and time constraints, various offerings of hand hygiene agents, and the preference and tolerance for such agents (Pittet et al., 2004). Factors associated with poor adherence include strenuous workloads, providing care with increased risks of cross-contamination, and practicing in technical medical specialties (Pittet et al., 2004). Skin irritation is another factor, which reduces adherence, as the agents can damage skin when used regularly (Pittet & Boyce, 2002).

A number of interventional studies have been done to evaluate hand hygiene compliance and its effects. In most cases compliance improves temporarily, however, after the completion of the observation period, continued improvement is rarely achieved (Pittet et al, 2000). As a result, it is difficult to evaluate the effects improved hand washing compliance can have in reducing nosocomial infections with the current data available.

As there is no current data available, this study's major goal is to evaluate the results of selected interventional studies and determine if there is a relationship between hand hygiene compliance and hospital-acquired infections.

Hospital-Acquired Infections

A hospital-acquired infection is an infection that occurs in a patient after being admitted to a hospital or other healthcare setting; this infection is neither present nor incubating during the time of admission and originates in the hospital.

Such infections, also known as nosocomial infections, can also emerge after the discharge of the patient from the healthcare facility (Benenson, 1995).

Nosocomial infections typically arise from endogenous flora (from the patient's body), hospital-staff contact through cross-contamination, contaminated instruments and needles, or exogenous flora (from the hospital environment) (Tietjen, Bossemeyer, & McIntosh, 2003). Infections that occur most frequently in the hospital setting are infections of the urinary tract, surgical site, pneumonia, and primary bloodstream (Garner, J.S., Jarvis, W.R., Emori T.G., Horan, T.C., & Hughes J.M, 1988).

Microorganisms that are common in the general population typically cause nosocomial infections. Such microorganisms usually cause no or mild illnesses. However, these microorganisms more severely affect hospital-admitted patients (World Health Organization [WHO], 2002). A patient's susceptibility can be impacted by their age, immune status, present disease, and medical treatment. Infants and the elderly are less resistant to infection. Individuals using immunosuppressant drugs may have a decreased resistance to infection as well. Patients with chronic illnesses such as various forms of cancer, diabetes mellitus, renal failure, or acquired immunodeficiency syndrome (AIDS) are also more susceptible to nosocomial infections. A great number of medical procedures such as biopsies, endoscopic exams, catheterization, intubation, ventilation, suction, and surgery increase infection risk, as typically sterile areas are exposed to contamination (WHO, 2002).

The very young, elderly, immunocompromised, diseased, and medically treated comprise a particularly vulnerable group of patients who are typically treated in the intensive care unit (ICU) (Weber, Raasch, & Rutala, 1999). As a result, the highest infection rates exist in the adult and pediatric ICUs. The infection sites and microorganisms frequently involved with nosocomial infections are strongly associated with medical treatment in ICUs, which often involve invasive vascular-catheters and monitoring devices (Weinstein, 1998).

Consequences

Nosocomial infections can result in disability, emotional stress, and reduced quality of life. Such hospital-acquired infections quite often result in death (Tietjen, Bossemeyer, & McIntosh, 2003). In 2002 there were approximately 1.7 million nosocomial deaths. There were also around 98,987 deaths due to nosocomial infections. Of the 98,987 deaths, 35,967 were pneumonia cases, 30,665 were bloodstream infections, 13,088 were urinary tract infections, 8,205 were surgical site infections, and 11,062 infections related to other body sites (Klevens et al., 2007).

The last estimate of direct medical costs of nosocomial infections was made in 1992 using the results from the Study on the Efficacy of Nosocomial Infection Control (SENIC), which was performed in the 1970s. At the time there were 4.5 nosocomial infections for every 100 patient admissions, and the measured cost in 1992 was $4.5 billion (Martone et al., 1992). When adjusted for 2007 using the Consumer Price Index (CPI), the estimated annual direct medical costs of

nosocomial infections in the United States ranges from $28.4 to $33.8 billion for urban consumers and from $35.7 to 45 billion for inpatient services (Scott, 2009).

The operating costs due to a nosocomial blood stream infection have been valued at $46,133 and $40,000 per case by two separate studies evaluating the costs associated with such infections in patients requiring intensive care (Slonim, Kurtines, Sprague, & Singh, 2001 and Pittet, Tarara, & Wenzel, 1994). The average per patient costs estimated using 2007 CPIs ranges from $11,874 to $34,670 for surgical site infections. The costs for ventilator-associated pneumonia ranged from $7,288 to $29,156. In 2007 catheter-associated urinary tract infections costs ranged from $862 to $1,007 per patient (Scott, 2009).

Control Methods

As nosocomial infections are prevalent in healthcare facilities, infection control is important. Limiting the spread of microorganisms between patients through patient care can occur by using proper hand hygiene, which includes sufficient handwashing and glove use. The spread of infection can also be reduced by proper isolation, sterilization, and disinfection practices. Reducing the number of invasive procedures will also constrain the risk of endogenous nosocomial infections (WHO, 2002).

A number of efforts can be made to prevent nosocomial infections. Avoiding the use of invasive medical devices or limiting the duration of use of such devices is highly recommended. The pre-operative/procedure stay should also be limited, as patients' exposure to infections could be reduced (WHO, 2002).

At the Children's Hospital of Philadelphia an infection control program was implemented to reduce nosocomial respiratory syncytial virus (RSV). The intervention involved creating cohorts of patients and healthcare workers, gown and glove barrier prevention precautions, vigilant monitoring, and education of hospital staff. After 8 years of study, it was concluded that the target infection control program was successful and cost-effect in reducing the rate of nosocomial RSV. Six dollars were saved for every dollar spent on the program (Macartney, Gorelick, Manning, Hodinka, & Bell, 2000).

CHAPTER 2

II. Purpose

The purpose of this study is to identify the overall effect of hand hygiene interventions on the reduction of nosocomial infections in hospital settings. I will employ meta-analysis to obtain an overall effect for the relationship between hand hygiene and nosocomial infection rates for hospital based intervention studies. My specific aims are:

1) To conduct a literature review to identify appropriate hand hygiene intervention studies.
2) Use the odds-ratio statistic to identify a total effect size for the relationship between hand hygiene interventions and nosocomial infection rates.
    a. I predict that improved hand hygiene compliance results in lower rates of nosocomial infections.

Hand hygiene, specifically handwashing, has been determined the most impactful way to reduce nosocomial infections (Tietjen, Bossemeyer, & McIntosh, 2003). Unfortunately, the relationship between hand hygiene compliance and nosocomial infections has not been evaluated recently and there is no current data available. This meta-analysis will compare data from the selected hand hygiene interventional studies to determine whether improved compliance has a significant overall effect on nosocomial infection rates at the facilities in the various studies selected.

Methods

A literature search was performed to find hand hygiene interventional studies (Specific Aim 1). After finding studies that met all of the inclusion criteria, a statistics based meta-analysis was performed using the odds ratio effect-size statistic. The overall odds-ratio statistic was used to determine the overall effect hand hygiene interventions had on nosocomial infection rates (Specific Aim 2).

METHODS FOR SPECIFIC AIM 1:

Literature Search

The terms *nosocomial infection*, *hospital-acquired infection,* or *nosocomial infection rates* were searched for with the linking terms of *handwashing intervention* or *hand hygiene intervention* in order to find studies involving interventional and randomized controlled trials. The databases that were utilized were PubMed, ScienceDirect, JSTOR, and the Pennsylvania State University's Libraries Online Catalog. The papers found had additional references that were reviewed.

The search only included peer-reviewed journals. Only studies that occurred in a hospital setting were included in the analysis. Studies involving any hospital department and unit were included. No age groups were excluded in the search. Studies that focused solely on hand hygiene compliance were excluded. The outcome of interest was nosocomial infection rate; only studies that provided such rates were included. Only interventional studies focused on hand hygiene were included. If studies focused on hand hygiene and other infection prevention efforts, they were excluded from the meta-analysis.

METHODS FOR SPECIFIC AIM 2:

Meta-analysis

Hand hygiene interventions are only able to observe and analyze nosocomial infection rates for a fixed period of time. As these interventions occur at one location, whether it is a medical department, hospital, or health system, there are some limitations on the analysis. If there is an improvement in compliance and infection rate, it is difficult to determine whether the effects will last. It is also difficult to project the potential widespread outcome of such experiments, when the intervention only occurs at one location and is only one instance. A meta-analysis analyzes the various interventions as a whole to easily interpret their results and summarize the effects and findings.

The odds-ratio statistic was chosen as the effect size statistic because it was necessary to use a statistic that measured the pre-post proportions of the number of patients who acquired an infection. This effect size statistic compares two groups in terms of the odds of a status or event. In this case the odds-ratio statistic is comparing the odds of the baseline patient admits (pre-intervention) obtaining a nosocomial infection to the odds of the post-intervention patient admits obtaining a nosocomial infection. We analyze the event or odds of obtaining a nosocomial infection for pre –intervention admissions(group 1) compared to post-intervention admissions (group 2).The results of the study are presented in frequencies or proportions in a 2x2 table (Table 2.1).

Table 2.1: *2x2 Odds Ratio Table*

	Frequencies		Proportions	
	Infection	No Infection	Infection	No Infection
Group 1	a	b	p_a=a/(a+b)	p_b=b/(a+b)
Group 2	c	d	p_c=c/(c+d)	p_d=d/(c+d)

In order to calculate the odds-ratio effect statistic, the following equation is used:

$$ES_{OR} = \frac{ad}{bc} = \frac{p_a p_d}{p_b p_c} = \frac{p_a p_b}{p_c p_d} = \frac{p_a(1-p_c)}{p_a(1-p_c)}$$

Statistical analyses were performed using MedCalc for Windows, version 9.5.0.0 (MedCalc Software, Mariakerke, Belgium). The frequencies of nosocomial infections before-and-after the hand hygiene intervention were entered into the software for each of the 7 studies used. The software provided the odds ratio and confidence interval for each study. The total fixed effect model and random effects model odds ratio statistics were used to determine an overall effect (odds ratio) for all included studies. The random effects odds ratio statistic is preferred because it accounts for differences among studies that cannot be controlled or identified. The sample varied in terms of patient population, infection type, medical unit, and hand hygiene procedure. Thus, a random effects model was more appropriate because of the study and subject variability (DelliFraine &Dansky, 2008).

CHAPTER 3

III. Results

A total of 7 hand hygiene interventional studies were found that matched the inclusion criteria. A meta-analysis was then performed using the odds-ratio statistic

to find the effect size. The mean total random effects model odds-ratio statistic was 0.454.

RESULTS FOR SPECIFIC AIM 1:
Literature Search

The search yielded 135 articles. Many articles solely focused on handwashing compliance and did not report infection rates; they were eliminated. Of the remaining articles 3 studies focused on household hand hygiene interventions, and they were eliminated. 8 studies were eliminated because they focused on interventions in schools. There were 4 studies eliminated because they occurred in elderly care facilities. 2 more studies were eliminated because those interventions' setting was the workplace. 3 studies were eliminated because they were randomized controlled trials; this study only included observational studies. Another 13 studies were not used because they used a different outcome measure that did not provide an odds-ratio or the data needed to calculate an odds-ratio. The search resulted in 7 articles that met all of the inclusion criteria.

The 7 articles represented varying patient populations, infections, hospital units, and intervention programs. 2 of the studies occurred in adult care units, 2 occurred in NICUs, 1 study was hospital-wide, 1 study occurred in a plastic surgery unit, and 1 study occurred in 2 wards of a children's hospital. Interventions differed for every study. Most interventions involved educational sessions, poster reminders, hand hygiene observation, performance feedback, or the introduction of an alcohol-based rub. The hand hygiene aspect of the interventions also varied. For the interventions, an alcohol-based rub, chlorhexidine, triclosan, or soap and water

were used. Two studies used only alcohol-based hand gel (Study 1 and 6). One study used soap and water and alcohol-based hand gel (0.5% chlorhexidine gluconate and skin emollients) (Study 2). Another study used 0.5% triclosan, soap (0.4% chlorhexidine gluconate) and water, and alcohol-based hand rub (Study 4). Two studies used soap and water and an unspecified alcohol-based hand gel (Study 3 and 5). One study used 4% chlorhexidine gluconate solution (Study 7).

Table 3.1: *Interventional studies of hand hygiene included in the analysis*

Study	Source	Year	Hospital Setting	Intervention	Follow-Up Period	Randomized?	Effect?
1	Pessoa-Silva *et al.*	2007	Neonatal unit	Posters, focus groups, hand hygiene observation, perception assessments, performance feedback	27 months	No	Yes
2	Pittet *et al.*	2000	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, performance feedback, posters	96 months	No	Yes
3	Swoboda *et al.*	2004	Adult Intermediate Care Unit	Hand hygiene electronic monitoring at exit from patient rooms, direct observation and voice prompts	2.5 months	No	Yes
4	Capretti *et al.*	2008	NICU	Alcohol-based hand rub introduction, training, posters	18 months	No	Yes
5	Zerr *et al.*	2005	Children's Hospital: 1 surgical ward, 1 cardiology ward	Alcohol-based hand rub introduction, hand hygiene observation, training, posters	48 months	No	Yes
6	Macdonald *et al.*	2004	Plastic surgery unit	Alcohol-based hand rub introduction, hand hygiene observation, posters, performance feedback, informal discussions	12 months	No	Yes
7	Conly *et al.*	1989	Adult ICU	Education on hand washing, hand hygiene observation, performance feedback	72 months	No	Yes

RESULTS FOR SPECIFIC AIM 3.2:
Meta-analysis

After using the MedCalc software to calculate the odds ratios, it was determined that the total random effect odds ratio statistic was 0.454. The overall odds of getting a nosocomial infection were 0.454 times less post-intervention compared to pre-intervention. The odds ratio of 0.454 indicates that compared to pre-intervention, the post-intervention group had only about half the odds of developing an infection. The confidence interval was 0.350 to 0.590 and indicates that the effect size statistic is significant, as it does not span one (Table 2).

Table 2: Odds-ratio statistic results

Study		**Pre-Intervention**	**Post-Intervention**	**Odds**	**95% CI**
	1	48/264	32/296	0.545	0.337 to 0.883
	2	16.9/100	9.9/100	0.540	0.233 to 1.250
	3	100/790	20/301	0.491	0.298 to 0.809
	4	16/85	5/80	0.287	0.100 to 0.827
	5	30/5118	7/3203	0.371	0.163 to 0.847
	6	23/1211	11/1261	0.455	0.221 to 0.937
	7	16/48	4/47	0.186	0.057 to 0.610
		Total Fixed Effect		0.450	0.347 to 0.583
		Total Random Effect		0.454	0.350 to 0.590

CHAPTER 4

IV. Discussion and Policy Recommendations

Meta-analysis

The odds ratio statistic of 0.454 supports the hypothesis that increased hand hygiene compliance results in lower rates of nosocomial infections. The improved compliance has a significant overall effect on nosocomial infection rates at the facilities in the various studies selected.

Hand hygiene interventions focus on one hand hygiene protocol at one facility for a fixed period of time. In some cases, they also study specific infection types, and nosocomial infection rates do not include all nosocomial infections acquired. Because of such limitations it is difficult to extrapolate the data from one study and determine the potential large-scale outcomes of improving hand hygiene compliance. This meta-analysis analyzed multiple interventions to interpret the overall results and effects. The overall effect of improved hand hygiene, exhibited by the total random effect odds ratio statistic, expresses that increased hand hygiene compliance at 7 different medical units within hospitals improved nosocomial infection rates. The overall effect was significant and positive. An increase in hand hygiene compliance on a large scale can dramatically reduce the number of nosocomial infections acquired affecting patients. The reduction in such infections would decrease costs, as patients would not need care for the additional infection and their hospital-stay would be shorter (Klevens et al., 2007). The number of deaths would decrease as well (Tietjen, Bossemeyer, & McIntosh, 2003).

Study Limitations

While performing this study, I faced a number of limitations involving the identification of appropriate studies and the analysis itself. During the literature search, a number of studies were not used because they did not meet the inclusion criteria. Some studies met most of the inclusion criteria, but the outcome measures were different than the one used in this study. As a result, I was not able to use all of

the studies that were essentially available. If I were able to include these studies, they would have altered the results for the overall effect size.

None of the studies used in this meta-analysis were randomized, and consequently there could be biases affecting the results. Because the studies were not randomized, confounding factors related to characteristics of the health care facility and the medical personnel could have affected study outcomes, which would therefore affect my results.

Other limitations involve individual study protocol. As there were a number of hand hygiene techniques, there could be differences in the effectiveness of the varying hand washing agents and implementation protocols. Patients could also contract nosocomial infections in other ways besides healthcare workers' poor hand hygiene, and it is incredibly difficult to determine the cause of infection. The studies included in this meta-analysis only focused on hand hygiene interventions. If other infection prevention efforts took place in conjunction with the hand hygiene interventions, which is realistically what should occur in hospitals, the nosocomial infection rates could be vastly different.

Policy Recommendations

It is already incredibly difficult to monitor hand hygiene compliance in a hospital. If possible, facilities should educate their staff about the importance of hand hygiene. Figure 1A in Appendix is a 29" x 19" poster provided by the Center for Disease Control (Centers for Disease Control and Prevention [CDC], 2011). Placing posters and visual prompts to handwash could encourage healthcare workers to

engage in hand hygiene practices. Healthcare workers should be made aware of their access to hand hygiene designated locations and alcohol-based hand rub dispensers. Alcohol-based antiseptic rub dispensers were located immediately outside of every patient's room in Study 3. Study 5 had such dispensers on both sides of the patient's room or outside of the room, in addition to 2 or 3 movable dispensers within the room. Some facilities request keeping hands as bare as possible to reduce cross-contamination. Study 4 required the removal of all rings, bracelets and watches.

It would be most effective if all healthcare facilities provided explicit instructions for handwashing. The Association for Professionals in Infection Control and Epidemiology (APIC) provides guidelines for hand hygiene in healthcare settings. Study 4 uses these guidelines, which stated that the hands should be washed from fingertip to elbow, including nails, with soap for at least 15 seconds, rinsed with water, and then dried with a clean disposable, paper towel. The study also mentioned that a healthcare worker could only use the alcohol-based rub 10 times before having to wash their hands using soap and water at a basin. This protocol was placed at every basin to remind healthcare workers of the proper hand hygiene method (Capretti et al., 2008). An image of this poster is in the appendix (Figure 2A) (Capretti et al., 2008).

Every healthcare facility should implement a similar hand hygiene protocol that is explicit and detailed. Placing the poster at every handwashing basin serves as a constant reminder to engage in proper hand hygiene, which can significantly reduce the rate of nosocomial infection.

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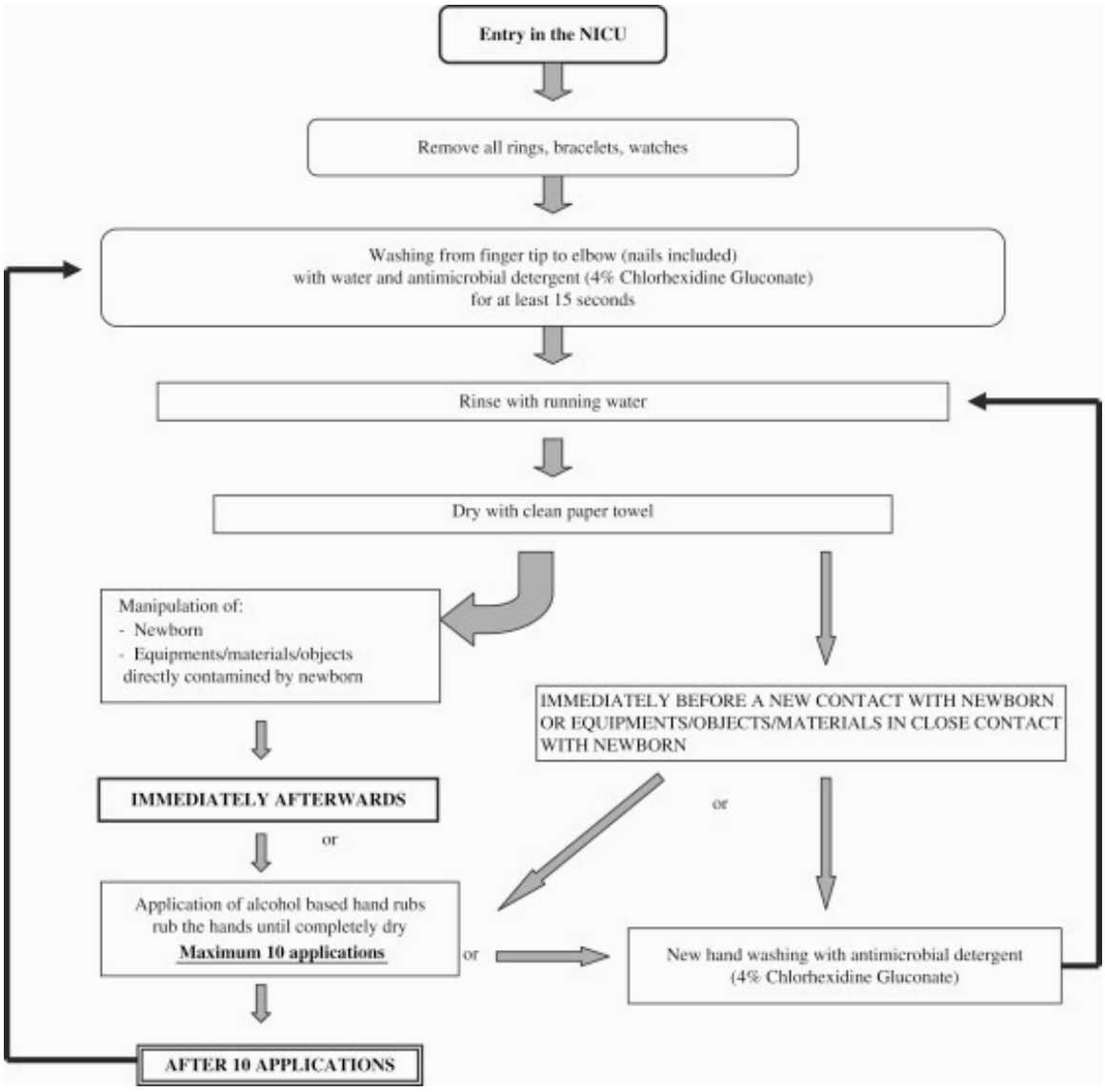
APPENDIX A: Figures

Figure 1A. Center for Disease Control (CDC) hand hygiene promotion poster

Figure 2A. Hand hygiene protocol poster from Study 4 (placed above all basins)



APPENDIX B: Academic Vita

SHAUNA SUTHERSAN

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OBJECTIVE

Health Policy & Administration major seeking an internship in the health care industry

EDUCATION

SCHREYER HONORS COLLEGE / PENNSYLVANIA STATE UNIVERSITY State College, PA
Bachelor of Science, Class of 2012 08/2009-Present

- Major: Health Policy & Administration; Minors: Economics and Information Sciences & Technology
- Selected as the Spring 2012 Student Marshal for the Health Policy & Administration Department
- Selected to the Schreyer Honors College- Schreyer Scholars represent the top 5% of students at Penn State and are required to complete honors courses and an undergraduate honors thesis.
  - Lead and coordinate events and tours with donors and alumni as well as recruit prospective honors students with the Schreyer Scholar Advancement Team
- Selected to participate in the Altria Sophomore Leadership Development Program
- Plan cultural events with the South Asian Students Association
- Member of the Penn State chapter of the Women in Business organization
- Analyzed various healthcare issues and proposed solutions with the Penn State Future Health Executives Club

PENNSBURY HIGH SCHOOL
Fairless Hills, PA
High School Diploma, Class of 2009
09/2005 – 06/2009

- ACT 32/36; AP Scholar, National Honor Society, Sociedad Honoraria Hispánica
- Elected an officer in an award winning high school marching band as an accomplished flautist and pianist

WORK EXPERIENCE

ARCADIS
Newtown , PA
Part-time Intern
Summer 2010 - Present

- Researched and developed presentations on the persistence of pharmaceuticals in the environment
- Researched and collected data on specific groundwater contaminants and its effect on human health

COMMUNITY SERVICE

- Volunteered at Frankford Hospital in Philadelphia for four years

- Organized fundraisers as a Youth Coordinator for the International Medical Health Organization
- Raise funds and awareness for pediatric cancer with FOTO THON
- Cared for children of various ages during summers of 2008 & 2009

EXTRA-CURRICULAR INTERESTS & ACTIVITIES

- Well versed in Eastern and Western classical music - Won numerous national awards and an invited performer in Veena (an ancient Indian instrument); Conversant in Spanish & Tamil (a leading regional language in India);

COMPUTER SKILLS

- Microsoft Word, Microsoft PowerPoint, Microsoft Excel; Statistical Analysis Software (SAS), Statistical Package for the Social Sciences (SPSS)