

Increasing Hand Hygiene Compliance Through Priming Interventions

by

Sara Stumpo

B.S. in Public Health, Slippery Rock University, 2020

Submitted to the Graduate Faculty of the
Department of Infectious Diseases and Microbiology
School of Public Health in partial fulfillment
of the requirements for the degree of
Master of Public Health

University of Pittsburgh

2023

UNIVERSITY OF PITTSBURGH

SCHOOL OF PUBLIC HEALTH

This essay is submitted

by

Sara Stumpo

on

April 28, 2023

and approved by

Essay Advisor: Graham Snyder, MD, MS, Associate Professor, Department of Medicine,
School of Medicine, University of Pittsburgh

Essay Reader: Jeremy Martinson, DPhil, Assistant Professor, Infectious Diseases and
Microbiology, Human Genetics, School of Public Health, University of Pittsburgh

Copyright © by Sara Stumpo

2023

Increasing Hand Hygiene Compliance Through Priming Interventions

Sara Stumpo, MPH

University of Pittsburgh, 2023

Abstract

Healthcare-associated pathogens are present in medical settings, and healthcare workers' hands are the most common route of transmission for spreading bacteria to patients resulting in infection. Hand hygiene is essential for preventing hospital-acquired infections (HAIs); however, compliance remains suboptimal, even after decades of studies aim to improve, so further innovation is needed. Psychological priming is exposure to certain cues (primes) which stimulates mental activity. Priming modifies behavior without the subjects' knowledge of the impact the cues have on their performance. Priming has been shown to be useful in increasing hand hygiene compliance across medical settings. This literature review and study conducted at a University of Pittsburgh Medical Center (UPMC) aim to investigate the influence that the induction of priming conditioning has on hand hygiene compliance in medical settings.

Table of Contents

Preface.....	ix
1.0 Inadequate Hand Hygiene Attributes to Multidrug-Resistant Organisms and Hospital-Acquired Infections	1
1.1 Evidence for Correlation Between Hand Hygiene and Infection.....	2
1.2 Mechanisms of Transmission by Hands	3
1.3 How Hand Hygiene is Performed	4
1.4 When Hand Hygiene Should be Performed.....	4
1.5 Current Hand Hygiene Observation Methods.....	5
1.6 Direct Observation	6
1.6.1 Without Electronic Data.....	6
1.6.2 Applications to Assist.....	7
1.6.3 Behind the Scenes – Not in Person.....	8
1.6.4 With Electronic Data	9
1.7 Indirect Observation	10
1.7.1 Product Usage.....	10
1.8 Current Hand Hygiene Compliance	10
2.0 Literature Review: The Influence that Priming Interventions Have on Hand Hygiene Compliance	13
2.1 “Priming Hand Hygiene Compliance in Clinical Environments (King et al., 2016) 	15

2.2 A Crossover Randomized Controlled Trial of Priming Interventions to Increase Hand Hygiene at Ward Entrances (Schmidtke et al., 2022).....	17
2.3 Impact of Environmental Olfactory Cues on Hand Hygiene Behavior in a Simulated Hospital Environment (Birnbach et al., 2013).....	18
2.4 Improving Hand Hygiene in Hospitals: Comparing the Effect of a Nudge and a Boost on Protocol Compliance (van Roekel et al., 2021)	19
2.5 Promoting Hand Hygiene with a Lighting Prompt (Diegel-Vacek et al., 2016).....	20
2.6 Effect of Frequency of Changing Point-of-Use Reminder Signs on Health Care Worker Hand Hygiene Adherence A Cluster Randomized Clinical Trial (Vander Weg et al., 2019)	21
2.7 Interpretations	23
3.0 Study Design	25
3.1 Study Setting	25
3.2 Intervention.....	26
3.3 Results.....	28
3.4 Discussion	30
3.5 Limitations	31
4.0 Conclusions.....	33
5.0 Public Health Significance	34
Bibliography	35

List of Tables

Table 1. Potential Interventions to Increase Hand Hygiene Compliance..... 14

**Table 2. Measuring the Effectiveness of the Interventions at Baseline Compared to Post-
Intervention (Bad = Compliance 0%-50.9%, Good = Compliance 51.0%-100%) 15**

**Table 3. Description of the Units that Were Introduced to the Priming Intervention at
UPMC Hospital 26**

Table 4. Baseline and Intervention Hand Hygiene Compliance on Units A-D 29

List of Figures

Figure 1. The World Health Organization’s Five Moments for Hand Hygiene Poster (WHO, 2009).....	5
Figure 2. iScrub Application’s Customization Features Allow Users to Monitor Staff Catered to Their Facility (Hlady et al., 2010).....	8
Figure 3. Photographs of Female and Male Eyes (King et al., 2016)	16
Figure 4. Sign Used for Priming Intervention (Vander Weg et al., 2019)	22
Figure 5. A) The Two Visual Priming Cues Placed Outside of a Patient Room on Units A-D. B) The Current Hand Hygiene Signage on All Units of UPMC Hospital. C) The Added Signage Placed on Units A-D. D) The Added Emoji Placed on the Alcohol-Based Hand Rub Dispensers on Units A-D	28
Figure 6. Average Compliance Baseline and Intervention on Units A-D	30

Preface

I would first like to thank Dr. Graham Snyder for agreeing to be my essay advisor and providing me with extremely helpful feedback and suggestions to improve this literature review and intervention. Without his knowledge and guidance, this essay would not have been possible.

I would also like to thank Dr. Jeremy Martinson for being a reader on my essay committee. Not only has he been helpful throughout the process of this research, but he has been a fantastic academic advisor to me and has provided me with support and guidance over my academic career at Pitt's School of Public Health. Without his encouragement and advice, I would not be where I am today.

Next, I would like to thank Ashley Ayres, Elizabeth Bell, Isabella Castronova, and Julie Slaughter for assisting me in formulating an intervention as part of this research for this essay. Their content expertise has been tremendously helpful to me throughout the whole process, and I cannot thank them enough for taking the time out of their schedules to assist me with this project.

Lastly, I want to thank Dr. Linda Frank and Dr. Mohamed Yassin for organizing the practicum IDM 2068. The practicum has provided me with an incredible experience in infection prevention and control and has confirmed the decision I made to pursue a career in infection prevention.

1.0 Inadequate Hand Hygiene Attributes to Multidrug-Resistant Organisms and Hospital-Acquired Infections

Pathogens are present in medical settings and have the potential to cause severe harm to patients. Substantial epidemiological evidence supports that healthcare workers' hands are the most common route of transmission for spreading bacteria to patients and can result in a hospital-acquired infection (HAI) (CDC, 2022), (Glowicz et al., 2023). According to the Centers for Disease Control and Prevention (CDC), HAIs are defined as “infections resulting from complications of healthcare” (CDC, 2021). HAIs are nosocomial infections that are not present or incubating in patients at the time of hospital admission, and typically manifest 48 hours after admission (Monegro et al., 2022). HAIs include catheter-associated urinary tract infections, central line-associated bloodstream infections, surgical site infections, ventilator-associated pneumonia, hospital-acquired pneumonia, and *Clostridioides difficile* infections (Monegro et al., 2022).

HAIs are directly associated with morbidity and mortality; one in 31 patients develops an HAI during their hospital stay (CDC, 2021). In addition, HAIs are heterogenous and may be caused by multidrug-resistant organisms (MDROs) which are antibiotic-resistant bacteria that have the potential to lead to sepsis and death (CDC, 2021). Inadequate handwashing increases the likelihood that MDROs will lead to HAIs. However, MDRO transmission may or may not result in an HAI since patients can be asymptomatic carriers, but it is important for healthcare workers to do their part in preventing them by performing proper hand hygiene. Not only are HAIs harmful to the patient, but they are also costly and create an extreme financial burden to the patient and hospital (CDC, 2021), (Douglas, 2009). In the United States, hospitals pay a

range of \$28.4 billion to \$33.8 billion in direct medical costs annually due to HAIs (Douglas, 2009). HAIs are taken seriously by medical facilities and are monitored closely by the CDC and the National Healthcare Safety Network (NHSN) to prevent further infections and improve patient safety (Monegro et al., 2022). Methods to minimize HAIs include infection tracking and surveillance, such as correct hand hygiene performance (Douglas et al., 2009).

Mechanisms of HAIs can be a portal of entry through devices, deficiency in aseptic technique, or natural sequelae of medical conditions, and can be caused by endogenous or exogenous flora being introduced or transmitted. People harbor resistant bacteria in the community which can transmit fully susceptible organisms. These clarifications are important to hand hygiene because failure of hand hygiene can result in HAIs, as previously mentioned. HAIs can arise when a device or procedure that should be free of bacteria is contaminated or when a pathogen is newly acquired by the patient, who may later develop an infection due to insufficient hand hygiene performed by a healthcare worker. However, hand hygiene cannot prevent all HAIs since some arise from endogenous bacteria occurring in the absence of a deficiency in aseptic technique or maintenance care (Poczai et al., 2022).

1.1 Evidence for Correlation Between Hand Hygiene and Infection

Hand hygiene is a foundation of all infection prevention and control programs, with healthcare employees' hands being the number one promoter of infection in patients, especially those who are critically ill and immunocompromised (Shobowale et al., 2016). In the mid-1800s, Ignaz Semmelweis of Vienna, Austria, and Oliver Wendell Holmes of Boston, United States,

discovered that hospital-acquired diseases were transmitted directly through the hands of healthcare workers, and since then, new strategies have been developed to reduce the risk of spread (WHO, 1970). Hand hygiene has been identified as an intervention that will decrease the cross-transmission of pathogens between staff and patients and has been proven to reduce the incidence of nosocomial infections (Shobowale et al., 2016). It is important to point out that hand hygiene plays only a part in reducing MDROs and HAIs. Both MDROs and HAIs tend to arise from multiple factors, and poor hand hygiene is just one of them.

1.2 Mechanisms of Transmission by Hands

On average, a person's skin is home to around one thousand different kinds of bacteria, though not all pathogenic. Regardless, hand hygiene is still essential (Poczai et al., 2022). Transmission of pathogens from one patient to another via the hands of healthcare workers requires the following sequence of events: organisms present on the patient's skin or that have been shed onto inanimate objects near the patient must be transferred to the healthcare workers' hands. These organisms must be capable of surviving for at least several minutes on the hands of the healthcare worker. Next, handwashing must be inadequate or omitted entirely, or the agent used for hand hygiene must be inappropriate. Lastly, the contaminated hands of the healthcare worker must come in direct contact with another patient, or with an inanimate object that will come into direct contact with the patient (WHO, 1970).

1.3 How Hand Hygiene is Performed

Hand hygiene can be defined as “the act of cleaning one’s hands for the purpose of substantially removing soil, dirt, and/or microorganisms (WHO, 1970), (CDC, 2016).” To prevent the spread of nosocomial diseases, proper hand hygiene must be performed by all healthcare workers. Alcohol-based hand rub containing at least 60-95% alcohol or handwashing with soap and water are both compliant hand hygiene measures (CDC, 2020). If the hands are visibly soiled (containing dirt, blood, and body fluids), or if a patient has a *Clostridioides difficile* or norovirus infection, then handwashing with soap and water must be achieved and is deemed the most effective way to kill bacteria (CDC, 2020). Hand washing with alcohol-based hand rub moves the spores around when hands are soiled, but soap and water improve removal of pathogens from the hands. However, if hands are not soiled, alcohol-based hand rub is actually preferred over soap and water in many clinical settings because it requires less time, is more accessible for healthcare workers, produces reduced bacterial counts on hands, and improves skin condition with less irritation and dryness than handwashing with soap and water (CDC, 2016).


1.4 When Hand Hygiene Should be Performed

Healthcare workers must follow the World Health Organization’s (WHO’s) “Five Moments for Hand Hygiene” approach to be compliant with hand hygiene guidelines. The five moments for hand hygiene consist of: before touching a patient, before clean/aseptic procedure, after body fluid exposure risk, after touching a patient, and after touching patient surroundings. It

is important to note that wearing gloves does not replace the need to perform hand hygiene before touching a patient. Healthcare workers still must perform proper hand hygiene before they put on gloves (WHO, 2023).

Your 5 Moments for Hand Hygiene

1	BEFORE TOUCHING A PATIENT	WHEN? Clean your hands before touching a patient when approaching him/her. WHY? To protect the patient against harmful germs carried on your hands.
2	BEFORE CLEAN/ASEPTIC PROCEDURE	WHEN? Clean your hands immediately before performing a clean/aseptic procedure. WHY? To protect the patient against harmful germs, including the patient's own, from entering his/her body.
3	AFTER BODY FLUID EXPOSURE RISK	WHEN? Clean your hands immediately after an exposure risk to body fluids (and after glove removal). WHY? To protect yourself and the health-care environment from harmful patient germs.
4	AFTER TOUCHING A PATIENT	WHEN? Clean your hands after touching a patient and his/her immediate surroundings, when leaving the patient's side. WHY? To protect yourself and the health-care environment from harmful patient germs.
5	AFTER TOUCHING PATIENT SURROUNDINGS	WHEN? Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving – even if the patient has not been touched. WHY? To protect yourself and the health-care environment from harmful patient germs.



World Health Organization

Patient Safety
A World Alliance for Safer Health Care

SAVE LIVES
Clean Your Hands

All illustrative photographs have been taken by the World Health Organization for public use. The photographs contained in this document represent the published material in being disseminated without identity of any kind. Where indicated in brackets, the responsibility for the photographs lies with the media. In the event that the World Health Organization be held for copyright, please contact the WHO. WHO acknowledges the valuable contribution of various NGOs, in particular the members of the Infection Control Programme, for their active participation in developing this material.

Figure 1. The World Health Organization’s Five Moments for Hand Hygiene Poster (WHO, 2009)

1.5 Current Hand Hygiene Observation Methods

The goal of measuring hand hygiene behaviors is to provide timely and significant responses to guide improvement. Routine measurement should be completed to establish a performance baseline, to support improvement efforts, and to identify barriers of adherence

(Glowicz et al., 2023). There are several ways to measure hand hygiene compliance. Each method has its own advantages and disadvantages.

1.6 Direct Observation

1.6.1 Without Electronic Data

The most common and most effective way is through direct observation, which is considered to be the gold standard (Bredin et al., 2022). Observers may be workers or volunteers who are primarily assigned to monitor compliance on their own units, or “secret shoppers” who are workers from other units who make observations clandestinely (Marra et al., 2014). There are certain drawbacks to direct observation though.

For example, through observers or secret shoppers, issues with validity can arise. Observers may only be able to capture a fraction of hand hygiene compliance opportunities that take place on a daily basis. Moreover, another issue that can be seen is the Hawthorne effect (Marra et al., 2010). The Hawthorne effect can become a bias in an observational study, where handwashing behaviors are documented since behavior changes when the observed individual is aware they are being watched (Marra et al., 2010). The presence of auditors has been proven to inflate compliance scores by between 30-50% (Jeanes et al., 2019).

1.6.2 Applications to Assist

Technology can be useful and plays a large role in healthcare today. Hand-held personal digital assistants, such as Apple's iPhone using the iScrub application, have been noted to successfully record hand hygiene observations and analyze compliance (Marra et al., 2014). The iScrub application takes advantage of Apple's touchscreen products and can be customized to reflect each user's specific healthcare environment. Observers using iScrub can indicate when they arrive and leave a location from the menu altered to their institution. From there, observers have the option to select personnel they want to record, such as nurses or physicians for example. To record observations, observers document whether healthcare staff have taken advantage of hand hygiene opportunities before entering and after exiting patient rooms. Each entry is automatically time and date stamped, and all data is exported to a database where observers can access recordings (Hlady et al., 2010).

The limitations of these assisting applications such as iScrub include concerns about patient privacy, the need for Wi-Fi, and purchasing of Apple products which can be expensive, and not all medical settings are acclimated to the specific brand, regardless of the program being free. Though iScrub and other applications aids observers in hand hygiene monitoring, it does not measure all of the WHO's Five Moments for Hand Hygiene opportunities. Future directions include allowing users to observe more than just moments in and out of patient rooms (Hlady et al., 2010).

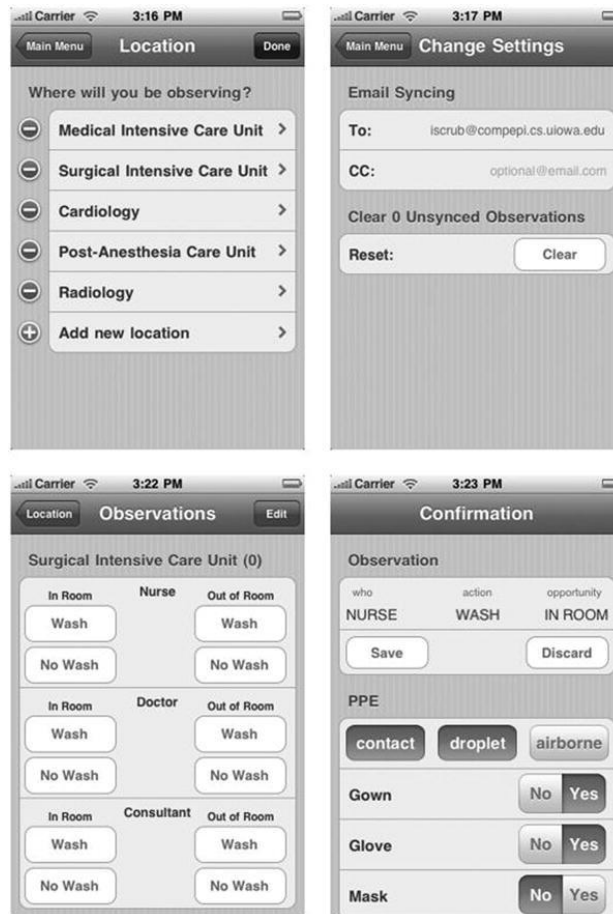


Figure 2. iScrub Application’s Customization Features Allow Users to Monitor Staff Catered to Their Facility (Hlady et al., 2010)

1.6.3 Behind the Scenes – Not in Person

Some facilities choose to audit through video cameras, which capture healthcare workers’ compliance, though this is rather rare (Bilgin et al., 2023). The Joint Commission argues that observing staff members’ hand hygiene behaviors using cameras is an unobtrusive way to collect data. There is less evidence of selection bias occurring using this method, but that does not mean bias is eliminated. The range of cameras can be limited in some healthcare settings, making it

difficult for the cameras to view all alcohol-based hand rub dispensers. Purchasing and installing the camera equipment can be expensive as well. Plus, someone will need to be responsible for reviewing and interpreting the recordings. In addition, there are also concerns that the cameras can interfere with both patient and staff privacy (The Joint Commission, 2009).

1.6.4 With Electronic Data

Another method to measure compliance that can be useful is electronic monitoring. Many studies that employ observers have been noted to have relatively short observation periods, whereas electronic counters have the ability to constantly monitor handwashing 24/7. Electronic counters deliver instant results without requiring the disbursement of several hours to gather a lesser sample of observations (Marra et al., 2011). More recently, electronic hand hygiene systems have developed into a major promotion for hand hygiene. Electronic hand hygiene systems record compliance and are designed to ensure that healthcare workers perform hand hygiene before approaching their patients by delivering an alert. Some versions of these systems use radiofrequency identification to determine whether handwashing has occurred or sensors that detect alcohol vapors (de Macedo et al., 2012), (Edmond et al., 2016).

The main limitation of electronic hand hygiene systems is that they are extremely costly and create a large financial burden for the healthcare facility. Furthermore, some systems are not able to account for compliance when healthcare workers perform hand hygiene at a sink with soap and water (Wang et al., 2021), which in turn raises concerns for accuracy since they lack utility in determining the appropriateness of hand hygiene opportunities by healthcare workers and cannot determine the quality of handwashing (Marra et al., 2010).

1.7 Indirect Observation

1.7.1 Product Usage

Determining hand hygiene compliance through electronic counters along with measuring product usage (alcohol-based hand rub) can be a helpful method of assessing hand hygiene adherence. Normally, the total volume of product is expressed in liters per 1,000 patient days, so studies have deemed this method of measuring adherence as useful (Marra et al., 2010). Product usage offers researchers simple data collection and provides healthcare facilities with less expense than direct observation. Basically, researchers can calculate indications for hand hygiene by time and task studies if they know how many times on a unit that healthcare workers should be performing hand hygiene by using patient admission volume to calculate, then they can estimate how fast they should be using alcohol-based hand rub and soap. However, this method can be inaccurate and produce misleading results (Boyce et al., 2011).

1.8 Current Hand Hygiene Compliance

Unfortunately, current hand hygiene compliance has been historically low in healthcare settings, with a lower-than-desired rate of 50% (Mouajou et al., 2021). Ajzen's theory of planned behavior (Ajzen, 1991) is a highly used model to explain hand hygiene behavior (Gaubert et al., 2018). Ajzen's credible concept suggests that behavior, or hand hygiene in this case, is motivated by the intent to perform an action, in which the intention is predicted by three factors: attitude, subjective norms, and perceived behavior control (Troiano et al., 2018). For hand

hygiene measures, Ajzen's theory can be used because the research attributes that attitudes are formed by knowledge and beliefs about hand hygiene and its outcomes, subjective norms are shaped by an individual's insight of what others think about hand hygiene, and perceived behavior control is composed of beliefs about the ease or difficulty of performing correct hand hygiene (Ajzen, 1991).

However, researchers have indicated that focusing just on Ajzen's theory of planned behavior is too broad of an approach (Gaube et al., 2018). As a result, they have examined predictors for non-adherence with hand hygiene guidelines among healthcare workers using a range of behavioral theories (Michie, 2005). Further research showed three theoretical domains to predict non-compliance, including memory/attention/decision making (forgetting to perform hand hygiene, prioritizing another task, or being too distracted), knowledge or lack of knowledge about guidelines and expectations, and environmental context/resources (lack of time or availability to hand hygiene products) (Gaube et al., 2018). A survey administered to understand barriers to hand hygiene adherence by Vaughan-Malloy et al, (2023) confirmed the majority of healthcare workers know when and how to perform hand hygiene. However, a significant number of healthcare workers felt that wearing gloves replaced the need for handwashing (Vaughan-Malloy et al., 2023). There are numerous reasons why a healthcare provider may choose not to perform adequate hand hygiene. Environmental factors largely contribute to the deficiency of proper performance and may be the most common factor for non-compliance. Visibility and proximity to room entrance and alcohol-based hand rub dispenser height contribute to handwashing behaviors performed by healthcare workers. If dispensers are located in close proximity to patient rooms, healthcare workers are more likely to perform hand hygiene (Drews et al., 2019). Environmental factors can also include the lack of leadership and policy or

high patient load. 77% of healthcare workers reported being unable to comply with hand hygiene guidelines due to dispensers often being empty, which would contribute to the environmental context/resources factor as well (Vaughan-Malloy et al., 2023). Studies have established the most common reason given by healthcare workers for non-compliance include insufficient time, work overload, lack of knowledge, forgetfulness, and inconvenient placement of handwashing supplies, with forgetfulness being the most common reason (Schmidtke et al., 2022), (Novák et al., 2019). Other research supports that healthcare staff tend to be overconfident about their personal immunity to infection (Diegel-Vacek, 2016), which may also explain a lack in compliance.

This paper consists of a literature review and will also partially look at an intervention that took place at a University of Pittsburgh Medical Center (UPMC) hospital. UPMC Hospital uses direct observation through secret shoppers to measure their hand hygiene compliance rates. Secret shoppers document their observations via the facility-designed web-based application which infection prevention and control staff and hand hygiene observers have access to. The infection prevention department records the data from the app and turns it into an excel spreadsheet where they are able to view trends and monitor compliance rates from each unit.

Recently, in January 2023, hand hygiene compliance was observed in each unit. Some units had outstanding compliance rates, but many units were lower than 50%. The compliance rates of four units stand out in particular. All units were inpatient units. A range of 95-110 observations were recorded for the four units and compliance ranged from 41.3%-50.5%. However, other units that demonstrated higher hand hygiene compliance had rates of 89.1%-93.2%. A study that aimed to increase compliance in a number of units will be further discussed.

2.0 Literature Review: The Influence that Priming Interventions Have on Hand Hygiene Compliance

The American Psychological Association defines priming as “the effect in which recent experience of a stimulus facilitates or inhibits later processing of the same or a similar stimulus” (APA, 2023). In repetition priming, which was completed for the UPMC Hospital experiment, priming is “the presentation of a particular sensory stimulus increases the likelihood that participants will identify the same or a similar stimulus later in the test” (APA, 2023), which is hand hygiene compliance in this case. In other words, psychological priming is the exposure to certain cues, or primes, which stimulate mental activity and modifies a behavior without the subjects’ knowledge of the impact the cues have on their performance (King et al., 2016). Priming may be useful in increasing hand hygiene compliance across medical settings, and that is what the experiment at UPMC Hospital and this literature review aim to discover.

To investigate if psychological priming shows evidence to be a successful method for enhancing hand hygiene adherence, a literature search was conducted on PubMed. Key words and phrases were “hand hygiene,” AND “environmental cues,” “priming,” “visual,” “olfactory,” “behavior change,” and “compliance.” Six articles were chosen in a ten-year timeframe (2013-2023) to review findings (**table 1**).

Table 1. Potential Interventions to Increase Hand Hygiene Compliance

Intervention	Reference	Experiment Design	Setting	Increase in Hand Hygiene Compliance?
Olfactory prime (clean, citrus scent) and visual prime (male or female eyes)	King et al., 2016	Randomized controlled trial	Surgical intensive care unit (SICU)	Yes – olfactory prime Yes – visual prime (male eyes) No – visual prime (female eyes)
Olfactory prime (citrus scent) and visual prime (eyes)	Schmidtke et al., 2022	Crossover randomized controlled trial	Four wards	No – olfactory prime No – visual prime
Olfactory prime (fresh scent)	Birnbach et al., 2013	Randomized study	Simulation center	Yes
Visual prime (picture of washing hands and tagline) and visual prime (poster with infection risk facts)	van Roekel et al., 2021	Nonrandomized quasi-experiment	Three wards	Yes – both visual primes
Visual prime (light above sink)	Diegel-Vacek et al., 2013	Prospective, longitudinal observational study	Two patient rooms	Yes
Visual primes (frequent change in signage)	Vander Weg et al., 2019	Cluster randomized clinical trial	Nine Veterans Affairs hospitals – 58 units	No

Table 2. Measuring the Effectiveness of the Interventions at Baseline Compared to Post-Intervention (Bad = Compliance 0%-50.9%, Good = Compliance 51.0%-100%)

Study	Baseline	Baseline Compliance	Post-Intervention	Post-Intervention Compliance	Difference	Improvement
King et al., 2016	15.0%	Bad	31.0%	Bad	16.0%	Increase
Schmidtke et al., 2022	15.8%	Bad	14.7%	Bad	-1.1%	Decrease
Birnbach et al., 2013	51.0%	Good	80.0%	Good	29.0%	Increase
van Roekel et al., 2021	54.6%	Good	83.2%	Good	28.6%	Increase
Diegel-Vacek et al., 2016	15.3%	Bad	25.3%	Bad	10.0%	Increase
Vander Weg et al., 2019	56.5%	Good	57.8%	Good	1.3%	Increase (Not Significant)

Within each study, the results of all priming techniques were combined to get an overall averaged post-intervention compliance rate (**Table 2**).

2.1 “Priming Hand Hygiene Compliance in Clinical Environments (King et al., 2016)

A study conducted by King et al. used both visual and olfactory primes to investigate whether priming has an impact on hand hygiene compliance. Participants consisted of 404 healthcare workers and hospital visitors at a hospital who entered the SICU during a three-month period. Anyone entering the SICU was expected to perform hand hygiene at the entrance where an alcohol-based hand rub dispenser was placed along with signage regarding the expectations.

During the first intervention, participants were exposed to an olfactory prime of a clean, citrus smell that was distributed through the atmosphere by the use of an aroma diffuser. Next,

for the second intervention, participants were exposed to a visual priming condition that consisted of a photograph of eyes that were placed directly above the alcohol-based hand rub dispenser. During half of the second intervention, a female's eyes were used, and for the other half, a stern-looking middle-aged male's eyes were used (**Figure 3**).



Figure 3. Photographs of Female and Male Eyes (King et al., 2016)

The authors found that the participants who were exposed to the olfactory prime were significantly more likely to perform hand hygiene (46.9%) versus the control group (15%). When exposed to the visual primes, the authors noted a significant increase in handwashing when the photograph of the male's eyes was displayed, but no evidence of any significant impact to exposure of the female's eyes. In fact, compliance was actually worse at 10% than the control group of 15%, compared to exposure of the male's eyes in which the compliance rate was 33.3%. The authors suggest the difference in effect of visual primes may be that the male's eyes

cued different feelings, thoughts, and emotions due to the stern nature of the eyes compared to the females who can be described as more soft and comforting. Overall, olfactory priming demonstrated to have the most success in this study.

2.2 A Crossover Randomized Controlled Trial of Priming Interventions to Increase Hand Hygiene at Ward Entrances (Schmidtke et al., 2022)

Similar to King et al.'s study, Schmidtke et al. also used both visual and olfactory primes to study the influence the primes had on handwashing behaviors. The olfactory prime was a citrus smell dispersed in the air using a scent diffuser, and the visual prime was a laminated picture of a person's eye region placed above the gel and soap dispensers in the wards. Four wards were assigned to undergo the intervention for six weeks of observation to each of the following conditions: control, olfactory, visual, and both (olfactory and visual combined). The handwashing behaviors of all healthcare workers entering each ward during 15-minute observation sessions were documented by researchers. Researchers also measured the cleansing products by weighing the soap and gel containers.

Contrary to King et al.'s findings, the authors did not have the same results and their hypotheses that compliance would be enhanced due to the primes were rejected. The results showed that the olfactory and visual priming conditions were less effective than the control condition of 15.8%, and that they were each less effective than the combined condition too of 12.1%, providing evidence of a 3.7% decrease. An increase in soap use in ward A during the condition when both primes were present was observed. However, the authors made note that the primes that were introduced did not consistently enhance hand hygiene compliance. The fact that

an increase in soap usage only occurred in ward A may suggest that the variables lessen the efficacy of the priming conditions.

Researchers conducted a follow-up cross-sectional survey to investigate why the primes did not increase hand hygiene compliance as originally anticipated. Memory and attention piqued the most interest, due to most healthcare workers stating they simply forgot to wash their hands, which ties back into Ajzen's theory that perceived behavior control is made of the difficulty of performing hand hygiene (Ajzen, 1991). The proposed primes were expected to make handwashing behaviors more accessible in the healthcare workers' memories, but as previously mentioned, that was not the case.

2.3 Impact of Environmental Olfactory Cues on Hand Hygiene Behavior in a Simulated Hospital Environment (Birnbach et al., 2013)

A four-day study conducted by Birnbach et al. used olfactory priming to investigate if hand hygiene compliance would enhance when exposed to a clean aroma. Participation was comprised of medical students and recent medical school graduates about to complete their internships. Participants were asked to examine a standardized patient with heart palpitations as part of their safety training course. Researchers observed the trainees' handwashing behaviors and recorded the results. Participants were randomly assigned to groups; one group encountered the olfactory prime and the other was a control group in the standard setting. Four sessions took place, two of which introduced scent manipulation. 79 participants were subjected to the olfactory prime, and 86 experienced the standard environment.

The authors reported that the control group had a hand hygiene compliance rate of 51%, whereas the manipulation group had a significantly higher rate of 80%. Birnbach et al. came to the conclusion that olfactory priming can substantially influence hand hygiene adherence. When exposed to the fresh scent, the researchers detected the participants in this study to be more compliant compared with their baseline colleagues.

2.4 Improving Hand Hygiene in Hospitals: Comparing the Effect of a Nudge and a Boost on Protocol Compliance (van Roekel et al., 2021)

A four-week nonrandomized quasi-experiment conducted by van Roekel et al. aimed to discover the influence of visual primes on hand hygiene compliance of nurses. This study took place in three wards at a large Dutch hospital. Ward one received images of hands being cleaned accompanied by the tagline “in good hands.” Ward two was given posters with the tagline “prevent infections.” On the poster, facts about infection risks were provided. Factual material included: “one in every twenty patients receive a hospital-induced infection” and “research shows that in two American hospitals, the number of cases with Methicillin-resistant *Staphylococcus aureus* (MRSA) infections decreased by half after healthcare employees improved their hand hygiene.” Lastly, ward three did not receive any intervention, as it acted as the control group. Signage was placed in highly visible locations on wards one and two, as well as the nurses’ break rooms.

Hand hygiene compliance was measured through standardized observations. Nurses were individually observed at a time from the time of patient contact to leaving the ward or moving on to computer work. The researchers observed a strong increase in compliance in ward one. During

the intervention period, the handwashing compliance increased in ward one by 21.4% and increased in ward two by 35.8%. Meanwhile, the control group, ward three, did not show significant differences during the intervention period, supplying evidence that both priming interventions were effective in increasing hand hygiene compliance among nurses. Furthermore, the authors suggest there might be a difference in effectiveness between the two interventions, as seen after the removal. After the removal of the signage, ward two remained on a similarly high level of compliance, while this effect somewhat faded in ward one.

2.5 Promoting Hand Hygiene with a Lighting Prompt (Diegel-Vacek et al., 2016)

A prospective, longitudinal observational study completed by Deigel-Vacek et al. explored the impact of visual priming on hand hygiene compliance. This study took place at a hospital in two patient rooms adjacent to one another. One room received the intervention, and the second room was assigned to be the control. The room that was given the intervention entailed a light above the sink turning on as healthcare workers entered to initiate a visually cued reminder to perform hand hygiene prior to patient contact. The observer was not visible to the patient or healthcare worker but was visible on the unit and performed observations during three periods. A total of 88 healthcare worker encounters were examined during the study period.

During the first observation session, the hand hygiene compliance rate was 7% in the control room and 23% in the intervention room. On day two of observations, the investigator noted compliance to be 16% in the control room and 30% in the intervention room. Finally, during the third observational period, the rate of compliance was 23% for both the control and intervention rooms. Although a greater percentage of healthcare workers performed hand

hygiene in the intervention room during the first two observation sessions, these results indicate that using light as a visual cue to enhance hand hygiene was effective in this case.

2.6 Effect of Frequency of Changing Point-of-Use Reminder Signs on Health Care Worker Hand Hygiene Adherence A Cluster Randomized Clinical Trial (Vander Weg et al., 2019)

Vander Weg et al. conducted a cluster randomized clinical trial and used environmental manipulation through a frequency of change in hand hygiene signage to promote the adherence of hand hygiene for a duration of six months. Observations were limited to 15-minute intervals in an effort to reduce the Hawthorne effect. The first group of units that were assessed were selected for signage to be changed on a weekly basis. Signage was changed monthly for the second group of units, and another group of units acted as a control group, where no changes were made. Signs consisted of pictures of different health care workers and patients and used a variety of colors (**figure 4**). The authors used message framing in which designing the wording of material in the most positive manner is more likely to influence decision making and behavior change. In this case, messages were designed to alter behavior by reminding the healthcare worker to keep their patients safe.



Figure 4. Sign Used for Priming Intervention (Vander Weg et al., 2019)

No significant changes were noted for the units that did not change signs at all or for the units that changed signs monthly. However, on units that the signs were changed weekly, a significant reduction in hand hygiene adherence was observed. Also, adherence declined weekly as the intervention went on. Overall, the frequency of changing signs had minimal effect on hand hygiene compliance. It is important to note the baseline compliance rate was 56.7% for all nine hospitals combined. The total compliance only increased to 57.8% when the intervention was implemented and does not offer a significant increase in results. These findings suggest that frequent signage change may be too weak of a signal to have a clinically meaningful effect, or that signs are insufficient by themselves to significantly affect compliance. Changing signs on a

regular basis was not an adequate cue for handwashing behavior and in turn adversely affected adherence for this study.

2.7 Interpretations

Of the studies reviewed, many were successful in engaging healthcare workers to perform hand hygiene. Olfactory priming seems to have a significant impact on influencing handwashing in healthcare settings. Perhaps the pleasant aroma stimulates decision making activity in which healthcare workers are more likely to comply with hospital standards. All of the olfactory priming studies diffused the scent throughout the air, but it would be interesting to test compliance after introducing a citrus or clean smelling alcohol-based hand rub, instead of it just existing in the environment.

Visual priming seems to show the most success when it stands out to healthcare workers. Signage may not be the most effective way to increase adherence for reasons that signs blend in throughout the busy hospital environment. Diegel-Vacek et al. noticed a major improvement when they introduced a red light above the sink to direct healthcare workers to wash their hands, as opposed to some of the other studies that used visual cues that did not draw as much attention.

As for signs that contained messages rather than pictures, they tend to show the most success when they are worded in a meaningful way. Prior work has shown that framing messages that focus on positive outcomes associated with correct hand hygiene and on the outcomes for patients rather than on healthcare workers themselves are associated with better adherence (van Roekel et al., 2021), (Vander Weg et al., 2019). It would be interesting to further investigate whether changes in attitudes would be observed if education was geared more toward the

benefits of how hand hygiene protects the patient rather than how hand hygiene protects the healthcare worker.

The conditions of the duration of the primes and healthcare settings certainly affect how well the prime works. For example, in King et al.'s study, the authors reported an incline in adherence over their three-month study (King et al., 2016). Schmidtke et al.'s intervention did not create an improvement in hand hygiene compliance, even though it was very similar to the King et al. study. A major difference was that Schmidtke et al. conducted a six-week intervention, which was shorter in duration, indicating that for that particular experiment, more time was needed to really inspire behavior change.

Generally, adopting priming would benefit other healthcare facilities to enhance hand hygiene behaviors, and visual priming showed supporting evidence of being a successful intervention, so we wanted to try for ourselves.

3.0 Study Design

This is a comparative study of pre-and post-intervention study outcomes. The objectives are to improve hand hygiene compliance in the units of UPMC Hospital that are given visual priming interventions and to compare hand hygiene data prior to the intervention with data gathered after the priming conditions have been implemented. It is hypothesized that hand hygiene compliance will be enhanced in the units when the primes are introduced.

3.1 Study Setting

Research was organized under four units of UPMC Hospital. Units will be referred to as unit A, unit B, unit C, and unit D. Units A-D were chosen for this study as their hand hygiene compliance tends to be rather low, but the number of audits is comparably high. Units were also chosen based on their capacity (number of beds) and unit shape. Units were selected to be as comparable to one another as possible. Units A-D consists of two medical/surgical units and two intensive care units (ICUs). **Table 3** illustrates the units studied for this intervention.

Table 3. Description of the Units that Were Introduced to the Priming Intervention at UPMC Hospital

Unit	Unit Type	Number of Beds	Unit Shape
A	Private ICU	20	Straight hallway on both sides
B	Private ICU	20	Straight hallway on both sides
C	Private medical/surgical	18	Square
D	Private medical/surgical	24	Square

Participation consisted of all healthcare workers entering and leaving patient rooms in units A-D at UPMC Hospital during observation sessions conducted by the secret shoppers for a ten-week period. Unit directors were notified of the project and priming conditions, but participation was incidental as hand hygiene compliance is observed on a regular basis regardless. Unit directors were asked not to mention the project to their staff, as the staff being notified of the project would skew data.

3.2 Intervention

Current hand hygiene signage is placed throughout UPMC Hospital in a protective case beside each patient door. Current signage is a dark purple color that reminds healthcare workers of the in/out protocol. Two visual priming cues were added to units A-D in an attempt to stimulate mental activity and alter behavior to increase compliance.

A bright blue sign, augmented with increasing the number of signs is the first visual prime. The new sign visually reminds healthcare workers of the WHO's Five Moments for Hand Hygiene approach. The signs were laminated and hung on the wall at eye level to the right of the

door next to patient rooms, or between two patient doors if two rooms were close beside one another. The second visual cue that was implemented was an approved UPMC Hospital-specific handwashing emoji that was placed in the middle of each alcohol-based hand rub dispenser on each unit given the intervention. Lotfinejad et al. found that the use of emojis may be beneficial in infection prevention and control measures. As technology advances and emojis continue to improve digitally, various researchers have studied the impact of emoji symbols in the scientific field. Emojis represent non-verbal communication and can be beneficial in facilitating infection prevention and control measures such as promoting hand hygiene, consequently enhancing public health (Lotfinejad et al., 2020).

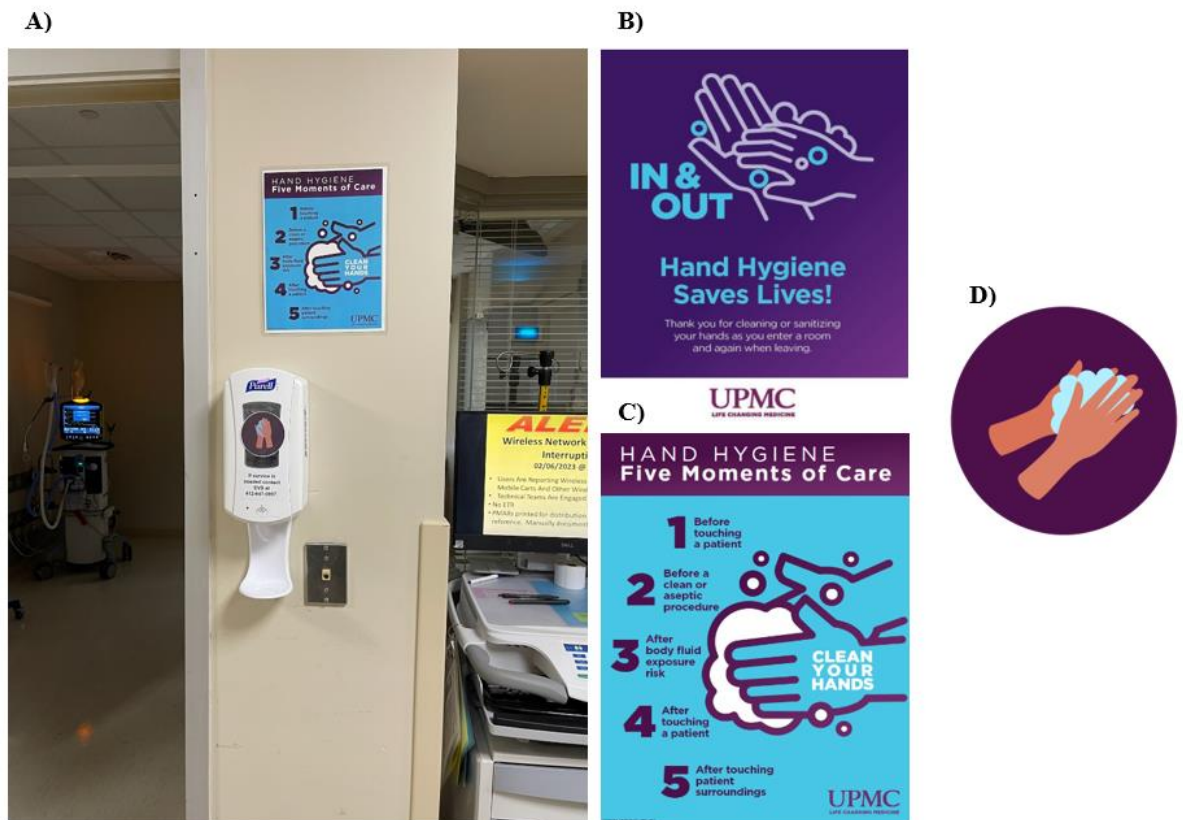


Figure 5. A) The Two Visual Priming Cues Placed Outside of a Patient Room on Units A-D. B) The Current Hand Hygiene Signage on All Units of UPMC Hospital. C) The Added Signage Placed on Units A-D. D) The Added Emoji Placed on the Alcohol-Based Hand Rub Dispensers on Units A-D

3.3 Results

Hand hygiene data prior to the initiation of the primes was analyzed for ten weeks from October 2022 – December 2022 as a comparison component, illustrated in **Table 4**. Unit A had the highest compliance rates overall of the four units that were assessed.

Results were reviewed after the ten-week intervention period from February 2023 – April 2023 to see what effect the visual primes had on healthcare workers’ hand hygiene behaviors,

which is depicted in **Table 4**. Units B, C, and D showed an increased average compliance from when the primes were present, but unit A’s average compliance rate decreased from the pre-intervention period. These findings are available in **Figure 6**. Even though Unit A was the only unit that did not show improvement, the average compliance rate was still the highest out of all four units that were studied. The average compliance rate in unit A decreased by 11.1%. Units B, C, and D demonstrated increased compliance rates of 27%, 20.1%, and 17.3%, with unit B revealing the greatest improvement.

Table 4. Baseline and Intervention Hand Hygiene Compliance on Units A-D

Baseline				
Unit	October 2022	November 2022	December 2022	Average
A	90.9%	79.7%	68.6%	79.7%
B	15.0%	50.0%	19.0%	28.0%
C	38.1%	29.1%	33.3%	33.5%
D	42.9%	60.3%	18.8%	40.7%
Intervention				
Unit	February 2023	March 2023	April 2023	Average
A	52.4%	75.0%	78.3%	68.6%
B	30.4%	56.9%	77.8%	55.0%
C	56.9%	66.4%	37.5%	53.6%
D	40.4%	64.1%	69.4%	58.0%

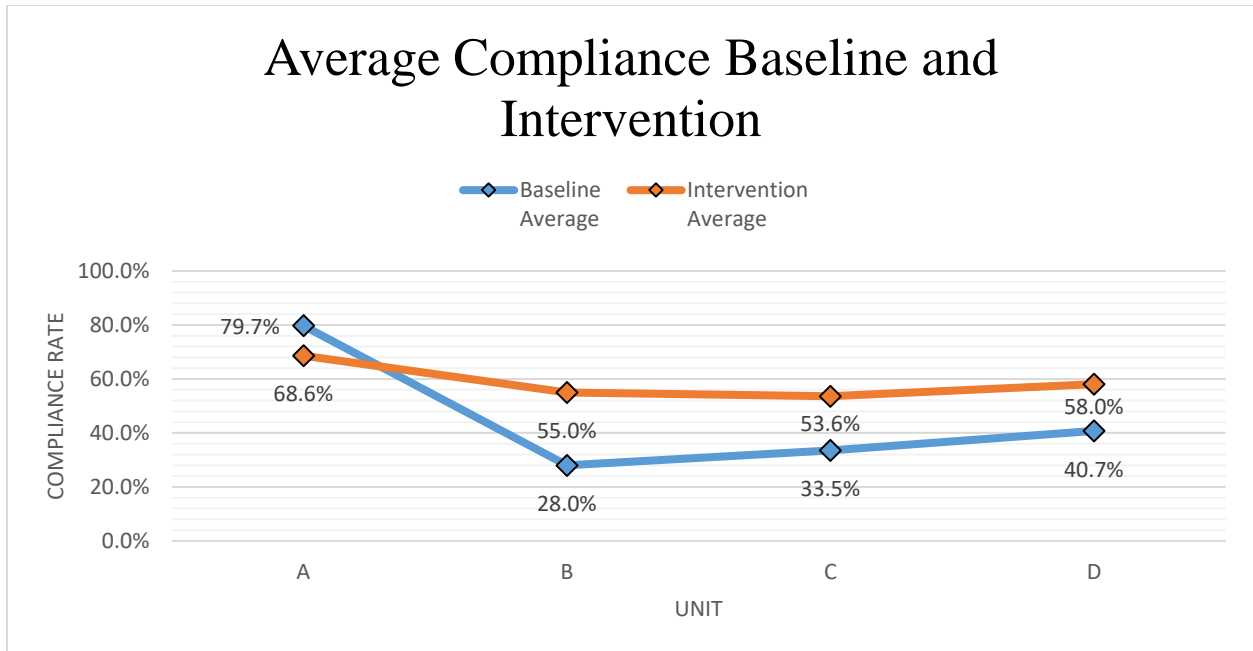


Figure 6. Average Compliance Baseline and Intervention on Units A-D

3.4 Discussion

Overall, the intervention demonstrated significant improvement on three of the units, suggesting that priming can be a successful method in combatting non-adherence. Unit A was the only unit where compliance decreased post-intervention. Before the intervention took place, compliance has been noted to be much less in the past on unit A which is why it was selected to study, however, the data was much higher than originally anticipated. Even so, unit A still had the highest averaged compliance rate. Each unit that was measured demonstrated an averaged adherence rate of above 50%.

It is important to note that the overall hospital rates of hand hygiene compliance stayed consistent prior to and during the study. The overall compliance for the entire hospital was

66.3% pre-intervention, and at 61.74% during the period when the new signage and emojis were added to units A-D, further pointing to the success of the visual primes.

Compared to the studies identified in the literature review, the intervention at the UPMC facility demonstrated similar results. Using signage as a visual cue demonstrates the strongest likelihood of being effective when it draws more attention. It would be interesting to extend this study and implement other signs and emojis that are not UPMC colors to allow them to stand out to healthcare workers even further. The intervention was successful in increasing hand hygiene adherence and supports the hypothesis that priming is an effective method to improving compliance.

3.5 Limitations

Due to the study design and the short nature of time, there are some limitations that are important to make note of. It is worth stating that staff are not engaged and less than responsive in the units that were selected to undergo the intervention. As previously mentioned, direct observation has the potential to cause the Hawthorne effect in studies. If healthcare workers are aware they are being watched they are more likely to demonstrate appropriate behaviors, which can significantly skew results (Slaughter et al., 2022).

UPMC approved material that incorporated their colors was used for this study, so compliance may have been at higher rates if other colors would have been able to be used.

Lastly, another design flaw of this intervention is that on unit B, due to the textured Acrovyn material on the walls, signs were not able to be placed outside of each patient room door. Instead, signs were hung on three bulletin boards, one at each end of the unit, and one

centrally, near the nurse's station, though interestingly this unit demonstrated the greatest improvement in hand hygiene adherence.

4.0 Conclusions

Hand Hygiene adherence remains stubbornly suboptimal in healthcare settings. Priming occurs when an individual's exposure to certain cues guides their response to behavior change without any knowledge of the connection it brings. Studies have confirmed that priming interventions have shown to be a successful method in combatting non-compliance. Priming interventions empower infection prevention by raising awareness with no language barrier and educating healthcare workers to adopt healthy, hygienic behaviors (Lotfinjad et al., 2020). Nonetheless, future directions could include further research on priming to aid in creating additional interventions to increase hand hygiene compliance. So far, studies have supported the evidence that priming is an effective way to influence decision-making and alter behavior. Multicomponent strategies are necessary to obtain the most significant and lasting improvements in hand hygiene adherence (Vander Weg et al., 2019). Understanding what interventions do not lead to desired improvements is arguably just as important as understanding what interventions provide the most improvement.

5.0 Public Health Significance

Availability of alcohol-based hand rub and other handwashing materials is important to adherence, so it is imperative that staff have access to the proper resources needed to prevent the transmission of germs and infections among patients. Healthcare workers face conditions that make repetitive behaviors difficult and proper hand hygiene gets deprioritized to their subconscious, increasing the likelihood for infection. Infections can lead to serious health implications for the patient as well as morbidity and mortality. High-quality education is needed to achieve proper adherence, which will ultimately reduce infections and increase the quality of care and patient safety, which is a goal of public health.

Bibliography

- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-t](https://doi.org/10.1016/0749-5978(91)90020-t)
- American Psychological Association. (n.d.). *Apa Dictionary of Psychology*. American Psychological Association. Retrieved from <https://dictionary.apa.org/priming>
- Bilgin, H., Sili, U., Pazar, N., Kucuker, I., Kepenekli, E., Yanar, M. A., Memisoglu, A., Ozek, E., Adhikari, N. K. J., Pinto, R., & Kortan, V. (2023). Effect of video camera monitoring feedback on hand hygiene compliance in Neonatal Intensive Care Unit, an interventional study. *American Journal of Infection Control*. <https://doi.org/10.1016/j.ajic.2022.12.011>
- Birnback, D. J., King, D., Vlaev, I., Rosen, L. F., & Harvey, P. D. (2013). Impact of environmental olfactory cues on hand hygiene behaviour in a simulated hospital environment: A randomized study. *Journal of Hospital Infection*, 85(1), 79–81. <https://doi.org/10.1016/j.jhin.2013.06.008>
- Boyce, J. M. (2011). Measuring healthcare worker hand hygiene activity: Current practices and emerging technologies. *Infection Control and Hospital Epidemiology*, 32(10), 1016–1028. <https://doi.org/10.1086/662015>
- Bredin, D., O'Doherty, D., Hannigan, A., & Kingston, L. (2022). Hand hygiene compliance by direct observation in physicians and nurses: A systematic review and meta-analysis. *Journal of Hospital Infection*, 130, 20–33. <https://doi.org/10.1016/j.jhin.2022.08.013de>
- Centers for Disease Control and Prevention. (2016, March 1). *Hand hygiene*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/oralhealth/infectioncontrol/faqs/hand-hygiene.html>
- Centers for Disease Control and Prevention. (2021, June 21). *Health topics - hai - polaris*. Centers for Disease Control and Prevention. Retrieved March 6, 2023, from <https://www.cdc.gov/policy/polaris/healthtopics/hai/index.html#:~:text=HAIs%20are%20infections%20resulting%20from,occur%20in%20other%20healthcare%20settings.>
- Centers for Disease Control and Prevention. (2002, October 25). *Guideline for hand hygiene in health-care settings*. Retrieved from <https://www.cdc.gov/mmwr/PDF/rr/rr5116.pdf>
- Centers for Disease Control and Prevention. (2020, September 10). *Show me the science – when & how to use hand sanitizer in community settings*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/handwashing/show-me-the-science-hand-sanitizer.html>

- de Macedo, R. de, Oliveira Jacob, E. M., da Silva, V. P., Santana, E. A., de Souza, A. F., Gonçalves, P., Marra, A. R., Pavão dos Santos, O. F., Cendoroglo, M., & Edmond, M. B. (2012). Positive deviance: Using a nurse call system to evaluate hand hygiene practices. *American Journal of Infection Control*, 40(10), 946–950. <https://doi.org/10.1016/j.ajic.2011.11.015>
- Diegel-Vacek L, Ryan C. Promoting Hand Hygiene With a Lighting Prompt. *HERD: Health Environments Research & Design Journal*. 2016;10(1):65-75. doi:10.1177/1937586716651967
- Douglas Scott, R. (2009, March). *The direct medical costs of - Centers for Disease Control and Prevention*. cdc.gov. Retrieved from https://www.cdc.gov/HAI/pdfs/hai/Scott_CostPaper.pdf
- Drews, F. A., Visnovsky, L. C., & Mayer, J. (2019). Human factors engineering contributions to infection prevention and Control. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 61(5), 693–701. <https://doi.org/10.1177/0018720819833214>
- Edmond, M. B., Goodell, A., Zuelzer, W., Sanogo, K., Elam, K., & Bearman, G. (2010). Successful use of alcohol sensor technology to monitor and report hand hygiene compliance. *Journal of Hospital Infection*, 76(4), 364–365. <https://doi.org/10.1016/j.jhin.2010.07.006>
- Gaube, S., Tsivrikos, D., Dollinger, D., & Lermer, E. (2018). How a smiley protects health: A pilot intervention to improve hand hygiene in hospitals by activating injunctive norms through emoticons. *PLOS ONE*, 13(5). <https://doi.org/10.1371/journal.pone.0197465>
- Glowicz, J. B., Landon, E., Sickbert-Bennett, E. E., Aiello, A. E., deKay, K., Hoffmann, K. K., Maragakis, L., Olmsted, R. N., Polgreen, P. M., Trexler, P. A., VanAmringe, M. A., Wood, A. R., Yokoe, D., & Ellingson, K. D. (2023). Shea/IDSA/APIC Practice Recommendation: Strategies to prevent healthcare-associated infections through hand hygiene: 2022 update. *Infection Control & Hospital Epidemiology*, 44(3), 355–376. <https://doi.org/10.1017/ice.2022.304>
- Hlady CS, Severson MA, Segre AM, Polgreen PM. A mobile handheld computing application for recording hand hygiene observations. *Infect Control Hosp Epidemiol*. 2010 Sep;31(9):975-7. doi: 10.1086/655834. PMID: 20636134; PMCID: PMC3024852.
- Jeanes, A., Coen, P. G., Gould, D. J., & Drey, N. S. (2019). Validity of hand hygiene compliance measurement by Observation: A Systematic Review. *American Journal of Infection Control*, 47(3), 313–322. <https://doi.org/10.1016/j.ajic.2018.08.004>
- King, D., Vlaev, I., Everett-Thomas, R., Fitzpatrick, M., Darzi, A., & Birnbach, D. J. (2016). “priming” hand hygiene compliance in clinical environments. *Health Psychology*, 35(1), 96–101. <https://doi.org/10.1037/hea0000239>

- Lotfinejad, N., Assadi, R., Aelami, M. H., & Pittet, D. (2020). Emojis in public health and how they might be used for hand hygiene and Infection Prevention and control. *Antimicrobial Resistance & Infection Control*, 9(1). <https://doi.org/10.1186/s13756-020-0692-2>
- Marra, A. R., & Edmond, M. B. (2014). New technologies to Monitor Healthcare Worker Hand Hygiene. *Clinical Microbiology and Infection*, 20(1), 29–33. <https://doi.org/10.1111/1469-0691.12458>
- Marra, A. R., Moura, D. F., Paes, Â. T., dos Santos, O. F., & Edmond, M. B. (2010). Measuring rates of hand hygiene adherence in the Intensive Care Setting: A Comparative Study of direct observation, product usage, and electronic counting devices. *Infection Control & Hospital Epidemiology*, 31(8), 796–801. <https://doi.org/10.1086/653999>
- Michie, S. (2005). Making psychological theory useful for implementing evidence based practice: A consensus approach. *Quality and Safety in Health Care*, 14(1), 26–33. <https://doi.org/10.1136/qshc.2004.011155>
- Monegro AF, Muppidi V, Regunath H. Hospital Acquired Infections. [Updated 2022 Aug 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK441857/>
- Mouajou, V., Adams, K., DeLisle, G., & Quach, C. (2021, September 25). Hand hygiene compliance in the Prevention of Hospital-Acquired Infections: A systematic review. *Journal of Hospital Infection*, 119, 33–48. <https://doi.org/10.1016/j.jhin.2021.09.016>
- Novák, M., Breznický, J., Kompaníková, J., Malinovská, N., & Hudečková, H. (2019). Impact of hand hygiene knowledge on the hand hygiene compliance. <https://doi.org/10.17392/1051-20>
- Poczai, P., & Karvalics, L. Z. (2022). The little-known history of cleanliness and the forgotten pioneers of handwashing. *Frontiers in Public Health*, 10. <https://doi.org/10.3389/fpubh.2022.979464>
- Schmidtke, K. A., Aujla, N., Marshall, T., Hussain, A., Hodgkinson, G. P., Arheart, K. L., Birnbach, D. J., Kudrna, L., & Vlaev, I. (2022). A crossover randomized controlled trial of priming interventions to increase hand hygiene at ward entrances. *Frontiers in Public Health*, 9. <https://doi.org/10.3389/fpubh.2021.781359>
- Schmidtke, K. A., Aujla, N., Marshall, T., Hussain, A., Hodgkinson, G. P., Arheart, K., Marti, J., Birnbach, D. J., & Vlaev, I. (2017). Using environmental engineering to Increase Hand Hygiene Compliance: A cross-over study protocol. *BMJ Open*, 7(9). <https://doi.org/10.1136/bmjopen-2017-017108>
- Shobowale, E. O., Adegunle, B., & Onyedibe, K. (2016). An assessment of hand hygiene practices of healthcare workers of a semi-urban teaching hospital using the five moments of Hand Hygiene. *Nigerian Medical Journal*, 57(3), 150. <https://doi.org/10.4103/0300-1652.184058>

- Slaughter, J., Arya, E., Bell, E., Ayres, A., Martin, E. M., & Snyder, G. M. (2022). Utilizing an interview method to estimate potential bias in silent observer hand hygiene observations. *American Journal of Infection Control*. <https://doi.org/10.1016/j.ajic.2022.11.022>
- The Joint Commission. (2009). *A trusted partner in Patient Care | The Joint Commission*. [jointcommission.org](https://www.jointcommission.org/-/media/tjc/documents/resources/hai/hh_monograph.pdf). Retrieved from https://www.jointcommission.org/-/media/tjc/documents/resources/hai/hh_monograph.pdf
- Troiano, G., & Nante, N. (2018). Emoji: What does the scientific literature say about them?-a new way to communicate in the 21st century. *Journal of Human Behavior in the Social Environment*, 28(4), 528–533. <https://doi.org/10.1080/10911359.2018.1437103>
- Vander Weg, M. W., Perencevich, E. N., O’Shea, A. M., Jones, M. P., Vaughan Sarrazin, M. S., Franciscus, C. L., Goedken, C. C., Baracco, G. J., Bradley, S. F., Cadena, J., Forrest, G. N., Gupta, K., Morgan, D. J., Rubin, M. A., Thurn, J., Bittner, M. J., & Reisinger, H. S. (2019). Effect of frequency of changing point-of-use reminder signs on health care worker hand hygiene adherence. *JAMA Network Open*, 2(10). <https://doi.org/10.1001/jamanetworkopen.2019.13823>
- van Roekel, H., Reinhard, J., & Grimmelikhuijsen, S. (2021). Improving hand hygiene in hospitals: Comparing the effect of a nudge and a boost on protocol compliance. *Behavioural Public Policy*, 6(1), 52–74. <https://doi.org/10.1017/bpp.2021.15>
- Vaughan-Malloy, A. M., Chan Yuen, J., & Sandora, T. J. (2023). Using a human factors framework to assess clinician perceptions of and barriers to high reliability in hand hygiene. *American Journal of Infection Control*. <https://doi.org/10.1016/j.ajic.2023.01.013>
- Wang C, Jiang W, Yang K, Yu D, Newn J, Sarsenbayeva Z, Goncalves J, Kostakos V. Electronic Monitoring Systems for Hand Hygiene: Systematic Review of Technology. *J Med Internet Res*. 2021 Nov 24;23(11):e27880. doi: 10.2196/27880. PMID: 34821565; PMCID: PMC8663600.
- World Health Organization. (1970, January 1). *WHO guidelines on hand hygiene in Health Care*. World Health Organization. Retrieved from <https://apps.who.int/iris/handle/10665/44102>
- World Health Organization. (n.d.). *World Hand Hygiene Day*. World Health Organization. Retrieved from <https://www.who.int/campaigns/world-hand-hygiene-day>