HEALTHCARE PROVIDERS AND PARENTS OF PATIENTS IN THE NICU: WHAT ARE THE BARRIERS AND FACILITATORS TO MOBILE DEVICE CLEANING?

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A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Public Health in the Department of Health Policy and Management in the Gillings School of Global Public Health.

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ABSTRACT

R. Marty Cooney: Healthcare Providers and Parents of Patients in the NICU:
What Are the Barriers and Facilitators to Mobile Device Cleaning?
(Under the direction of Morris Weinberger)

Patients in the neonatal intensive care unit (NICU) are at an increased risk of acquiring a healthcare-associated infection (HAI) due to multiple procedures, invasive lines, co-morbidities, and the care involved with a critically ill patient. A mobile cell phone used by a healthcare worker or parent of a patient can become contaminated and increase the risk of spreading harmful organisms which can cause infection. Pathogen transmission from healthcare worker or visitor to a patient happens when hands or other inanimate objects become contaminated with microorganisms and subsequently come in direct contact with the patient. Many hospitals lack specific guidelines that address mobile devices carried in the hands and pockets of healthcare workers and parents who venture into a NICU room.

This study used a mixed-methods approach to understand possible barriers and facilitators to mobile device disinfection for healthcare workers and parents of patients in the NICU. The goal was to identify environmental and behavioral interventions that help healthcare workers and parents of NICU patients increase phone disinfection practices. Lessons learned from this study show that there is a need for a mobile device disinfection program in all hospital NICUs. The plan for change will guide the UNC Health system to implement a safe mobile device disinfection policy and protocol for use in all NICU settings to help prevent HAIs in patients.

For the many small NICU babies.

To my mom who never gave up on me when I thought I did not want to go to college.
I could not have done this without you. Thank you for all your love and support along the way.

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
CMS	Centers for Medicare & Medicaid Services
HAI	healthcare-associated infection
HBM	Health Belief Model
HCAHPS	Hospital Consumer Assessment of Healthcare Providers and Systems
HCW	healthcare workers (e.g., physicians, nurses, respiratory therapists, nurse technicians, pharmacists, hospital volunteers, and administrative staff)
ICU	intensive care unit
IPA	isopropyl alcohol
IRB	institutional review board
MDRO	multidrug-resistant organism
MRSA	methicillin-resistant *Staphylococcus aureus*
NHLBI	National Heart, Lung, and Blood Institute
NICU	neonatal intensive care unit
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analysis
UV	ultraviolet
UNC	University of North Carolina

CHAPTER 1: INTRODUCTION

Background and Significance

Patients in the neonatal intensive care unit (NICU) are at an increased risk of acquiring a healthcare-associated infection (HAI) due to co-morbidities, procedures, invasive devices, and the general care involved with a critically ill patient.[1] According to the Centers for Disease Control and Prevention (CDC), evidence of pathogen transmission directly from healthcare workers (HCWs) to patients involves "organisms present on the skin, or that have been shed onto inanimate objects capable of surviving for at least several minutes."[2] HCWs and parents of patients frequently use unclean cell phones and mobile devices daily while working or visiting in the NICU. Parents take pictures of their new baby as a way to get actively involved and tell their baby's story.[3] Mobile devices that have not been properly disinfected have the potential to expose patients and communities to harmful microbial transmission.[4,5] Mobile cell phones used by HCWs, parents of patients, and visitors can carry harmful organisms that contaminate inanimate surfaces and essential lines that are used to help sustain life.[6]

Personal mobile devices are ubiquitous among HCWs[7] and are frequently touched, enabling contamination and introducing the potential to infect patients. Heyba et al.[8] found that the phones of 157 of 213 intensive care unit (ICU)/NICU HCWs were colonized with deadly bacteria, and 66.5% of those clinicians reported never having disinfected their phones. Without proper disinfection of personal mobile devices, the risk of microbe cross-contamination between patients and the patient care environment increases.

Mobile devices are integrated into most individuals' daily routines.[9] As individuals go from place to place, they can easily pick up and spread organisms in the environment unless they take steps such as wiping down their mobile devices with an appropriate disinfectant or using an ultraviolet (UV) sanitation device. In one large cross-sectional study, 238 of 256 samples (92.9%) taken at a public convention center showed evidence of bacterial contamination on mobile phone surfaces; this included 3% with fungi and other deadly antibiotic-resistant strains.[10] These deadly strains are circulating in and out of the hospital setting on the surfaces of mobile devices.

Inadequate personal hand hygiene, lack of cleaning behaviors before and after handling a mobile device, and lack of prevention strategies can further contribute to HAI risk.[11] To reduce the risk of spreading organisms, hospitals need to supply adequate cell phone disinfecting resources or guidance for HCWs or visitors to properly disinfect their cell phones.

Olsen et al.[4] found that hospitals and clinics around the world lack cell phone cleaning guidelines, including training in decontaminating mobile phones. A mobile device disinfection program has the potential to minimize the risk of transmitting HAIs from organisms commonly found on the cell phones of providers, parents, and visitors. Appropriate disinfection of devices should be considered an essential part of keeping patients safe.[12]

Study Aims

To reduce HAIs among patients in the NICU, the overall goal of this study was to develop and implement a mobile device cleaning strategy that accounts for barriers and facilitators identified by healthcare providers and parents of patients in the NICU. The specific aims were as follows: 1) identify barriers and facilitators to mobile device cleaning in the NICU

for HCWs and parents of patients, 2) develop an intervention to increase cleaning phones in the NICU, and 3) evaluate the effectiveness of the intervention.

CHAPTER 2: LITERATURE REVIEW

Methods

Information Sources

Three sources were chosen for this systemic review, including the US National Library of Medicine PubMed, Elsevier Embase, and Science & Technology (general) databases. These databases were chosen because they are highly respected in medical and technology fields.

Search Strategy

The search terms used are described in Table 1. The search strategy consisted of retrieving published articles from the key databases described above and framing the search on specific inclusion/exclusion criteria described below.

TABLE 1: Search Terms for the Literature Review

Concept	Search Terms
Mobile portable electronic devices used	"Mobile devices" or "cellphones" or "cell phone" "mobile phones" or "mobile" or "phone" or "telephone" or "electronic tablets" or "tablets" or "electronic notebooks" or "personal digital assistants" or "PDA" or "multimedia players"
	AND
Microorganisms potentially found on mobile devices	"Germs" or "bacteria" or "organisms" or "flora" or "microorganisms" or "multi-drug resistant organisms" or "MDRO" or "pathogens" or "bacterium" or "microbe" or "virus" or "fungus" or "fungi" or "yeast"
	AND
Infections related to mobile devices	"Infection" or "contamination" or "disease" or "morbidity" or "mortality" or "death" or "deceased" or "sepsis" or "septicemia"
	AND
Outbreaks potentially from mobile devices	"Outbreak" or "epidemic" or "flare-up" or "up-tic" or "onset"

Eligibility Criteria

The search strategy for this review used a standard criterion to capture transmission of microorganism. Table 2 provides the inclusion/exclusion criteria involved in this research, including the rationale for each.

TABLE 2: Inclusion Criteria, Exclusion Criteria, and Rationale for Literature Review

Inclusion Criteria	Exclusion Criteria	Rationale
Articles in English		To reduce overall interpretation bias and misunderstandings, English-language articles were selected to facilitate the literature review without use of interpreters
Published studies involving mobile devices (cell phones, electronic tablets, electronic notebooks, personal digital assistants)		Only personal, mobile devices that can frequently go in and out of patient rooms with potential cross-transmission were selected
Published studies that identify environmental microorganisms that can be found on mobile devices (germs, bacteria, organisms, microorganisms, and multidrug-resistant organisms)		The type of organisms on mobile devices are important to identify because certain species are well known and increase the risk for human infection
Published international or domestic randomized controlled trials (RCTs), quasi-experimental trials, and other qualitative, quantitative, descriptive, and analytical research studies		RCTs and quasi-experimental studies are preferred but since many mobile devices are newer technology items without years of research, other types of published studies will be included (except study reviews to prevent reviewer bias to original research)
Hospital ICUs		Hospital ICUs house the greatest risk for morbidity and mortality due to complex comorbidity and immunosuppression therapy
Healthcare workers, providers, patients, and visitors	Students	Students have limited access and are supervised with care

Study Selection

The study selection process involved a two-stage approach by a single reviewer. The first stage involved a title and abstract review to screen articles and remove duplicates. At the second stage, a full text review of the selected articles was conducted to determine eligibility using the inclusion/exclusion criteria in Table 2. In addition, eligible articles were identified by manual searches of the references of selected articles.

Studies were reviewed for quality, content, and strength of evidence while recognizing any major limitations using the National Heart, Lung, and Blood Institute (NHLBI) Quality Assessment Tools for Systematic Reviews.

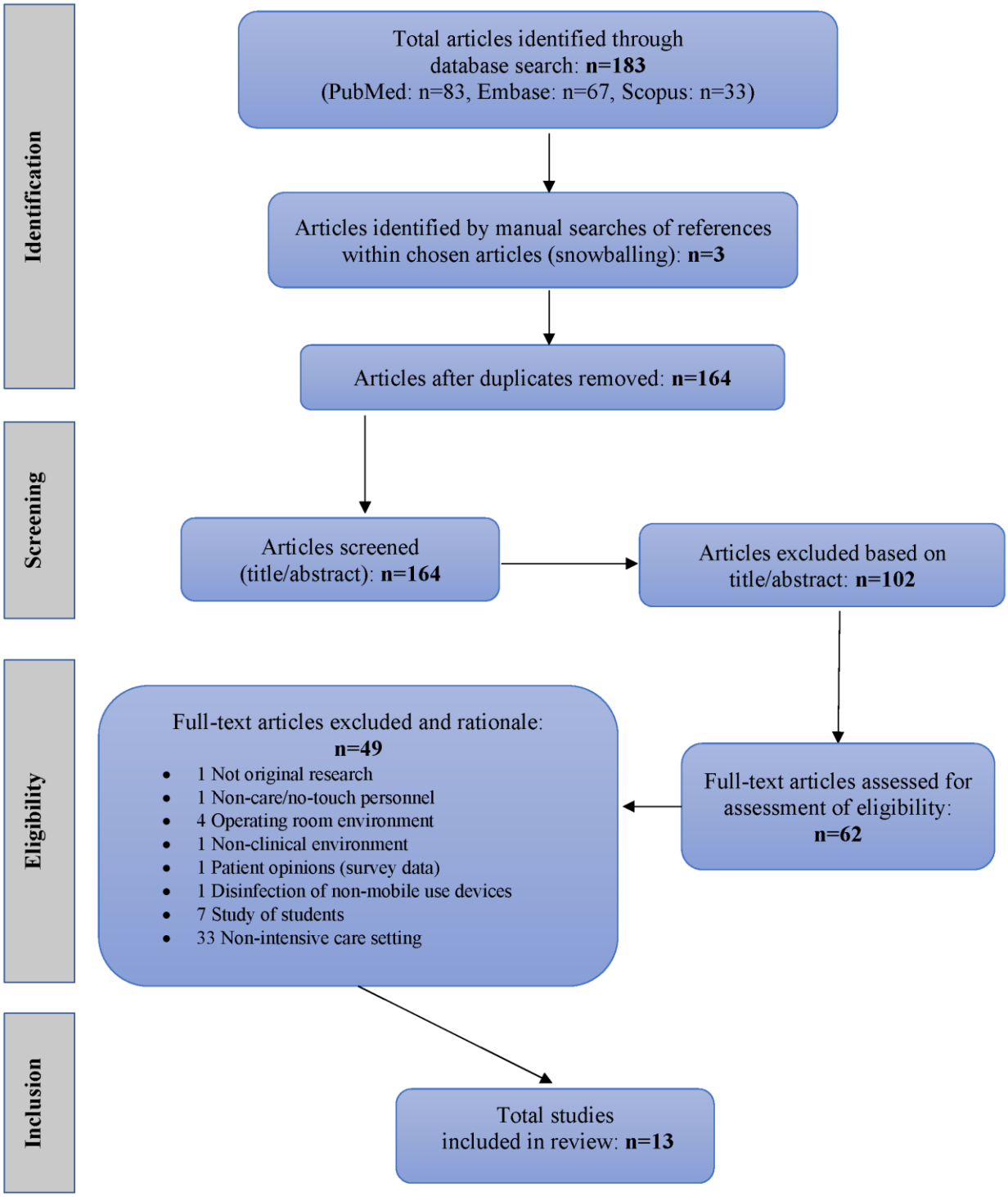
The following information was extracted from each study and included on the data extraction spreadsheet:

1. Study design
2. Study setting
3. Study population
4. Type of mobile device
5. Microbiological data from surfaces of mobile devices
6. Mobile device bioburden that had spread onto environmental reservoirs
7. Infections related to microbiological mobile device bioburden
8. Outbreaks associated from microbiological certainty involving mobile devices
9. Disinfection practices
10. Author conclusions
11. Validity threats (internal/external)
12. Limitations
13. Risk of bias

Results

The literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines[13] (Figure 1). The first stage identified 183 references; 3 additional articles were identified through manual bibliographic review. After 22 duplicates were removed, 164 records remained for title and abstract review; 102 studies were removed based on in-depth review of remaining title and abstract, leaving 62 studies for further review. Of the 62 studies, 49 were removed for the following reasons: not original research (n=1), non-care/no-touch personnel (n=1), operating room outpatient environment (n=4), non-clinical environment (n=1), patient opinions (survey data) (n=1), disinfection of non-mobile use devices (n=1), study of students (n=7), and non-intensive care settings (n=33). Thus, 13 studies were included for final review.

FIGURE 1: Search Strategy (PRISMA Guidelines)



Study Characteristics

The 13 included articles came from hospital intensive care environments within the United States (n=3), Peru (n=3), France (n=2), Italy (n=2), Kuwait (n=1), Turkey (n=1), and Croatia (n=1). These studies had various study designs, including cross-sectional (n=1), prospective observational (n=1), prospective monocentric (n=1), observational cohort (n=2), before and after observational (n=7), and case control (n=1). There were no randomized controlled trials within the included studies.

Results are presented separately for adult and pediatric patients due to differences involving the type of care, patient rooming, staffing, training, co-morbidities, medication regimens, and visitation policies.

Pediatric ICU/NICU Findings

In the pediatric/NICU studies, cell phones were often contaminated and presented an increased risk for spreading germs. In one study, cell phones were described as a vector and reservoir to cause a true nosocomial infection.[14] The study by Beckstrom et al.[15] also 1) recognized that cell phones with bacteria can serve as vectors for HAIs in the NICU; 2) argued for specific cleaning guidelines for cell phones; and 3) was the only one that attempted to link bacterial contamination of the parent's cell phone in the NICU setting to patients, but attempts were unsuccessful. Loyola et al.[16] had similar findings but added concerns claiming that three-quarters of HCWs admitted to not cleaning their phones, and 47% used those contaminated phones during patient care work shifts.

Kirkby et al.[17] recommended creating a simple cell phone cleaning process in the NICU and diligently adhering to hand hygiene practices after cell phone use to provide a safer cleaner environment. Notably, cell phones of different types were not easy to clean, and difficulties in

cleaning and decontamination of these devices were felt to increase infection risks due to individual device differences.[18]

None of these studies were able to show a direct causal relationship between cell phone bacterial contamination and HAIs. However, HCW behavioral practices revealed consistent findings with opportunities for improvement in mobile device hygiene.[14,15,17]

Adult ICU Findings

Galazzi et al.[19] found that 100% of HCWs' cell phones tested were contaminated with bacteria; however, "no patient admitted to the ICU during the study period was positive for the bacteria found on HCWs' mobile phones." These results differ from a study in Peru, in which all ICU cell phones also had bacteria but only 44% had bacteria of "clinical significance." [20] The authors did not define clinical significance nor is this mentioned in other studies. It is commonly understood that various bacteria types found in the blood can be a source of infection.

Types of Cell Phone Organisms Found

Kotris et al.[21] found that coagulase-negative staphylococci and *Staphylococcus aureus* were the most common organisms and that most HCWs reported cleaning their cell phones at least once a week. Another study found *S. aureus* as the most common organism, but their disinfection protocol appeared insufficient as only 5 of 47 participants (10.6%) reported washing their cell phones monthly.[22]

Singh et al.[23] found that HCWs' hands and cell phones were contaminated with multiple types of bacterial pathogens that contribute to nosocomial infections in hospitals. A recent study at Duke University's medical and surgical ICUs recommended initiatives to support basic hygiene guidelines for cell phones that include disinfecting mobile devices after patient contact and adherence to good hand hygiene practices.[24]

In a five-ICU study that included 491 samples, multidrug-resistant organisms (MDROs) detected included *Acinetobacter* spp. (31.3%), *S. aureus* (46.7%), *Pseudomonas aeruginosa* (2.9%), and *Enterococcus* spp. (80.8%).[25] These findings directly contradict another ICU study in which "colonization with pathogens was frequent, but colonization with multi-drug resistant bacteria was rare."[26] MDROs in a patient's blood samples are common, and resistance to antibiotics can severely limit treatment options and survival rates. Recognizing that microbiologic techniques and sampling methods varied significantly, organisms found on cell phones included various potential pathogens (Table 3). *S. aureus* was the most common organism found, and *Aeromonas* was the least common.

TABLE 3: Identification of Cell Phone Contamination with Separate Microbial Species

Pathogen (Most to Least Common)
Staphylococcus aureus (methicillin-resistant [MRSA] and methicillin-susceptible [MSSA])
Enterobacteriaceae (*Proteus*, *Escherichia coli*, *Citrobacter freundii*, *Enterobacter aerogenes*, and *Klebsiella* spp.)
Coagulase-negative staphylococci (*S. epidermidis* and *S. saprophyticus*)
Bacillus spp.
Acinetobacter spp.
Enterococcus spp.
Stenotrophomonas maltophilia
Pseudomonas spp. (*P. aeruginosa* and *P. stutzeri*)
Sphingomonas paucimobilis
Aeromonas spp. (*A. hydrophila* and *A. caviae*)

Discussion

The results of this systematic review suggest that personal cell phones used in adult and pediatric ICUs are a potential vector for HAIs and prevention is important because HAIs can cause adverse events, including mortality.[27] This review provided overwhelming evidence that cell phones are a potential microbiological hazard in ICUs. Various organisms were found on

HCWs' cell phones in both adult ICUs and NICUs (Table 3). The study by Kirkby et al.[17] was the only one to include cultures of the parents' cell phones.

This literature review failed to identify a direct causal link of infection related to cell phone use. Ultimately, studies have speculated about the association of cell phone use with HAI. Although there is no DNA evidence (genetic sequencing indicating and exact DNA match) to prove transmission has occurred,[28] the exceedingly-high prevalence of microorganisms on cell phones in the ICU suggests that interventions to clean phones are important.

Study Quality

Using the NHLBI Quality Assessment Tools for Systematic Reviews,[29] two studies[17,20] were considered low quality: one for its very low sample size (n=18) and risk of selection bias and the other for a poor study protocol, respectively. Seven studies[14-16,19,21,22,24] were considered to be of medium quality due to the lack of control groups and unclear risk of selection bias. The four high-quality studies[18,23,25,26] directly examined contaminate sources while limiting bias.

Role of Identified Microorganisms

Contamination of microorganisms on cell phones among HCWs varied across studies. Among the organisms identified, both Gram-negative bacteria and Gram-positive cocci were isolated from HCW cell phones. *Acinetobacter*, an organism that is rarely seen in infections outside of healthcare settings and accounts for around 80% of reported infections, [30] was commonly found in the five-ICU study[25] but not found in other studies. *S. aureus* was the most common organism identified in the 13 studies. This observation is not surprising, given that *S. aureus* was the most commonly reported infection in a 2018 survey of 183 US hospitals.[31]

Cell Phone Germ Theory of Disease Outcomes

Each of the studies reviewed suggests that harmful microbes can cause HAIs if transmitted from a HCW's mobile phone to patients, although transmission could also occur via the HCW's hands. Notably, none of the 13 studies reviewed correlated DNA, so they could not provide empirical DNA directly linking a HCW's cell phone bacteria to a patient's bacterial infection. Despite the plausibility of this link, HCWs rarely cleaned their phones. For example, Beckstrom et al.[15] found that 62% of HCWs in a NICU reported never cleaning their cell phones. This increases the risk of spreading germs because even if HCWs clean their hands, they can become recontaminated once they touch their dirty cell phones. No studies explored whether having a cell phone disinfection protocol lowered infections in patients.

Limitations

There are several limitations of this literature review. First, there was only one reviewer who attempted to minimize this source of bias by following PRISMA guidelines. Second, none of the articles were randomized controlled trials; rather, they were cross-sectional (n=1), prospective observational (n=1), prospective monocentric (n=1), observational cohort (n=2), before and after observational (n=7), and case control (n=1) studies. Notably, 11 of the 13 articles were medium- or higher-quality studies. Third, the five studies reporting disinfection and cleaning methods showed variability with their products and applications, limiting the ability to make comparisons across studies. Finally, none of the studies tested the DNA to see whether transmission had occurred. DNA testing using genetic sequencing is an important measure to determine with certainty if direct causation exists.

Gaps in the Literature and Future Directions

Each of the studies concluded that cell phones used in adult ICU or NICU settings are frequently contaminated with microorganisms. Even without DNA evidence linking bacteria on a phone to a specific organism, effective behavioral strategies to increase phone disinfection practices by HCWs, patients, and visitors should be established. To do so requires qualitative methods to identify barriers and facilitators to mobile device disinfection practices for HCWs, patients, and visitors.

CHAPTER 3: METHODOLOGY

To reduce HAIs among infants in the NICU, the overarching goal of this study was to develop and implement a mobile device cleaning strategy that accounts for barriers and facilitators identified by healthcare providers and parents of patients in the NICU. To do so, the specific aims of this study were to 1) identify barriers and facilitators to mobile device cleaning in the NICU for HCWs and parents of patients, 2) develop and test an intervention that increases clean cell phone use in the NICU, and 3) evaluate the effectiveness of the intervention.

Qualitative and quantitative data were needed to aid in the development, implementation, and evaluation of an effective intervention. Qualitative data derived from key informant interviews helped the researcher identify feelings toward mobile device cleaning, why mobile device cleaning may not be consistently performed, and what strategies were needed to implement a successful mobile device disinfection program in the University of North Carolina (UNC) Rex NICU. Quantitative data derived from direct observation measured compliance rates of mobile device cleaning opportunities for comparison purposes. Use of the intervention, rather than infection rates, was tracked.

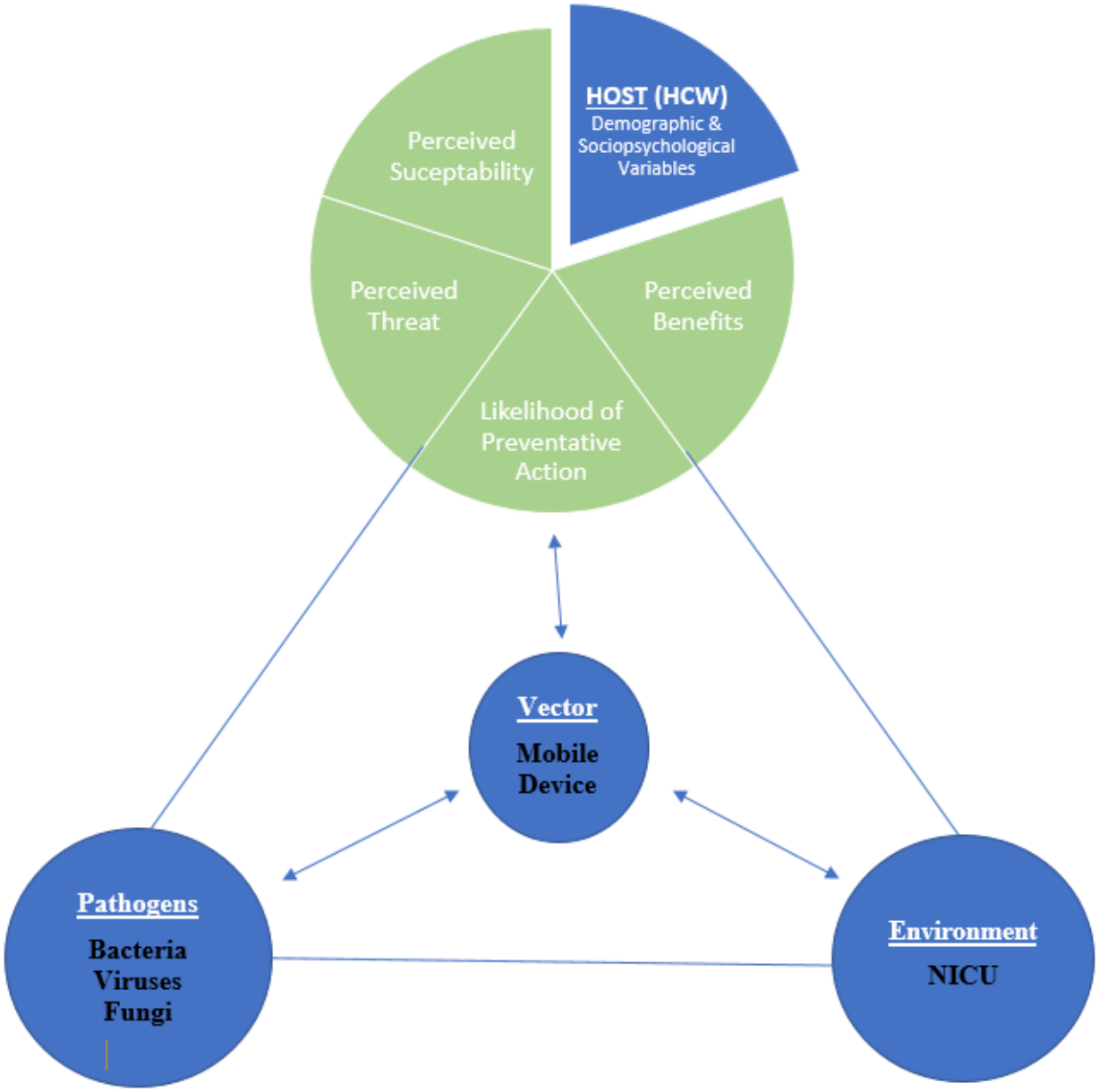
Conceptual Model

The conceptual framework for this dissertation (Figure 2) blended important concepts from the germ theory of disease and the Health Belief Model (HBM). In the late 19th century, Louis Pasteur popularized the germ theory of disease that described how microscopic organisms caused many diseases.[32] This germ theory provided a foundation that invisible bacteria can be

easily transmitted. In the early 1950s, social scientists developed the HBM to "understand the failure of people to adopt disease prevention strategies which suggests that a person's belief in a personal threat of an illness or disease together with a person's belief in the effectiveness of the recommended health behavior or action will predict the likelihood the person will adopt the behavior."[33] The HBM suggests that individuals' perceptions are related to the likelihood of adopting preventative cleaning behaviors (e.g., mobile device disinfection practices). This blended model was important because the researcher examined behaviors and choices made by HCWs and visitors in the NICU to disinfect their mobile devices.

Increasing device disinfection practices by motivating HCWs and NICU visitors can help 1) prevent inadvertent contamination of hands from cell phones, 2) reduce germs in the NICU environment from cross-contamination of cell phones to hands to NICU surfaces, and 3) eliminate harmful disease-causing germs before they reach vulnerable NICU patients or their essential life-sustaining medical lines.

FIGURE 2: Conceptual Model



Note: Adapted from the germ theory of disease and the Health Belief Model.

The key components to this conceptual model are described in Table 4. This model connects individual safety beliefs and health-related preventative behaviors (e.g., washing hands, cleaning germs off a dirty cell phone, etc.). The top circle in Figure 2 represents the host (i.e., HCW and/or parent of NICU patient) and outlines the specific HBM elements needed for

personal behavior change to occur (i.e., personal cell phone cleaning). The smaller circles in the model represent that host's link to disease transmission by using elements of the germ theory of disease such as the environment, pathogens, and the HCW's cell phone, which represents the disease vector able to transmit harmful microorganisms to NICU patients and/or the NICU environment. To help prevent the spread of germs from cell phones in the NICU environment, perceptions that influence beliefs which contribute to individual actions were methodologically analyzed to aid in implementing effective interventions that promote positive health outcomes for NICU patients.

TABLE 4: Key Components of the Conceptual Germ Theory of Disease/Health Belief Model

Concept	Origin	Key Model Points	Interview Question No.
Host	Germ theory	Individual with germs at risk for infection or spreading	HCW: 1, 2 Parent: 1, 2
Perceived benefits	HBM	Perception of actions to reduce threat of germs/illness	HCW: 3, 4, 6, 8 Parent: 3, 5, 7
Preventative action	HBM	Actions taken to reduce risk of spreading germs/illness	HCW: 4, 9, 10, 12 Parent: 4, 5, 8, 10
Perceived threat	HBM	Perception of threat from germ sickness or disease	HCW: 3, 5 Parent: 3, 6
Perceived susceptibility	HBM	Perception of ability to acquire harmful germs/illness	HCW: 5, 7 Parent: 6, 8
Vector	Germ theory	Helps spread disease from one host to another	HCW: 5, 11 Parent: 6, 8
Environment	Germ theory	NICU area where germs survive (hours/days/weeks)	HCW: 3, 9, 13 Parent: 6, 8, 10
Pathogens	Germ theory	Germs that can cause disease	HCW: 3, 11 Parent: 6, 9

Setting

The study was conducted with HCWs and parents of neonates previously in the NICU at UNC Rex Healthcare, a large community hospital in Raleigh, North Carolina. The hospital describes its mission and vision as "leading change, improving health and healing communities"

and “leading the transformation of healthcare, one person at a time,” respectively.[34] Protocols to clean mobile devices align with this organization’s mission and vision statements by focusing on improving the quality of care in a venue where neonates are at an increased risk of acquiring HAIs. The UNC Rex NICU is the right setting for this study because 1) it has a vulnerable neonate population frequently held/touched by HCWs and visitors; 2) neonates have many invasive lines that can easily become contaminated, which can lead to deadly infections; 3) picture taking using personal mobile devices is encouraged; 4) there is not a current mobile device disinfection policy or protocol in place for HCWs, providers, or visitors; and 5) the study environment can be easily monitored without disruption from a distance, due to large glass window/room separations.

The UNC Rex NICU admits 400 neonates annually, with an average daily census of 17.5. The median length of stay is 3 weeks. UNC Rex admits neonates from surrounding area hospitals at or after 27 weeks of birth; however, some neonates at 27 weeks will need to be transferred to the nearby UNC Medical Center Level IV NICU after stabilization (e.g., neonates requiring specialized surgical interventions, transplants, extracorporeal membrane oxygenation devices, or the highest level of care).

The UNC Rex NICU has 21 beds with varying acuity levels (15 intermediate-care beds dedicated for Levels II to III, and the 6 highest-acuity beds dedicated for Level IV). Neonate acuity levels are stratified by gestation and weight. Nursing ratios will vary for each neonate acuity level (i.e., intermediate care, 1:3 ratio; intensive care, 1:2 ratio; and very acute, 1:1 ratio used primarily for unstable or rapidly declining neonates). There are eight separate rooms dedicated for patient care that have large windows which allow good visibility for all staff on the unit. Neonates usually cohort in the same room with one or more neonates; however, special

considerations are given to cohort twins. An annual comparison of the UNC Rex NICU versus other UNC Rex ICUs is described in Table 5.

TABLE 5: Comparison of UNC Rex's Six ICUs in 2021

Unit	No. of Beds	No. of Patients per Year	Average Length of Stay (days)	Annual Central Line Days	Annual Vent Days	Annual Foley Catheter Days	Visitor Limit ≤ 2	Private Room
Neonatal intensive care unit (NICU)	21	400	21.0	535	45	0	Yes	No
Cardio-vascular intensive care unit (CICU)	20	1324	9.5	2812	2517	3761	Yes	Yes
Neuro-surgical intensive care unit (NSICU)	10	621	10.9	990	1030	1692	Yes	Yes
Special respiratory intensive care unit (SRIU)	8	301	17.9	1146	1241	1083	Yes	Yes
Medical-surgical intensive care unit (MSICU)	20	1625	12.1	3585	3546	4159	Yes	Yes
Cardio-thoracic surgical intensive care unit (CSICU)	12	980	8.5	2021	1332	2107	Yes	Yes

Neonatal Contact, Care, and Visitation

Contact with neonates in the NICU by UNC Rex caregivers and physician extenders (neonatologists, registered nurses, respiratory therapists, nursing assistants, volunteer cuddlers) and family in the NICU setting is more extensive than contact with patients in other Rex ICUs. Neonates can be attached to multiple complex machines/medical devices (e.g., baby warmers/incubators, cardiorespiratory monitors, temperature probes, pulse oximeters, central lines, chest tubes, nasogastric/orogastric tubes, endotracheal tubes attached to mechanical ventilators, continuous positive airway pressure devices, and feeding pumps), which provide life-sustaining interventions and make therapeutic encounters and visits more difficult. Medical and non-medical devices (e.g., employee badges) can become contaminated from a direct touch after contact with a contaminated cell phone and contribute to unwanted microorganism spread. Documented ICU patient encounters in a random 24-hour period (6 a.m. on day 2 through 6 a.m. on day 3) from randomly selected patients who had central lines are described in Table 6.

TABLE 6: UNC Rex ICU 24-Hour Documented Patient Encounters by Caregiver

Unit	RN	CNA	MD	RRT	XR	CT	PT/OT	US	EEG	Other	Total
NICU	3	0	2	3	2	2	1	0	0	1	**14**
CICU	4	2	5	3	1	3	0	1	1	0	**20**
CSICU	5	0	4	2	1	0	1	0	0	0	**13**
MSICU	7	2	5	1	0	1	0	0	0	1	**17**
NSICU	6	2	3	3	0	0	0	0	0	0	**14**
SRICU	5	2	3	2	2	0	0	0	0	0	**14**

Abbreviations: CICU, cardiovascular intensive care unit; CNA, certified nursing assistant; CSICU, cardiothoracic surgical intensive care unit; CT, computed tomography; EEG, electroencephalography; MD, medical doctor; MSICU, medical-surgical intensive care unit; NSICU, neurosurgical intensive care unit; PT/OT, physical therapy/occupational therapy; RN, registered nurse; RRT, registered respiratory therapist; SRICU, special respiratory intensive care unit; US, ultrasound; XR, X-ray.

UNC Rex NICU Visitor Picture/Video Policy

Visiting family members (aged >4 years and limited to two per day) are encouraged to touch, hold, and help feed the patient and to take pictures/video, and they may interact with other families during their visit. Parental bonding using skin-to-skin contact is strongly encouraged and therapeutic for the neonate despite the complexity of attached multiple medical lines/devices. UNC Rex picture/video policy allows recordings and/or picture taking of patients to occur as long as the rights and confidentiality of its patients are protected; however, recordings may also be disallowed at any time at the discretion of the responsible health care provider or manager when it may interfere with patient care, patient safety, privacy, treatment, and/or health care operations. Previous lack of mobile device cleaning observations in the UNC Rex NICU has shown that an opportunity for improvement exists among HCWs, providers, and visitors.

Infection Screening and Isolation Practices

HAIs are monitored by a dedicated infection preventionist certified in infection control and epidemiology in the UNC Rex NICU. Central line–associated bloodstream infections, ventilator-associated pneumonia infections, SARS-CoV-2 (COVID-19), influenza virus, respiratory syncytial virus, and methicillin-resistant *Staphylococcus aureus* (MRSA) infections can be problematic at UNC Rex and are closely monitored daily by reviewing laboratory evidence. Catheter-associated urinary tract infections and surgical site infections are not seen in the UNC Rex NICU, since Foley catheters are not utilized and surgical candidates would be transferred to the nearby UNC Medical Center.

Because of the ongoing COVID-19 pandemic, persons with a suspected or confirmed SARS-CoV-2 infection are not allowed to visit the UNC Rex NICU until they are asymptomatic and after their period of communicability passes. During visitation encounters, a room that is

cohorting will involve multiple families wearing medical masks within close a proximity (<6 feet) of other neonates and their family members; however, neonates having (or suspected of having) a communicable disease or easy to spread MDRO (e.g., MRSA, vancomycin-resistant enterococci, etc.) will usually be separated in an isolation room and placed in an isolette (a clear plastic enclosed crib that maintains a warm environment and isolates germs).

MRSA is easily spread between neonates in a NICU cohort setting; therefore, all neonates that transfer into the UNC Rex NICU are actively screened for MRSA colonization using an intranasal swab. Neonates with a positive MRSA result are cohorted with other neonates with such results or placed in a separate isolation room to help reduce the risk of MRSA transmission among neonates. Dedicated caregiver isolation assignments are usually implemented to reduce the risk of spreading harmful organisms when staffing allows.

Institutional Approval and Data Management

Institutional Review Board Approvals

This study required approval from the UNC Institutional Review Board (IRB) prior to commencing the research. UNC Rex uses the UNC IRB. The study received approval from the UNC Rex chief medical officer. All subjects provided informed consent to participate.

Data Management

This study collected both primary and secondary data. Data were derived from semi-structured key informant interviews taken from 1) participating UNC Rex NICU HCWs and 2) participating members from the UNC Rex NICU Parent and Family Advisory Council (PFAC).

Subjects were recruited via secure email, followed by a telephone call during which eligibility was confirmed and subjects were given the opportunity to ask questions prior to scheduling the key informant interviews. Study participants provided oral consent prior to any data

collection. To increase privacy, phone interviewees were encouraged to complete the interview in a private space. With subjects' permission, conversations were recorded and transcribed using secure WebEx transcription software utilized to transcribe key informant interviews. Field notes were taken to help provide comparison and validation of transcription data. The subjects' name, location, and other identifiable elements were kept confidential and locked in a secure private office. The identifiable study key was destroyed at the conclusion of the study.

Research Aims and Methods

Aim 1: Identify Barriers and Facilitators to Mobile Device Cleaning in the NICU for HCWs and Parents of Patients

Participants. Participants were as follows:

- HCWs who frequently work in the UNC Rex NICU such as 1) neonatologists, 2) registered nurses, 3) respiratory therapists, and 4) nursing assistants were included.
- Parents of NICU patients (i.e., PFAC members) were included. Parents whose infants were currently or have recently (<1 year) been in the NICU because of emotional concerns and overall well-being were excluded.

Procedures. Observations and semi-structured interviews were conducted to identify key barriers and facilitators for cleaning mobile devices in the NICU as follows.

- Preliminary NICU observational data consisted of 1) visually monitoring the number of cell phone (or other personal mobile device) touches and duration for care givers and families for at least 1 hour on three separate shifts and extrapolating to 24 hours (additionally, a determination regarding the use [i.e., medical care versus personal use] of the cell phone/device was noted for HCWs), and 2) tagging a NICU HCW's

phone with invisible UV dye and monitoring/identifying subsequent contacts around the NICU environment via UV light.

- NICU HCWs were informed of the study during a regularly scheduled NICU departmental meeting. HCWs were contacted separately and invited to participate at a convenient time to schedule key informant interviews via confidential secured email. After informed consent was obtained, qualitative data were retrieved during key informant interviews (see Appendix). Secure WebEx recording software included transcribing services utilized for interview and coding purposes. After the interview process was complete, HCW participants were thanked for their participation and reassured that their input and identity would remain anonymous and secure.
- PFAC members were informed of the study during a regularly scheduled PFAC group meeting. PFAC members were contacted separately and invited to participate at a convenient time to schedule key informant interviews via confidential secured email. After informed consent was obtained, qualitative data were retrieved during key informant interviews (see Appendix). Secure WebEx recording software included transcribing services utilized for interview and coding purposes. After the interview process was complete, PFAC member participants were thanked for their participation and reassured that their input and identity would remain anonymous and secure.

Analysis. After each interview, the digitally recorded files were uploaded and saved onto a password-protected computer kept secure in the principal investigator's locked private office. Interviews were transcribed and verified using the audio recording to ensure transcription was verbatim. After verification of the transcripts was complete, the investigator conducted content

analysis to identify themes and categories prior to coding the data. Subsequent codes and code definitions were developed and placed in a created codebook. All text was coded by alphanumeric identifiers to maintain confidentially. After completion of content analysis, transcripts from key informant interviews were placed in Microsoft Word, where highlighting and comment tools were utilized to apply codes. Significant themes were extracted, then grouped and labeled to identify different themes and relationships between them. In addition to the principal investigator, a second coder (recruited from the UNC DrPH program) independently reviewed 45% of the transcripts to ascertain themes and categories. For consistency and validity, intercoder reliability was achieved when the two researchers agreed on how to code the same content. Coding validation was performed by the independent second coder once saturation was met.

Aim 2: Develop an Intervention to Increase Cleaning Phones in the NICU

Participants. UNC Rex participants included the director of infection prevention, the chair of the Infection Prevention Committee, and NICU leadership (manager and director).

Procedures. Information learned about barriers and facilitators (Aim 1) was used to design an intervention that contained environmental and/or behavioral strategies to phone disinfection practices that were responsive to barriers and facilitators identified by HCWs and parents. Strategies included targeted signage and strategically placed disinfectants to increase compliance with mobile device cleaning/disinfection recommendations. Social and physical environmental changes contributed greatly to behaviors; by altering these environments, a catalyst for change typically requires minimal conscious engagement, thus influencing the behavior of many people simultaneously.[35]

Analysis. Content analysis was used to categorize/combine results for deeper insight. The primary categories and corresponding interview questions (Table 7) were utilized to aid in analysis, as these categories consider key concepts within the conceptual model (combination of the HBM and germ theory of disease) aided in developing the intervention that was effectively used by HCWs and parents of NICU patients.

TABLE 7: Primary Analysis Category and Corresponding Interview Questions

Analysis Category	Conceptual Model Concept	Interview Question No.
1. Attitudes and beliefs	Perceived benefits	HCW: 3, 4, 6, 8 Parent: 3, 5, 7
	Perceived threats	HCW: 3, 5 Parent: 3, 6
	Perceived susceptibility	HCW: 5, 7 Parent: 6, 8
2. Cleaning and disinfection practices	Preventative action	HCW: 4, 9, 10, 12 Parent: 4, 5, 8, 10
3. Barriers	Host	HCW: 1, 2 Parent: 1, 2
	Pathogens	HCW: 3, 11 Parent: 6, 9
	Vector	HCW: 5, 11 Parent: 6, 8
4. Facilitators	Environment	HCW: 3, 9, 13 Parent: 6, 8, 10

Suggestions from the semi-structured interviews developed into specific strategies related to nudge-focused research, which manipulates the environmental and social contingencies of choice behavior without delivering punishments and rewards.[36] Additionally, hospital-approved cell phone cleaning signage and a hospital-approved cleaning agent were strategically placed in the NICU setting to help offer a gentle nudge and reminder to clean a personal-use cell phone upon entry to the NICU. Research has shown that applying nudges right at the point of need and providing appropriate signage can be utilized for at-point education.[37] Reminders to disinfect cell

phone signage were strategically placed along with the appropriate disinfecting wipe product. Cell phone disinfectant wipes have been utilized to kill microorganisms. Innovative techniques were considered alongside of the disinfecting wipes (e.g., UV light, which rapidly kills organisms without damaging a cell phone's innermost parts); however, the majority of participants preferred the handheld disinfectant wipes.

Aim 3: Evaluate the Effectiveness of the Intervention

Participants. UNC Rex participants included the director of infection prevention, the chair of the Infection Prevention Committee, and NICU leadership (manager and director).

Procedures. After the 30-day trial period, quantitative and qualitative data for this study were derived from intervention analysis. Comparisons of product usage, staffing counts, and survey results were analyzed to provide quantitative rates. In addition, a follow-up survey was provided to study participants (e.g., through SurveyMonkey) for satisfaction and qualitative analysis. Utilization rates collected by the researcher from NICU cell phone disinfectant wipe usage were compared for statistical purposes to ultimately help identify compliance and product usage to direct future recommendations. Additionally, the survey (SurveyMonkey) was provided to the study participants for intervention feedback to gather any additional insights after using phone disinfection methods. Finally, the overall results of this study (commonalities, trending, outliers, and statistical significance) were reviewed and shared with appropriate stakeholders as follows:

1. *Significant study findings*. This information was delivered 1) after the initial interview results were coded and interpreted prior to the intervention development phase and 2) after testing the intervention and receipt of the final survey results.

2. *Barriers and facilitators to getting HCWs and parents of patients to clean their mobile devices in the NICU setting*. Key insights were reported out during the final stakeholder meeting after all study results were interpreted.
3. *Lessons learned*. Lessons from this study will help guide safe mobile device disinfection policy and protocols that can be adapted for use in other NICUs. Study lessons learned were written up as a plan for change after study commencement.

Study Design and Stakeholders

This study utilized a quasi-experimental design that consisted of three separate stages: pre-intervention, intervention, and post-intervention (Table 8).

TABLE 8: Quasi-Experimental Design Stages

Stage	Period	Action
I	Pre-intervention	• Gather baseline data to assess potential intervention strategy (semi-structured interviews)
II	Intervention	• Implementation of strategies
III	Post-intervention	• Data gathering to assess effectiveness (observation and post-survey) • Debrief with HCWs about the intervention

Pre-Intervention Stage

The researcher independently met with key stakeholders (Table 9) involved with the overall well-being of NICU patients. The researcher conducted semi-structured interviews to gather baseline data for NICU stakeholders using the screening tool (Appendix). Stakeholder engagement and support was critical for intervention development and success; therefore, each stakeholder was included in the interview process at a convenient time not interfering with patient care activities.

TABLE 9: NICU Stakeholders and Partner Agencies

Stakeholder/ Partner Agency	Interest	Power	Roles
Hospital executive team	Outcomes tied to public reported measures/bonuses	Ability to okay program and needed changes	Hospital leadership; final authority
Infection Control Committee members	Well-being of patients all populations	Disinfection protocol approvals	Evidenced-based recommendations
NICU neonatologists	Well-being of patients; medical license	Direct care and medical care decision making	Medical provider and mobile device wiper
NICU leadership (manager, director, vice president)	Well-being of patients; accountability for outcomes	Day-to-day decision making	Leadership representation; some authority
NICU nurses	Well-being of patients; nursing license	Provider of care; input to leadership and NICU team	Direct caregiver and mobile device wiper
NICU respiratory therapists	Well-being of patients; RT license	Provider of care; input to leadership and NICU team	Direct caregiver and mobile device wiper
NICU nurse assistants	Well-being of patients	Provider of care; input to leadership and NICU team	Direct caregiver and mobile device wiper
Cell phone disinfection product company	Financial and promotional	Supply	Product wipes and/or UV light device phone scrub device
NICU Parent and Family Advisory Council	Well-being of patients	Provider of input to hospital leadership and NICU team	Provide valuable input

Intervention Stage

In the intervention period, implementation of strategies commenced. Strategies were based on qualitative data retrieved from semi-structured interviews and the literature review. The researcher observed and tracked progress to assess the impact of the intervention.

Post-Intervention Stage

In the post-intervention time period, the researcher provided surveys (e.g., with SurveyMonkey) to research study participants to identify improvements attributable to the intervention. Both qualitative and quantitative data derived from the intervention were analyzed to identify barriers and facilitators to mobile device cleaning in the NICU among HCWs and parents of patients. Information learned from synthesized results from Aims 1 and 2 were used to develop a plan of change for implementing a mobile device cleaning program in other NICUs.

Analysis. During this phase of review, data were analyzed from the pre-intervention, intervention, and post-intervention periods (including post-survey) to determine the effectiveness of the intervention. Qualitative data analysis entailed narrative analysis used to understand the underlying events and their effect on the overall outcome. Quantitative data analysis consisted of measurements involving product use and/or product volumes, including duration to extend for more statistical manipulation. This mixed-method analysis approach helped derive meaningful conclusions and insights into the barriers and facilitators to mobile device cleaning in the NICU. Key insights obtained from both quantitative and qualitative data analysis were used to understand the underlying events, to assess their effect on the overall outcome, and to guide development of the future plan for change.

CHAPTER 4: RESULTS

Cell Phone Touch Observation Results

Observations monitoring the total number of cell phone touches while in the NICU were conducted prior to the September 2022 NICU trial in accordance with Aim 1 procedures. During July and August 2022, 70 cell phones were observed in use by HCWs and family members while in the NICU on 12 separate occasions (at random intervals on separate shifts), resulting in 6 hours of total observation time. Of the 70 cell phones observed, 69 (98.6%) were touched without cleaning or disinfection before or after use. One cell phone was disinfected when a parent entered the NICU and wiped alcohol foam over the cell phone's surface using a wall alcohol gel dispenser located outside his child's room. The purpose (i.e., medical care versus personal use) of the cell phones could not be determined.

Glo Germ NICU Environmental Test Results

Prior to the September NICU trial in accordance with Aim 1 procedures, a test with Glo Germ was conducted to simulate how germs can spread after a single cell phone touch to multiple NICU medical devices used for common patient care items in the NICU setting. The manufacturer describes Glo Germ as "a safe product that casts a revealing glow when exposed to Glo Germ's™ U.V. light, turning the invisible into germs you can see."[38]

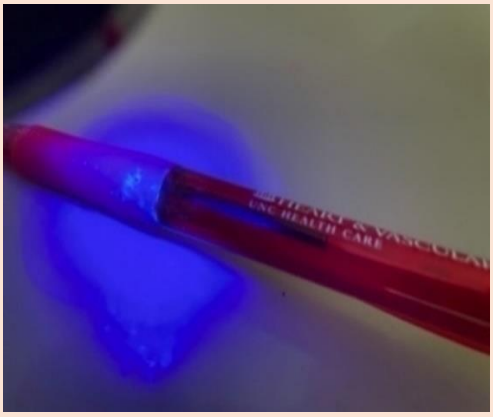
A NICU room ready for patient care (without patients) was selected to perform the Glo Germ test (Figure 3). A single application of Glo Germ was applied to the front surface of a cell phone of a registered nurse with NICU experience. After donning a pair of medical gloves, the

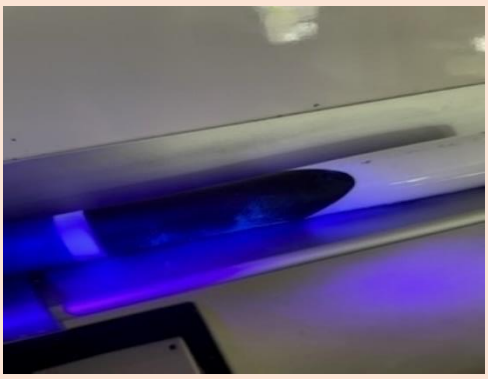
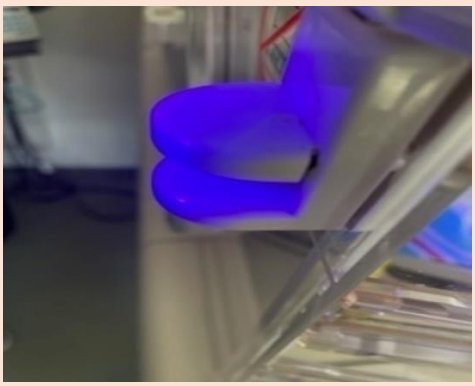
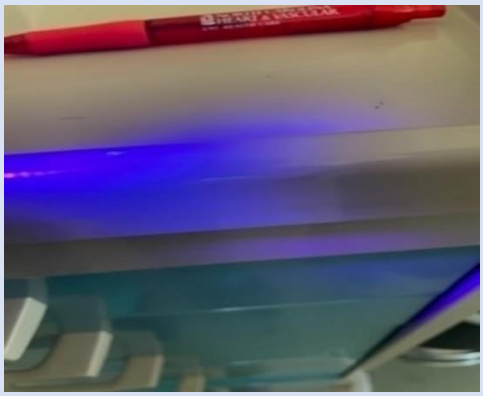
nurse touched her cell phone once, then proceeded to touch various medical devices and surfaces commonly used to care for NICU patients (without retouching her cell phone) until no Glo Germ could be seen under UV light. This process was repeated without the use of gloves to see if gloved hands or ungloved hands would spread more Glo Germ to different environmental surfaces in the NICU.

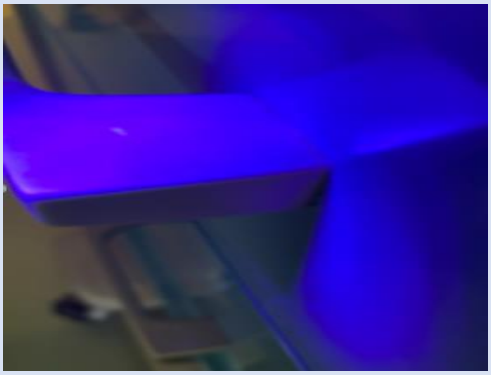
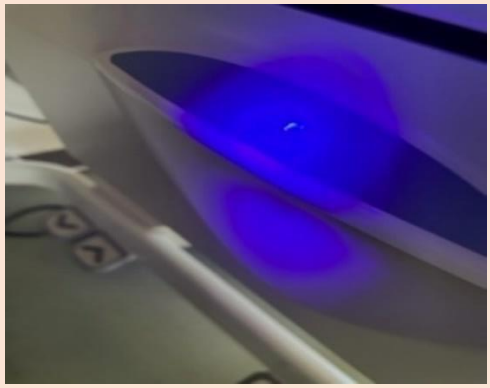
FIGURE 3: NICU Testing Room

Subsequent Glo Germ contacts around the NICU environment via UV light were identified. Under UV light, cross-contamination from Glo Germ shows up as a luminous blue florescent area on surfaces representing where germs were spread. During this experiment, 1) gloved hands contaminated eight separate NICU environmental surfaces with a single cell phone touch marked with Glo Germ, and 2) ungloved hands contaminated nine different NICU environmental surfaces consecutively after a single cell phone touch marked with Glo Germ (Figure 4).

FIGURE 4: NICU Glo Germ Experiment: Gloved Hands Versus Ungloved Hands

Gloved hands spread Glo Germ to 8 NICU surfaces after a single cell phone touch:		**Ungloved hands** spread Glo Germ to 9 NICU surfaces after single cell phone touch:
		
		
		

		
		
 PUSH TO OPEN		
		 Rx Only

Semi-Structured Interview Content Analysis Results

Semi-structured interviews to identify key barriers and facilitators for cleaning mobile devices in the NICU were conducted. Twenty-two respondents (18 NICU HCWs and 4 NICU PFACs) participated in the semi-structured key informant interviews. Coded highlighted and alphanumeric identified text was analyzed by the principal investigator. A second coder independently reviewed 10 of the 22 coded transcripts (45%). Coding validation was performed

by the original researcher and second independent coder as saturation was met. All personal identifying information of the study participants remained separate and confidential from the coded text. Eight significant themes were extracted (Table 10).

TABLE 10: Eight Significant Themes Extracted from the Coded Transcript

Theme	Definition
1. Safety	It is important to keep patients, staff, and visitors safe.
2. Education	Educating staff and visitors is essential when adding new products in a healthcare setting, and clear easy-to-understand educational signage is preferable.
3. Disinfectant wipes	Wipes are a preferred choice over UV light disinfection. Wipes disinfect faster, they are easier to use, and many people are familiar with cleaning wipe products.
4. Timing and placement	Exactly when to use the wipes and entry-point placement are important to consider when using a phone disinfectant.
5. Personal cleaning habits	The majority of participants admitted to cleaning their cell phone regularly; some said occasionally or never.
6. Bathroom use	The majority of participants admitted to using their cell phones or seeing others use theirs when in a hospital bathroom stall.
7. UV light	This approach was mostly discouraged due to the extensive time it takes to disinfect cell phones and unfamiliarity specific to cell phone disinfection.
8. Support and product availability	Availability was identified as the most important thing hospital leadership can do for the success of a cell phone cleaning program. Wipes are frequently perceived to continually run out.

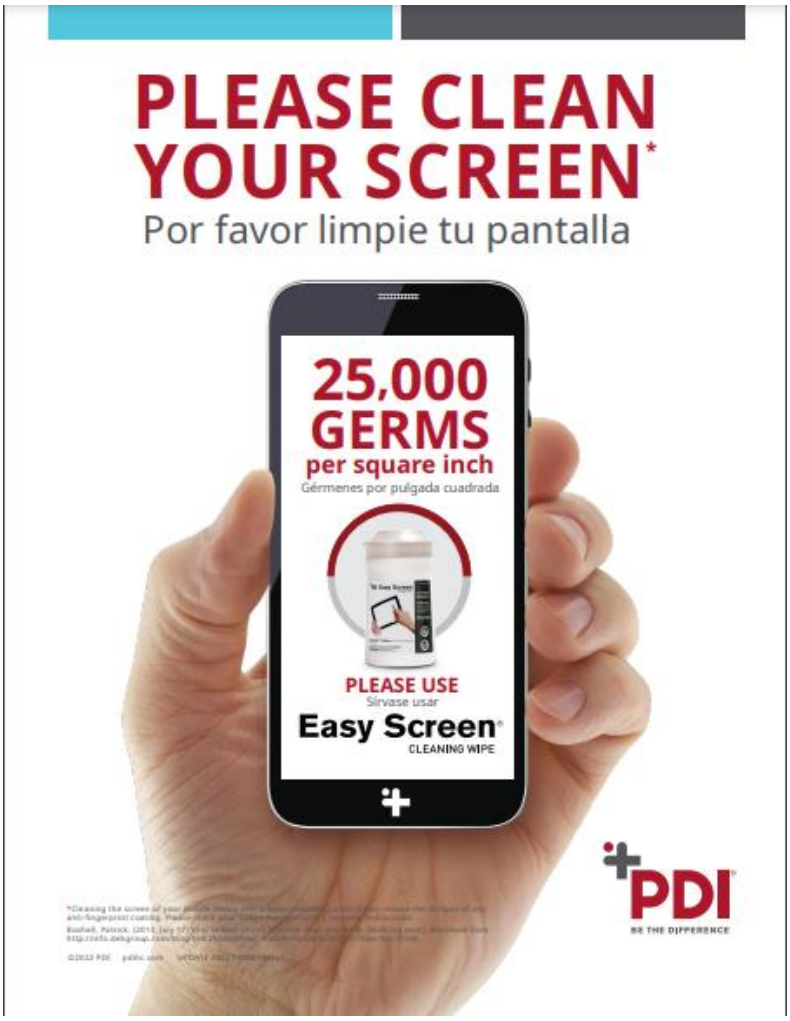
Intervention Development Results

In accordance with Aim 2, the principal investigator, Infection Prevention Committee chair, and NICU leadership utilized what was learned about barriers and facilitators (Aim 1), primary category analysis from interview questions, NICU staff workflows, and visitor pathways to design an intervention containing environmental and behavioral strategies to encourage phone disinfection practices. Key informant interviews provided overwhelming support for the

following: 1) encouraging disinfectant cell phone wipe use, 2) educating staff and visitors with clear visible signage near the cell phone wipe products, and 3) making sure cell phone cleaning wipe products will be readily available at both visitor and staff entry points.

Hospital- and Food and Drug Administration–approved cell phone/mobile device alcohol cleaning wipes and educational signage encouraging cell phone wipe use were strategically placed for the two targeted audiences (i.e., NICU staff and NICU visitors). The cleaning wipes and educational signage were strategically placed at two high-traffic locations: 1) the main entry doors to the NICU (near doors of the patient rooms and closely adjacent to the handwashing sink) and 2) the staff entrance to the NICU within inches of the staff time clock. A picture of a cell phone being held included germ messaging and a heading above labeled as "Please Clean Your Screen" in bright red was chosen for messaging (Figure 5). The cell phone wipe educational signage and cell phone alcohol disinfecting wipes were strategically placed adjacent to each other in two separate locations that would have the highest visibility. The individual canisters contained "single-use, pre-moistened [70% isopropyl alcohol (IPA)] disposable wipes that are easy to use and conveniently dispense one wipe at a time from the dispensing cap," with 70 wipes in each.[39] A number was written in black permanent marker on the bottom of each canister (e.g., 1-60) to help identify how much product was used and to assist with capturing usage rates.

FIGURE 5: NICU Signage With Cell Phone Germ Messaging



Trialing the Intervention Results

The NICU intervention trial period was from September 1 to 30, 2022. Education was provided to the NICU staff to describe the trial, signage, and cleaning wipe placement and to provide a contact number for the principal investigator in the event that additional questions or concerns arose.

One educational sign and one cell phone wipe canister were strategically placed at the staff entrance directly above the time clock, and the alcohol wipe canister was placed adjacent to the time clock (Figure 6).

FIGURE 6: NICU Staff Entrance Time Clock, Germ Signage, and Wipes

A sign directing patient visitors to wash their hands with soap and water was located at the hand hygiene station. One educational sign, two cleaning wipe holders loaded with two cleaning wipe canisters, and a trash can in which cleaning wipes could be discarded were added to a pedestal at the visitors' entrance adjacent to the hand hygiene station (Figure 7).

FIGURE 7: NICU Visitor Entrance Germ Signage, Wipes, and Pedestal Stand

Intervention Effectiveness Evaluation

In accordance with Aim 3, quantitative and qualitative data provided comparisons of staffing and visitor counts, product usage, survey results, and significant study findings, as discussed next.

Staffing and Visitor Counts

During the trial, 67 NICU staff members actively cared for 46 NICU patients. An accurate count of the NICU visitors was not able to be obtained, as the visitor log kept by security had missing entries because several visitors did not check in or recheck in from multiple morning, afternoon, or evening visits.

Product Usage

During the 30-day trial, 31 IPA wipe canisters (2170 wipes) were supplied to the NICU; 48 unused wipes remained in the opened NICU canisters at the end of the trial. A total of 2122 disinfecting wipes were used during this trial, which translates to 70.73 wipes per day, 46 wipes per patient, or 31.67 wipes per NICU staff member.

Post-Intervention Survey Results

Of the 22 study participants, 21 (95.5%) completed the post-intervention NICU study survey. Analysis of the survey revealed that all survey participants "liked" or "loved" the new NICU device cleaning intervention, and 18 (86%) felt there was nothing else to improve with the intervention. However, two respondents felt that the pedestal could be in a better location away from the hand sink to prevent a potential trip hazard, and one felt that the signage could be improved. All 21 survey participants felt that the new NICU mobile device cleaning intervention should be implemented in all ICU settings, noting "how accessible and easy to find the wipes were" and "please do not take away the alcohol wipe display and signs after the study is over."

Significant Study Findings

The barriers and facilitators to getting HCWs and parents of patients to clean their mobile devices in the NICU contained five critical key insights:

1. Educational signage strategically placed at staff and visitor entry points in the NICU can capture the attention of visitors and staff and can aid in cell phone mobile device disinfection prior to visiting patients, caring for patients, or touching NICU patients' environment.

2. Cell phone cleaning wipes are the preferable choice among NICU HCWs and parents of NICU patients due to their ease of use and decreased time of cleaning compared to other methods.
3. Cell phone mobile device cleaning wipes will be utilized frequently when available and when education is provided. However, there is a need for continual daily supply checks and restocking of supplies to ensure cleaning wipe availability.
4. Cell phone usage is high, but cleaning is sub-optimal. Thirteen participants reported using their cell phones or seeing others use their cell phones when in the NICU; however, 32% of participants reported not cleaning their cell phones.
5. Participants feel that a cell phone disinfection program using disinfecting cleaning wipes should be implemented in the NICU and other ICU environments to help protect the patients, visitors, and staff.

CHAPTER 5: PLAN FOR CHANGE

The findings from this study suggest that there is a need for a mobile device disinfection program in acute hospital settings that extends past hospital NICUs. Moreover, patients and HCWs believe that such a program should be implemented in ICU environments (including the NICU). The plan for change involves 1) implementing the mobile device cleaning protocol in this organization's NICU, 2) recruiting well-respected physicians and nurses to serve as role models to champion cell phone and mobile device cleaning, 3) incorporating academic detailing to change the behaviors of HCWs and visitors, and 4) obtaining the approval and support from hospital leadership at the system level and then implementing the program in all other NICUs across the organization.

The goal of this plan for change is to provide guidance for a safer environment for NICU patients to prevent HAIs. This can be accomplished by reducing germs of cell phones of HCWs and family members prior to use and after each patient contact when used in the NICU setting. I considered two options: (1) implementing an action plan for all ICUs at Rex Hospital and (2) doing so at NICUs in other hospitals in the UNC Healthcare System. The major challenge with the first option is that ICU cultures vary by patients' characteristics. Thus, doing so would require qualitative research within each Rex ICU. Although there may be differences across NICUs in the UNC Healthcare System, I felt that similarities would make this more feasible. Therefore, the plan of change will involve implementing the phone cleaning protocol in one NICU outside Rex, with the goal of doing so throughout the UNC Healthcare System. I also

believe it would be helpful to identify a respected physician and/or nurse opinion leader to advocate for the program.

Implementation Plan

Plan implementation will be guided by Kotter's Eight-Step Model for Leading Change (Figure 8).[40] Implementation steps include an explicit strategy for plan success by focusing on the resources, players, and contextual parameters affecting the plan for change.

Key topics covered in this plan are built around Kotter's model, which include 1) establishing a sense of urgency, 2) creating the guiding coalition, 3) developing a vision and strategy, 4) communicating the change vision, 5) empowering broad-based action, 6) generating short-term wins, 7) consolidating gains and producing more change, and 8) anchoring new approaches in the culture.[40]

FIGURE 8: Kotter's Eight-Step Model for Transforming Organizations

Source: Kotter.[40]

Kotter's Eight-Step Model for Transforming Organizations

Establishing a Sense of Urgency (Step 1)

This study's findings can be used by the UNC Rex infection prevention director to ignite a sense of urgency by sharing the findings with other UNC Health infection preventionists across the UNC healthcare system. This study provides examples of how personal-use mobile cell

phones used by HCWs and others can become contaminated with germs that can then be spread by hands contaminating inanimate surfaces and essential lines in a hospital's intensive care setting. Considering HCWs and parents of patients in the NICU as a target market, germ reduction methods are desirable and expected. Reducing germs on mobile cell phone devices in NICU settings can ultimately:

- ✓ Prevent harmful microorganisms from spreading in the NICU.
- ✓ Increase patient, staff, and visitor safety.
- ✓ Help reduce expensive HAIs.
- ✓ Increase value and overall satisfaction resulting from a cleaner environment.
- ✓ Positively affect service design and delivery, customer care, and recovery.

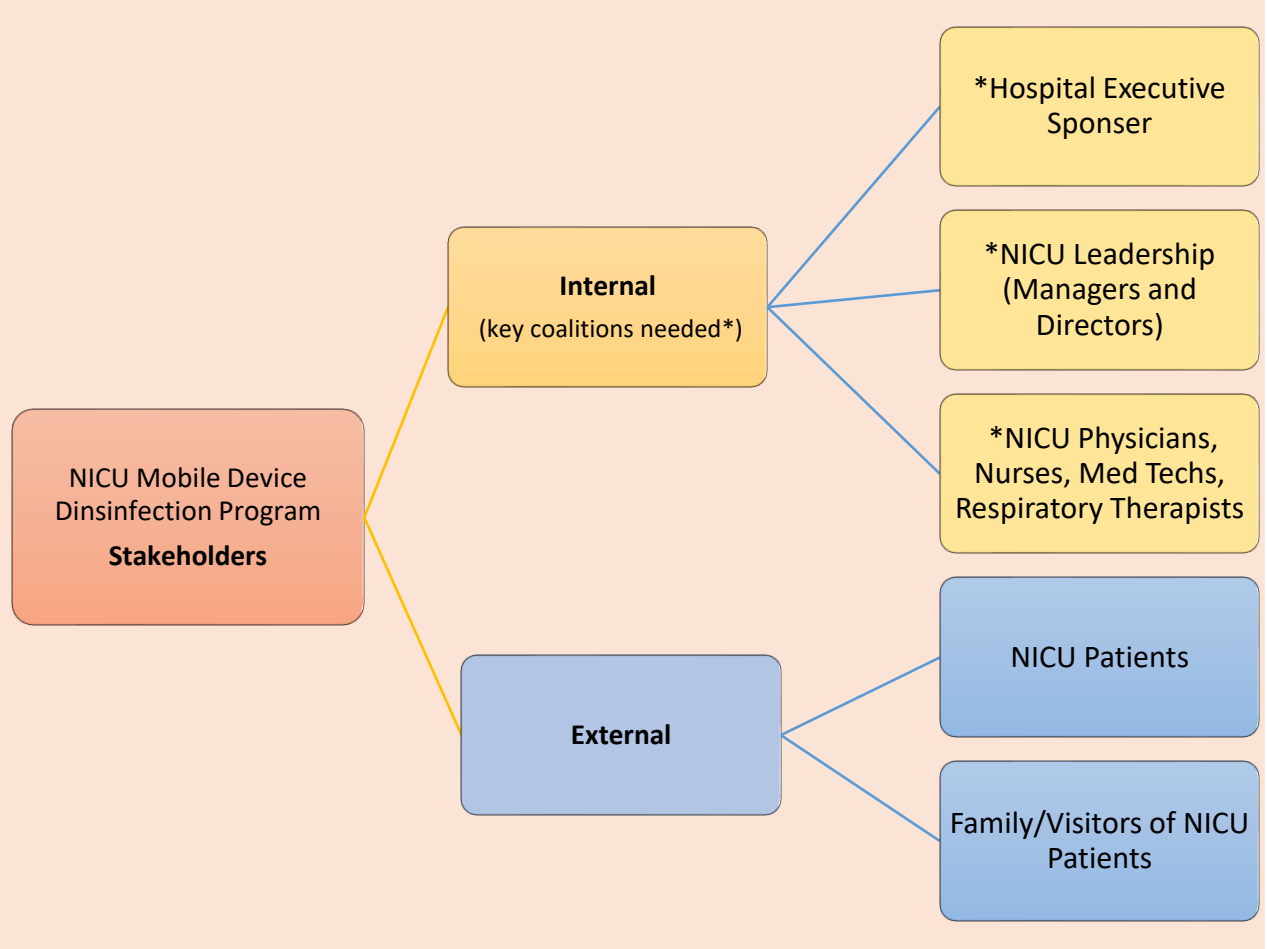
To create a sense of urgency, people need to understand how they will benefit from implementing a mobile device disinfection program. The most important benefactors are the neonates who are already at risk of infection and poor health outcomes. In addition, their families as well as providers and staff in the NICU will reduce the risk of acquiring infections through the germs on the surfaces of their mobile cell phones. The healthcare system will directly benefit by 1) increased satisfaction scores from NICU patient families and HCWs and 2) increased NICU cleanliness from reduced environmental germs (including harmful MDROs) that can be transferred to patients.

Creating the Guiding Coalition (Step 2)

Buy-in from stakeholders (as shown in Figure 9) is critical to the overall success of this program. However, stakeholder analysis has shown variation in the strength of importance given by key leadership and individuals directly involved in NICU patient care and outcomes. Sharing this study's findings, including the marketing communication plan that promotes program

benefits, with influential key stakeholders during a Quality Performance Improvement Committee meeting can help build a coalition of program supporters needed for continued program success.

FIGURE 9: Map of NICU Mobile Device Disinfection Program Stakeholders



The Hospital Executive Team and NICU leadership (manager and director) provide the needed coalition for approval for the mobile device cleaning program, including resources needed to sustain this program. However, the general NICU co-workers (neonatologists, registered nurses, medical technicians, and respiratory therapists) have direct influence on

program support and compliance. Funding, and future funds to facilitate program success, will need approval from key executive leadership.

Developing a Vision and Strategy (Step 3)

The overarching vision of this program is to create a safer environment for NICU patients by increasing compliance with mobile device cleaning to reduce environmental germs and infections. Developing support for this vision involves three important strategies: 1) effectively communicate mobile device disinfection program benefits to promote program buy-in by key stakeholders; 2) incorporate interventions supported by this study in all NICUs across the system, with a longer-term goal of implementing the program in other ICUs; and 3) include a program evaluation framework to help improve effectiveness, communication, safety, and support.

Communicating the Change Vision (Step 4)

Effective marketing communication strategies that highlight the benefits of a mobile device disinfection program can reduce resistance to change. The strategic marketing method will 1) contribute to program buy-in among key stakeholders; 2) help sustain important disinfection methods that will ultimately reduce germs on cell phones in the NICU setting; and 3) ultimately avoid harmful germs in the NICU environment, which can help save lives.

Implementation of a mobile device disinfection program requires the institution to proactively address concerns and minimize resistance to the program. These goals are described next.

Goal 1: Effectively Communicate Mobile Device Disinfection Program Benefits

Specific objectives are as follows:

1. Create a marketing communication plan that promotes NICU mobile device disinfection program benefits to vice presidents, and NICU leadership to promote support and buy-in.
2. Appoint an infection prevention director to gain vice president approval for program and communication plan.
3. Recognize program champions/liaisons at each co-worker level (e.g., NICU nurse champion, NICU physician champion, NICU respiratory champion, and vice president executive champion).
4. Highlight program benefits through positive verbiage in marketing materials.

To enhance implementation of a mobile device disinfection program, dedicated marketing materials and resources can greatly impact the overall program success. This includes increasing awareness, compliance, and safety.

Goal 2: Incorporate Key Interventions in the Marketing Communication Plan That Promote NICU Mobile Device Program Satisfaction

Specific objectives are as follows:

1. Review previous satisfaction survey results of key program stakeholder participants (e.g., parents of patients, providers, and HCWs).
2. Set new program satisfaction targets and goals.
3. Create a monthly dashboard for NICU leadership and NICU staff to review satisfaction scores.

Empowering Broad-Based Action (Step 5)

Findings from this study can help empower broad-based action for other ICUs who want to adapt and create a similar mobile device disinfection program. Strategies specified within this

plan could serve as a foundation for internal and external strategies, goal setting, and program evaluation to help create or improve a disinfection program. Lessons learned from this study can help other NICUs avoid obstacles when starting a new mobile device infection program.

Generating Short-Term Wins (Step 6)

To promote positive change, there are quantifiable parameters that can be measured, reviewed, and shared with NICU leadership and HCWs to provide short-term and long-term wins. By setting realistic goals and achieving desired outcomes, program support and compliance can be increased.

Strategic goal setting can involve targeted metrics (e.g., examples 2 and 3 below) that have large financial impacts from Centers for Medicare & Medicaid Services (CMS) reimbursements, which will also gain additional support. Examples to share include the following: 1) overall compliance rates with cell phone disinfection practices, 2) satisfaction scores (e.g., Press Ganey or Hospital Consumer Assessment of Healthcare Providers and Systems [HCAHPS] surveys) from patient encounters, and 3) monthly HAI rates (CDC's National Healthcare and Safety Network) with NICU staff and providers. Significant costs savings and long-term wins can occur from avoiding CMS penalties associated with HCAHPS and HAI rates.

Consolidating Gains and Producing More Change (Step 7)

To effectively evaluate gains and needed change, the CDC Framework for Program Evaluation in Public Health can be used (Figure 10).[41] This framework provides a proven systematic way to guide the use of healthcare leadership program evaluation designed to organize and summarize the essential elements of program evaluation.

This framework is important as it involves a deeper assessment of leadership communication styles, effectiveness, and satisfaction in implementing a new health initiative and guidance. From this evaluation, further recommendations may emerge to help improve the culture of safety, plan effectiveness, and leadership communication style within the NICU setting to ensure plan success.

FIGURE 10: CDC Framework for Program Evaluation in Public Health

Source: CDC.[41]

Anchoring New Approaches in the Culture (Step 8)

The COVID-19 pandemic has negatively impacted the culture, as evidenced by low morale and high personnel turnover. The draining effects of the pandemic on HCWs will need to be considered when developing messaging to ensure that HCWs do not feel additional overwhelming stress due to another change.

To create better behavior and program performance, digital marketing can be important to fully utilize in this plan as a new approach. To raise awareness for the new disinfection program, several key digital marketing tactics can be utilized such as 1) redesigning the

organization's homepage to incorporate the new ICU marketing campaign (with links to pictures and information about the program); 2) driving traffic strategy using various social media outlets to create blogs about the new ICU program to help appeal to targeted audiences such as HCWs, parents, those thinking about parenting, and new parents; and 3) using search engine optimization, which can be achieved by web optimization efforts including extra links within other affiliate websites with higher traffic.

CHAPTER 6: DISCUSSION

Lessons Learned

The findings of this study indicate that parents of NICU patients and NICU staff fully support and encourage all intensive care environments to have a dedicated cell phone mobile device disinfection program; however, many participants do not clean their cell phones regularly and need reminders and cleaning products available for use. Newer technologies (e.g., UV light) are not the preferred cleaning agent for a mobile device disinfection program. A short cleaning time is critical, as individuals do not want to wait lengthy periods for cleaning or to give up their phones and not be able to use them for more than a few seconds. Cleaning wipes that contain 70% IPA are the preferable product of a mobile device cleaning program and should be made readily available at all NICU staff and visitor entrances. Cell phone mobile device disinfection wipes should be checked daily to ensure that adequate amounts of wipes are readily available for staff and visitors. The anticipated costs associated with this program are minimal, as it only involved 1) two 8 × 10 strategically placed color signs and 2) approximately one mobile device cleaning wipe canister per day (which equals approximately $8 per day when taking care of 46 patients per month).

Limitations

During this study, several limitations emerged that should be considered. First, this study focused on one hospital's NICU; however, differences across hospitals within the UNC system are not expected. Second, this study primarily focused on mobile devices as a source of

contamination and potential transmission of pathogens; however, there are many other devices utilized in the NICU that can also be contributing factors for contamination and transmission that are not considered in this study.

Conclusions

Personal-use cell phones used by HCWs, parents of NICU patients, and visitors can result in contamination with harmful organisms, which can lead to cross-contamination of inanimate NICU surfaces. The addition of this mobile device disinfection program has positively impacted the perceptions of HCWs and parents of NICU patients while providing a cleaner environment for the patients. Kotter's eight steps to create change combined with the CDC evaluation planning framework is an effective approach to implement a successful mobile device disinfection program in the NICU setting and to reevaluate and adjust if desired results are not achieved. The same principles learned from this NICU study likely apply to all ICUs; however, further research is needed. HCWs who manage and work in ICUs are critical stakeholders for coalition, collaboration, plan development, implementation, and evaluation to achieve sustained success of the program. ICUs urgently need a mobile device disinfection program in place to help provide a safer environment for patients.

APPENDIX: SAMPLE KEY INFORMANT INTERVIEW SCRIPTS

Sample Key Informant Interview Script for Healthcare Workers

Questions for the Neonatal Intensive Care Unit (NICU) Healthcare Providers
Introduction/History *Good morning. My name is Marty Cooney, and I am a student in the Executive Doctoral Program in Health Leadership at Chapel Hill School of Public Health. Thank you for agreeing to participate in this study. As you may know, germs are everywhere, including on personal mobile devices. The results of this study will be used to develop a deeper understanding of mobile device cleaning mechanisms in the healthcare setting.*
1. To start off, please tell me about yourself. What is your job title?
2. How many years have you had this job?
Topic interest/culture/preference
3. Today, there is a lot of emphasis in the NICU on cleanliness and efforts to keep dangerous germs to a minimum. With this in mind, what are your thoughts about cleaning personal-use cell phones?
4. Do you regularly clean your cell phone? And if so, please describe how.
5. How would you describe the culture here as it relates to personal cell phone cleaning?
6. Disinfection wet wipes and ultraviolet (UV) light are both methods to clean cell phone devices. How do you feel about these two cleaning methods?
7. What are your thoughts/observations about how frequently healthcare workers clean their cell phones? 8. Have you used (or seen others use) a cell phone while in a hospital bathroom stall?
Barriers/facilitators
9. What obstacles or barriers have you encountered in trying to clean your personal-use cell phone, if any?
10. Are there approaches or actions you think a NICU can implement to help get healthcare workers to clean their cell phones more? If so, what?
11. How do you think a healthcare organization and NICU leaders should support cell phone cleaning moving forward?
12. In your opinion, what is the single most important thing that this organization could do to encourage healthcare workers and parents of NICU patients to clean their cell phones?
13. What advice would you give to new healthcare workers about cell phone cleaning, if any?
Closing
14. Do you have any additional comments you would like to make about a cell phone cleaning program in the NICU? *Thank you again for participating in this study and for your time. Your input and insights will be invaluable to this study.*

Sample Key Informant Interview Script for NICU Parent and Family Advisory Council Members

Questions for the NICU Parent and Family Advisory Council Members
Introduction/history *Good morning. My name is Marty Cooney, and I am a student in the Executive Doctoral Program in Health Leadership at Chapel Hill School of Public Health. Thank you for agreeing to participate in this study. As you may know, germs are everywhere, including on personal mobile devices. The results of this study will be used to develop a deeper understanding of mobile device cleaning mechanisms in the healthcare setting.*
1. To start off, please tell me about yourself. If you are employed, what type of work do you do?
2. How many years has it been since you visited in the NICU?
Topic interest/preference
3. How interested are you in having a clean cell phone?
4. Do you regularly clean your cell phone? And if so, please describe how.
5. Disinfection wet wipes and ultraviolet (UV) light are both methods to clean cell phone devices. How do you feel about these two cleaning methods?
6. What are your thoughts/observations about how frequently healthcare workers clean their cell phones?
7. Have you used (or seen others use) a cell phone while in a hospital bathroom stall?
Barriers/facilitators
8. What obstacles or barriers have you encountered in trying to clean your personal-use cell phone, if any?
9. Are there approaches or actions you think a NICU can implement to help get parents of NICU patients to clean their cell phones more? If so, what?
10. How do you think a healthcare organization and NICU leaders can support cell phone cleaning moving forward?
11. In your opinion, what is the single most important thing that an organization could do to encourage parents of NICU patients to clean their cell phones?
12. What advice would you give to new parents about cell phone cleaning, if any?
Closing
13. Do you have any additional comments you would like to make about a cell phone cleaning program in the NICU? *Thank you again for participating in this study and for your time. Your input and insights will be invaluable to this study.*

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