Daily Environmental Cleaning for the Prevention of Healthcare-Associated Infections: Evaluation of Predictors of Cleaning Compliance, Work System Analysis and Veteran Patient Perceptions in Acute and Long-term Care Veterans Administration Facilities

By

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ABSTRACT

Healthcare-associated infections (HAIs) are a significant source of morbidity and mortality causing serious physical, psychological and financial consequences. Although the risk of HAIs remains high, there are many opportunities to prevent HAIs. Environmental surfaces in healthcare settings are a major reservoir for pathogen transmission and subsequent infection. Cleaning and disinfection of environmental surfaces is a critical entry-point for HAI prevention strategies. However, cleaning compliance remains low, and we lack an understanding of variation in environmental cleaning practices. Key areas that have not been effectively studied are predictors of cleaning compliance and barriers and facilitators to the work system within the VA. Furthermore, patient perspectives on environmental cleaning within healthcare have not been examined.

This project contributes to closing the gaps in the literature through the following three specific aims: 1) To describe predictors of environmental cleaning compliance. 2) To conduct a work system analysis to identify contextual barriers and facilitators to environmental cleaning. 3) To explore the patient perspective on environmental cleaning within the healthcare environment by engaging patients in the research process.

A convergent mixed methods approach was used with quantitative (i.e., direct observation of environmental service staff performing environmental cleaning) and qualitative (i.e., semi-structured interviews of healthcare workers) data collection across three Veterans Affairs acute-care (AC) and long-term care (LTC) facilities. We performed descriptive and multiple logistic regression analysis on observation data. Interviews were audio recorded, transcribed, and analyzed for themes within The Systems Engineering Initiative for Patient Safety (SEIPS) model constructs (i.e., Person, Environment, Organization, Tasks, Tools and

Technologies). Semi-structured interviews with hospitalized patients were conducted at one of the VA sites and analyzed using rapid qualitative inquiry.

Sixty-two room observations occurred between December 2018 – May 2019. The average observed surface cleaning rate during daily cleaning in patient rooms was 33.6% for all environmental surfaces and 60.0% for high-touch surfaces (HTSs). Higher cleaning rates were observed with bathroom surfaces, Odds Ratio (OR) = 3.23 (2.70, 3.85), HTSs OR = 1.57 (1.32, 1.86)), and reusable medical equipment OR = 1.40 (2.70, 3.85). Lower cleaning rates were observed when cleaning semi-private rooms OR = 0.71 (0.53, 0.97)) and rooms in Acute Care OR = 0.56 (0.42, 0.75)). In analysis stratified by patient presence (i.e., present, or absent) in the room during cleaning, patient absence was associated with higher cleaning rates for HTSs OR = 1.71 (1.24, 2.36)). In addition, there was a decline in the odds of bathroom surfaces being cleaned more frequently than bedroom surfaces OR = 1.97 (1.42, 2.74) and of private rooms being cleaned more frequently than semi-private rooms OR = 0.26 (0.07 – 0.93).

Eighteen staff interviews were conducted between January – June 2019. Patient presence during cleaning and cleaning of semi-private rooms were identified as potential barriers; this supports findings from the quantitative analysis. We found many environmental services (EVS) staff were Veterans and motivated to serve fellow Veterans, especially to prevent them from acquiring infections. However, hiring of former service members comes with regulatory hurdles that impact staffing. Staffing challenges resulted in staff inconsistency. Staff consistency was felt to be essential to teamwork and improve cleaning practices.

Fifteen patient interviews were conducted between July – September 2020. Patients expressed feeling “in the way” while EVS staff were cleaning, possibly rushing cleaning procedures. Patients expressed confidence in EVS staff’s skilled work and noted “soft skills” as desirable

attributes, including camaraderie and relationship building which can develop between Veteran patients and Veteran EVS staff during daily room cleaning.

Overall observed rates of daily cleaning of environmental surfaces in both AC and LTC was low. Standardized environmental cleaning practices to address specific predictors of compliance, specifically cleaning practices when patients are present in rooms and semi-private rooms are needed to achieve improvements in cleaning rates. Using a human-factors work system analysis approach we identified barriers and facilitators to environmental cleaning. Addressing staffing challenges through staffing models that promote consistency and teamwork may be an important entry point for intervention to improve the work system for environmental cleaning. Engaging patients in the research process identified environmental cleaning as a priority for HAI patient-centered infection prevention practices. Interpersonal skill development of EVS staff is needed to address actual or perceived disruption to patients' quiet time or build upon Veteran peer relationships promoting a safe and healing environment. Cleaning procedures may become more patient-centric if rationale for cleaning is explained (e.g., importance to prevent infections) and based on patient preferences (e.g., while patient is out of the room). Future research is needed to evaluate people-centric interventions to standardize cleaning practices, address workplace barriers and facilitators and measure patient-centered outcomes.

DEDICATION

I dedicate this dissertation to:

The life of my brother Eric William Fredricks who passed on May 4, 2021, from diabetic complications and chronic osteomyelitis that developed following a surgical site infection.

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DISSERTATION COMPOSITION

This dissertation is organized into seven chapters. Chapters 1 – 3 provide an introduction, background, key literature, and frameworks that serves as the rationale for the study. The literature review focuses on three specific areas: 1) Participatory research and patient engagement, 2) HAIs and the role of the environment, and 3) Human factors engineering. Chapter 4 provides the specific aims of the study. Chapters 5 and 6 outline the study methods and results. Chapter 7 is the discussion, synthesis, and conclusion along with study strengths and limitations and the clinical and research implications. Data collection tools used and other material that were useful for conducting this study are presented as appendices at the end of the document.

TABLE OF CONTENTS

LIST OF TABLES

Chapter 6: Results

LIST OF FIGURES

Chapter 3: Frameworks

Chapter 6: Results

Chapter 7: Discussion, Synthesis, and Conclusions

CHAPTER 1. INTRODUCTION

OVERVIEW AND SIGNIFICANCE

Healthcare-associated infections (HAIs) are infections that patients acquire during the course of receiving treatment for other conditions within a healthcare facility. HAIs are the most common complication in hospitalized patients.[1] Each year approximately 1 million HAIs occur in the United States causing significant morbidity and 75,000 deaths.[2] HAI prevention, especially those caused by antibiotic-resistant organisms, are a national priority.[3] There is evidence that HAIs are preventable and HAI prevention interventions are imperative to improving patient safety.[4, 5] The healthcare environment is a reservoir for pathogens causing HAIs.[6] Public health and professional organizations have published HAI prevention guidelines which includes environmental cleaning as an evidence-based intervention.[7, 8] Although environmental cleaning have been included in HAI prevention bundles within the VA,[9, 10] variability in cleaning practice is common.[11] Little is understood about the predictors of cleaning compliance and barriers and facilitators to environmental cleaning within the VA work system. Furthermore, patient perspectives on environmental cleaning within healthcare has not been examined. This descriptive mixed method study provides an in-depth work system analysis, specifically for environmental cleaning within the VA across acute and long-term care settings and provides a rich contextual backdrop of environmental cleaning from perspectives of healthcare workers and veteran patients. The knowledge gained will advance our understanding of the role of the environment and infection transmission. This information will identify cleaning processes that could be targeted for improvement and the specific entry points for these improvement efforts in the work system. These interventions will need to be further evaluated for feasibility and effectiveness with the goal of improving work system processes and patient outcomes.

CHAPTER 2. BACKROUND/LITERATURE REVIEW

Participatory research has been found to be beneficial throughout the research life cycle: from improving research recruitment and response to progressing research perspectives, planning, processes and outcomes.[12] To facilitate participatory research and ensure studies are patient-centered, funding agencies, including the Patient-Centered Outcomes Research Institute and Veterans Health Administration (VA) Health Services Research and Development have prioritized patient engagement.[13, 14] Veteran engagement groups are a common model of participatory research within the VA.[15] However, patient engagement for healthcare-associated infections (HAIs) research has largely been limited to recruitment in research studies.[16] To facilitate patient and Veteran engagement for HAI prevention research, we developed a 'Patient Engagement in Education and Research (PEER) Group' with participants that have had HAI experiences[17] to facilitate development of a patient-centered research agenda.[18] One of the research priorities identified by the PEER group was evaluation of the environment as a source for infections causing HAIs.[18]

Healthcare-associated infections (HAIs) are a common complication of health care.[2] Despite national level efforts, HAIs remain a significant threat to patient health.[19] Risk of morbidity and mortality from HAIs increases with factors such as advanced age and conditions affecting anatomy and function such as diabetes and spinal cord injury – conditions of particularly high prevalence among Veterans.[20]

Contaminated surfaces in healthcare settings can serve as a reservoir of pathogens associated with HAIs including *Clostridium difficile*, Methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), gram-negative bacilli, and norovirus.[6, 21-25] MDRO biofilms on hospital surfaces has been found globally.[26] Once contaminated, these pathogens can remain in the environment from days to months.[27] Pathogen acquisition is two

times higher for patients admitted to rooms whose prior occupants were infected or colonized.[28] Furthermore, environmental cleaning failures are associated with higher rates of environmental contamination and HAIs[29] while enhanced cleaning is associated with lower rates of environmental contamination, interrupting transmission and subsequent HAIs.[22, 24, 30]

Because contaminated surfaces in healthcare settings are a significant contributor to transmission of HAI-causing pathogens, environmental cleaning and disinfection are important for preventing HAIs.[21, 30] Cleaning programs incorporating adequate physical and chemical disinfection of environmental surfaces has been shown to be successful in the interruption of transmission of these pathogens and subsequent infections.[22, 30] However, disinfection products alone are not sufficient to prevent HAI transmission, especially when practice variation exist. Although the level of cleanliness required to prevent pathogen colonization from the environment is unknown,[27] cleaning practices applied frequently[26] and consistently can reduce the environmental bioburden,[31] disrupting transmission of these pathogens, and preventing HAIs.

Studies have found that HAIs are preventable when evidence-based practices are effectively implemented.[32] National[33] and International[34] guidelines recommend enhanced environmental cleaning for *Clostridioides difficile* prevention. The Department of Veterans Affairs (VA) has also incorporated enhanced environmental cleaning as components of national Multidrug-resistant Organisms (MDRO) HAI prevention initiatives (i.e., C. difficile and MRSA HAI prevention),[9, 10, 35, 36] and while national VA sanitation guidelines exist,[37] the guidance lacks task specific details. Additionally, when enhanced cleaning is implemented as part of a multi-modal HAI prevention bundle, interventions are implemented simultaneously and therefore the direct influence of the cleaning component of the bundle cannot be measured.

Measuring the impact of cleaning on HAI outcomes is difficulty due to the variability in cleaning practices that have been reported. [38] [39, 40] Efforts to standardize environmental cleaning practices, including the Centers for Disease Control and Prevention (CDC) toolkit,[41] have focused on targeted cleaning of high-touch surfaces (HTSs) (i.e., surfaces frequently touched by healthcare workers and patients such as bedrails, overbed table, IV pole, door knobs, etc.)[42] and monitoring (i.e., audit and feedback) of environmental cleaning processes (i.e., direct observation of cleaning, microbiological or organic surface sampling or marking surfaces with fluorescent gels) as a means to improve cleaning efficacy and compliance.[43, 44] Despite efforts to standardize and monitor environmental cleaning and disinfection,[45] reported cleaning and disinfection compliance remains low ranging from 35 – 81%.[46]

Low practice compliance may partially be explained by practice variation.[47] Although a recent survey of VA medical facilities between 2005 and 2013 found high rates (80%) of VA facilities self-reporting daily cleaning of HTSs in patient rooms with *C. difficile*.[40] However, another recent VA-wide evaluation of infection prevention practices found significant variation in environmental cleaning, including differences in who performs disinfection of various surfaces in patient rooms—environmental services or nursing staff—and when, how, and by whom compliance is monitored.[48, 49] In addition, interviews with Environmental Service (EVS) personnel found a lack of standardization regarding which surfaces are important to clean regularly in a room.[39, 50]

These data support the need for understanding the context of practice variation (i.e., predictors of cleaning compliance)[47] which may lead to practice standardization, cleaning compliance and ultimately patient outcomes. A recent review of healthcare cleaning and disinfection strategies highlights the human element in the manual cleaning and disinfection

process and the need for evaluation of human factors to understand barriers and improve the quality of environmental cleaning and disinfection.[46] Understanding the human factors involved in the clinical translation of evidence-based practices that delay implementation, interrupt sustainment or explain variability are needed.

A human factors engineering work systems framework—the Systems Engineering Initiative for Patient Safety (SEIPS) model (**Figure 2**)[51-53] has been used extensively in healthcare as a road map describing elements of the work system that can affect processes and outcomes including its application for understanding processes for prevention MDROs and healthcare-associated infections (HAIs).[50, 54-58] The SEIPS model focuses on five interacting elements of the work system— person, tasks, tools and technologies, physical environment, and organizational factors. Interactions of these elements can affect care processes such as environmental cleaning practices in healthcare and subsequent outcomes such as poor cleaning compliance, pathogen transmission and HAIs. For example, various **people** are involved in the process environmental cleaning – care team, patients, family members and environmental services. The main **tasks** are product use, product complexity, time pressure of staff. The **tools** in this case are the cleaning disinfectants and supplies. The **organization** represents the policies related to environmental cleaning and leadership aspects of implementing cleaning procedures, such as incentives, work schedules, training, audits, etc. and the **environment** is the physical environment of the VA inpatient settings, involving factors such as the size of the room, room occupancy, and number of surfaces to clean. The SEIPS model emphasizes that any one work system component can affect changes in all other components. In this project, uncovering barriers and facilitators can assist with interventions to improve environmental cleaning. A SEIPS analysis can provide the foundation to understanding the work system barriers and

facilitators of environmental cleaning. This understanding is essential to improve fidelity of the cleaning process through development of standardized interventions and to identify entry points for these interventions leading improved compliance and outcomes.

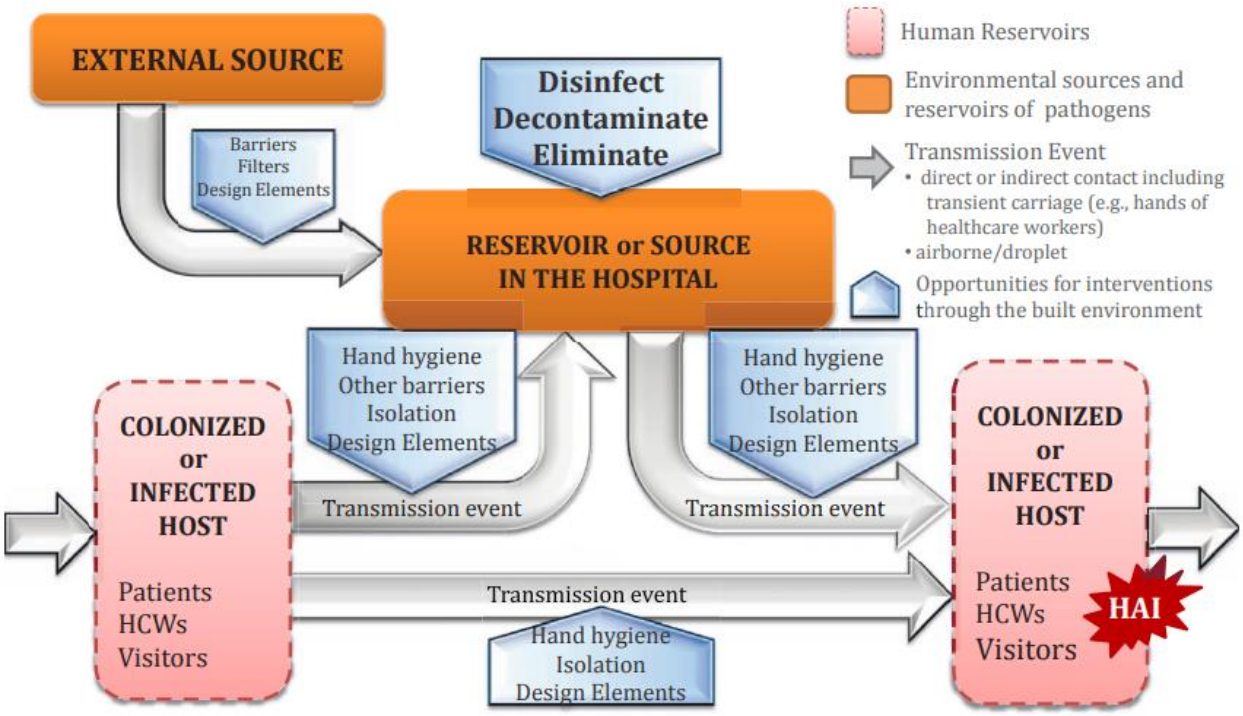
Within the SEIPS model, the person is at the center of the work system. For environmental cleaning and disinfection, the persons involved include EVS staff, members of the patient's care team (e.g., physicians and nurses), patients, and their visitors. Given the centrality of patients within the environmental cleaning and disinfection work system, engaging patients in this process can provide a perspective useful in identifying entry points for interventions and developing meaningful patient-centric interventions to enhance cleaning and disinfection effectiveness, reduce HAIs, and improve patient safety. In addition, because cleanliness of a hospital plays a large role in patient perception[59] of and ultimate satisfaction[60, 61] in their healthcare experience, it is clear that environmental cleaning and disinfection is a key area for patient involvement. However, patient engagement in the environmental cleaning and disinfection process has not yet been explored and thus patient perceptions of environmental cleaning and disinfection procedures remain unclear. To engage patients as part of achieving patient-centered care, we undertook a qualitative study to examine patient perspectives on environmental cleaning and disinfection in healthcare settings.

CHAPTER 3. FRAMEWORKS

CHAIN OF INFECTION

Pathogens causing HAIs are transmitted directly, from one patient to another primarily on hands of healthcare workers, or indirectly via contaminated patient equipment and environment.[44] A model depicting this predicted movement of pathogens is referred to as a "chain of infection."[62] Emerging and antibiotic-resistant microorganisms may persist for long periods of time in the hospital environment.[63] Once introduced into a healthcare setting, transmission and persistence of the resistant strain is determined by availability of vulnerable patients, selective pressure exerted by antimicrobial use, the numbers of colonized or infected patients, and the impact of implementation and adherence to infection prevention efforts.[44] **Figure 1** provides the conceptual model for chain of infection transmission and entry-points for intervention, including cleaning and disinfection of the environment.

Figure 1. Conceptual Framework for the Chain of Infection Transmission.



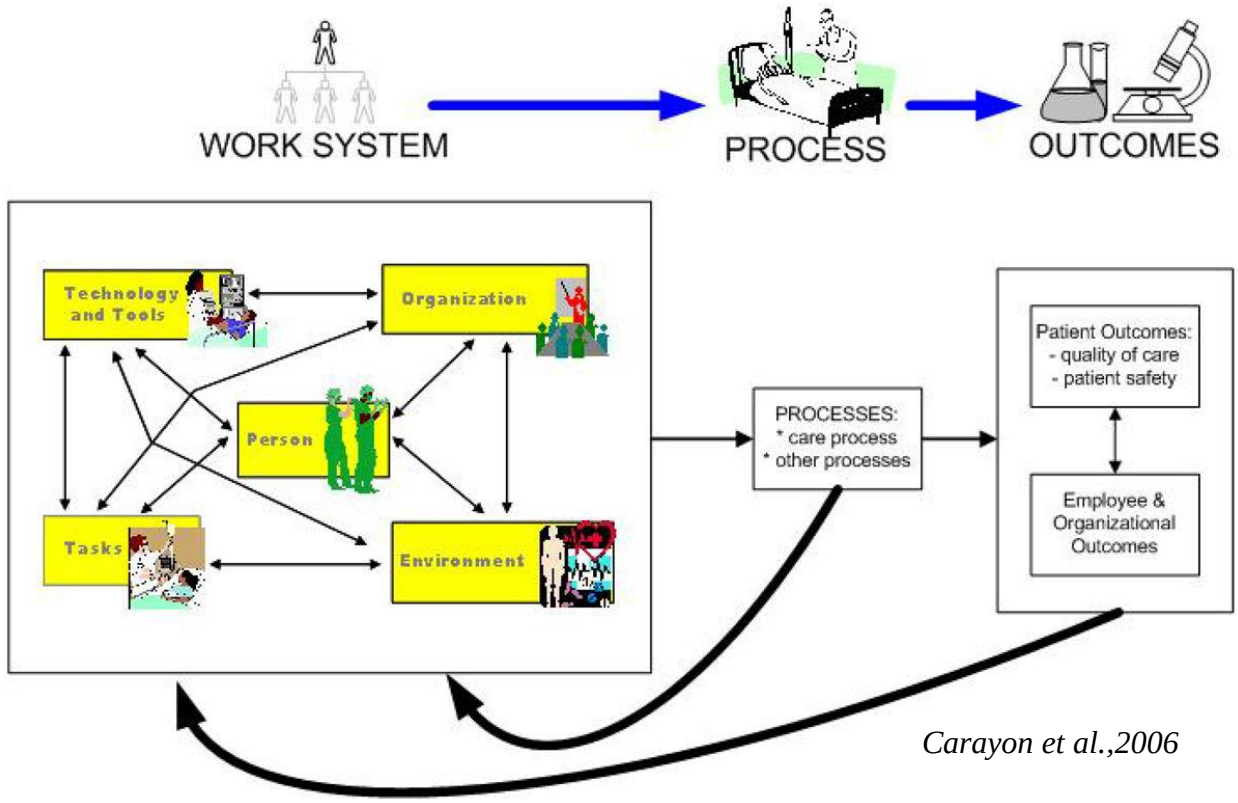
Reservoir: Place (human or environmental) where organisms reside and multiply.
Source: Place from which an organism is transmitted to the host. Source may be the same as the reservoir or become contaminated from the reservoir (e.g., a surface or instrument).

Zimring et al.,2013

SYTEMS ENGINEERING INITIATIVE FOR PATIENT SAFETY

Due to the complex nature of healthcare organizations , a report by the National Academy of Medicine (NAM; formerly U. S. Institute of Medicine) recommended the application of human factors and systems engineering to improve the safety of healthcare delivery.[64] Improvement in environmental cleaning practices will require understanding of these complexities and the context in which they occur. A recent review of healthcare cleaning strategies highlights the human element in the manual cleaning process and the need for evaluation of human factors to understand barriers and improve the quality of environmental cleaning.[46] A human-factors framework – the Systems Engineering Initiative for Patient Safety (SEIPS) model – has been used extensively in healthcare as a road map describing elements of the work system that can affect processes and outcomes (**Figure 2**).[51, 52]

Figure 2. The Systems Engineering Initiative for Patient Safety Model.

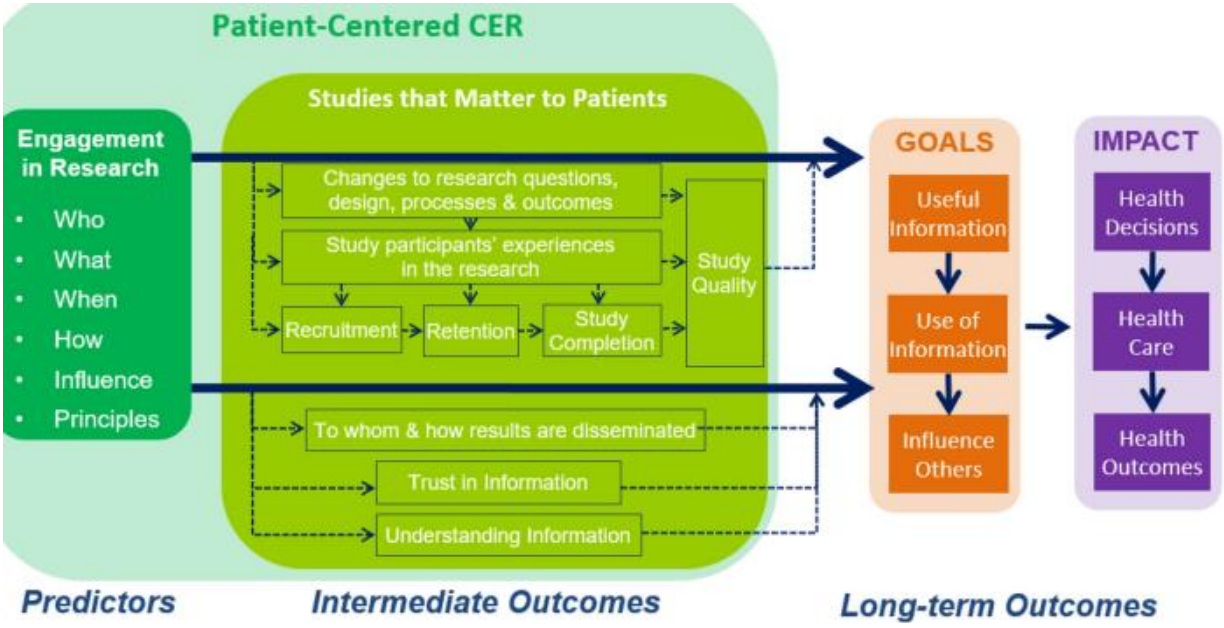


PATIENT ENGAGEMENT

Participatory research, sometimes referred to as patient engagement in research, has become a priority for researchers and funding agencies.[14] This partnership between researchers and patients has many benefits to patient-centered care and outcomes.[12] Patient involvement in the research process can occur anywhere on the research continuum from formulating clinical questions to data dissemination (**Figure 3**). The University of Wisconsin – Madison and Madison VA healthcare-associated infection (HAI) research group was awarded funding to build capacity for patient engagement from the patient-centered outcomes research institute (PCORI). A patient stakeholder group 'Patients (and Veterans) Engaged in Education and Research' (PEER) group was formed and initial work prioritized the hospital environment as a critical source of HAIs for our research agenda.[17, 18] In addition to prioritizing the HAI prevention

research agenda, once funded the patient stakeholders became involved in the grant process, study protocols, data analysis and dissemination (**see Appendix for a patient narrative of the participatory research experience**).

Figure 3. The PCORI Evaluation Framework for Engagement in Research.



Forsythe et al.,2018

CHAPTER 4. SPECIFIC AIMS

We hypothesize that predictors of environmental cleaning practice variations can be characterized through observation and interviews can identify work system barriers and facilitators and the patient perspectives. The overarching goal of this dissertation is to understand the predictors of environmental cleaning compliance and barriers and facilitators to environmental cleaning practices to lay the groundwork for developing an effective, practical, and acceptable patient-centric approach to environmental cleaning (standard set of procedures or bundled approach) that standardizes practices, improves compliance, and ultimately prevents the transmission of pathogens which cause HAIs.

The purpose of this dissertation was to describe daily environmental cleaning and disinfection practices and their associated cleaning rates while exploring key stakeholder experiences of the cleaning process within the context of the VA work system, in acute-care (AC) and long-term care (LTC) settings; LTC is sometimes referred to as Community Living Centers (CLC) within the VA. The dissertation addresses these gaps in the infection control literature related to environmental cleaning through the following three aims:

SPECIFIC AIM 1: To describe predictors of environmental cleaning compliance in acute and long-term care within the VA through direct observation of daily environmental cleaning by EVS staff.

SPECIFIC AIM 2: To conduct a work system analysis to identify contextual barriers and facilitators to environmental cleaning through interviews with healthcare workers.

SPECIFIC AIM 3: Explore the patient perspective on environmental cleaning within the healthcare environment by engaging patients in the research process and interviewing patients.

CHAPTER 5. METHODS

A mixed method study was used to evaluate environmental cleaning in three VA facilities across acute care and LTC settings; specifically, a convergent parallel design in which quantitative and qualitative data were collected concurrently, analyzed separately then merged for comparison.[65] Data were integrated using an convergent design whereby quantitative and qualitative data was used to explain results.[66] Data were merged using written narrative, data transformation, and through joint display to maximize strengths and minimize weaknesses from each of the different data sets.[67] The quantitative phase of the study was comprised of observations of EVS staff performing daily cleaning. The qualitative phase of the study was comprised of semi-structured interviews of key stakeholders including healthcare workers and patients to better understand contextual factors occurring during the cleaning process.

QUANTITATIVE DATA

Direct observations of daily environmental cleaning occurred from December 2018 – June 2019 at three VA facilities across acute and LTC. Each site was in a different geographic region within the U.S.; Site A had 102 acute care beds, Site B had 85 acute care beds and 26 LTC beds, Site C had 121 acute care beds and 40 LTC beds. There were twenty-four room observations at each site: Site A – acute care (N= 24), Site B – acute care (N=8) and LTC (N=16), Site C – acute care (N= 8) and LTC (N=16). Convenience sampling was used for selecting observations; the RAs shadowed EVS staff during day shift with each site expected to collect four observations per week over eight weeks for minimum of twenty-four observations per site; daily cleaning is typically conducted during day shift. Research Assistants (RAs) at each site collected standardized observation data. Prior to conducting observations, RAs received approximately two hours of didactic observer training on the data collection process provided by

subject matter experts from the research team (L.M., C.G., E.B, S.H.). Training covered the specific environmental cleaning processes they would observe and how to correctly fill out the observation form to accurately reflect the EVS staff practices. Complementary to the training, each RA was given a comprehensive data collection protocol and training manual (see Appendix). Each RA completed a pilot observation with same-day team feedback prior to data collection with subsequent data collection clarification occurring during weekly meetings with the research team. The observation form was adapted by the research team from the CDC environmental checklist for monitoring cleaning[68] including the following variables: cleaning duration, location of room cleaning (e.g., facility and patient setting), type of surface (e.g., high-touch, reusable medical equipment, bedroom or bathroom area), room characteristics (e.g., number of beds, number of people in room, whether patient on isolation precautions, presence of clutter), product characteristics (e.g., type of disinfectant, use of microfiber) and practice characteristics (e.g., cleaning path, surface friction – number of swipes, surface area – degree of surface area disinfectant applied, surface wetness – degree of disinfectant saturation, number of wipes used, number of staff interruptions, and EVS staff use of hand hygiene and personal protective equipment); **see Observation Form and Training Protocol in Appendix**. Observations were recorded using TeleForm® technology that could be later scanned and uploaded for data management. Observation forms were scanned using OpenText™ TeleForm (OpenText, Waterloo, ON) software.

Descriptive and multiple logistic regression analysis was performed using observational data. Descriptive statistics summarize the environmental cleaning practice variables using data from the room observations. Logistic regression analysis was used to evaluate the relationship between specific cleaning practices and daily environmental cleaning rates using data from the

total number of surface observations. Analysis for interdependence was conducted by cluster analysis; glimmix procedure with a random effect of the room number was used to account for clustering. Cleaning rates were defined by the percentage of surfaces cleaned in a room (number of surfaces cleaned/total number of surfaces); any attempt to wipe a surface with disinfectant was considered "cleaned". Observations were limited to disinfection and cleaning practices using chemical disinfection and manual cleaning; we did not ask observers to assess practice accuracy (or performed to a certain standard). Data were analyzed using SAS® version 9.4 (SAS Institute Inc., Cary, NC).

To explore the optimal number of environmental surface observations needed for an effective monitoring program we developed an estimate using a sampling with replacement (i.e., bootstrap) method. We examined six different sampling strategies: observing 20, 25, 30, 35, 40, and 45 rooms. The observer was assumed to be present in the room for the duration of the cleaning (maximum time of 30 minutes). We calculated each room's cleaning rate by dividing the number of surfaces cleaned (wiped with disinfectant) by total number of surfaces present in a room; total number of surfaces in each room were calculated from the observation form since this differed from room-to-room. We generated 1,000 bootstrap samples for each sampling strategy. We calculated sampling error, defined as the distance between each sample cleaning rate and the actual cleaning rate, and percent of samples with sampling error of ≤ 5% and ≤ 10%, reported for each strategy. The optimal sampling strategy was defined as the minimal number of surfaces needed to reach a tolerable frequency of sampling error (≤10%) for all samples, representing the "tipping point" where additional surfaces would be unlikely to increase accuracy. We stratified the rooms by greater than mean (All Surfaces: <33.7% and HTS: <60.2%) cleaning rate to explore how the prediction might vary.

QUALITATIVE DATA

Healthcare Workers

Qualitative data were collected through eighteen semi-structured in-person interviews[69-71] with key stakeholders including staff and mangers from environmental services (EVS), nursing, and infection control (IP) between Jan – Jun 2019 at all three sites; EVS (N=11), Nursing (N=4), IPs (N=3).

The interview guides were developed by the research team and questions focused on facility environmental cleaning practices with critical engagement by patient and Veteran stakeholders from the UW – Madison PEER group (**see Interview Guides in Appendix**). Development of the interview guide questions was influenced by the SEIPS framework which emphasizes human factors involved in the work system, specifically people, organizations, tools/technology, tasks and the physical environment.[53]

Healthcare interviews were conducted by research personnel trained on use of the interview guide. Prior to conducting interviews, research assistants (RAs) received approximately eight hours of didactic training on conducting qualitative interviews (e.g., the interview process, the notetaking process, time management, etc.) led by our team of qualitative experts (L.M., C.G., E.B., S.H.).

A combination of purposive and convenience sampling was used to identify subjects for interviews. Eligibility criteria included healthcare workers managing or performing environmental cleaning or those healthcare workers closely involved in the cleaning processes (e.g., nursing and infection control) working on the inpatient and LTC patient units and the ability to understand English. E-mails were sent to all ESV, Nursing and IP staff on these units to introduce the project and invite participation; no compensation was provided. Interviews were

conducted on day shifts during the work week when RA staff who were typically assigned to work and staff availability were more likely. Interviews lasted 45 minutes on average and were audio-recorded using encrypted recorders and transcribed verbatim. One interview was not recorded due to participant refusal, therefore detailed notes were used in analysis. Electronic transcripts were managed and analyzed using MAXQDA® (VERBI Software, Berlin, Germany) software.

We conducted qualitative descriptive analysis applying unconstrained directed content methods.[71-74] Transcripts were analyzed for themes within the SEIPS constructs (i.e., Person, Environment, Organization, Tasks, Tools). Analysis was conducted with a core team of six members; four investigators performed coding (L.M., C.G., S.H., E.B.), and two senior investigators (H.R., M.K.) were available to assist in resolving disagreements and discussing discrepancies. Our interdisciplinary team, including trained social scientists with backgrounds in anthropology (H.R.), public health (M.K., C.G., S.H., E.B., L.M.), nursing (L.M.), and infection control (L.M.). The following coding process was used to maximize trustworthiness during analysis:

1. Development of a matrix display for each of the 5 SEIPS work system elements.
2. Independent reading of each interview transcripts to achieve a deeper understanding of the contextual factors of the work system experienced by EVS and other stakeholders.
3. Independent line-by-line open coding of ten (56%) of the transcripts by 4 coders (L.M., C.G., S.H., E.B.) followed by group consensus to:
    a. Develop subcategories of codes within each SEIPS elements
    b. Compare consistency of text assignment to emerging codes
    c. Discuss and refine code definitions and descriptions using an iterative process.
    d. Apply final coding assignment.[75]

4. Review, discuss, and refine code definitions and descriptions to develop a comprehensive codebook.
5. Independent line-by-line coding of the remaining eight (44%) of the transcripts [2 coders (L.M., C.G.) assigned to transcripts 1 – 4 and 2 coders (S.H., E.B.) assigned to transcripts 5 – 8] followed by:
    a. Comparison of consistency of text assignment to codes
    b. Application of final code assignment using paired consensus.[75]
    c. Discussion of discrepancies among paired coders using group agreement and consensus.
6. Review, discussion, and refinement of subcode assignment to SEIPS elements using group consensus; final mapping to the to the SEIPS matrix; **see SEIPS Coding Matrix in Appendix**.

Trustworthiness and Rigor

Criteria for rigor in qualitative research (i.e., credibility, dependability, and confirmability) where followed to insure trustworthiness of the data during the data collection and analysis process.[75, 76] Credibility (confidence in truth of findings) was enhanced through the use of interviews with different healthcare worker disciplines; multiple perspectives revealed a more complete picture of work system elements impacting environmental cleaning. The coding process is outlined to maximize credibility and trustworthiness of coding. Dependability of findings (consistency of findings) was enhanced through use of a team of 4 coders for analysis. Three of the coders had minimal clinical experience, 1 coder was not involved in the development of the interview guide and none of the coders conducted interviews; this added to dependability of data because it limited the potential for coder's experience to influence the analysis. To support confirmability of the data, the coders created an audit trail by recording operational memo, thereby documenting the decisions they made throughout the analytic process.

Patient

Qualitative data was collected through semi-structured interviews[69] with fifteen patients at one site between July and September 2020.[70, 71] The interview guides were developed by the research team and questions focused on patient perceptions of environmental cleaning practices with critical engagement by patient and Veteran stakeholders of the UW – Madison PEER group (**see Interview Guides in Appendix**). The interview guide was reviewed for comprehension and piloted with one patient stakeholder prior to use.

Development of the interview guide questions was influenced by the SEIPS framework which emphasizes human factors involved in work systems, specifically people, organizations, tools/technology, tasks and the physical environment (**Figure 1**).[53] Interview questions focused around these five work system components. For example, we assessed the patient's knowledge (knowledge as an element within the 'person' component) of environmental cleaning by asking "How is cleaning in the hospital room different from cleaning in your home?". An element within the organizational component is teamwork, we questioned "How do clinical staff (providers and nurses), help in the room cleaning process?" To broadly explore potential elements as barriers or facilitators of any of the five components we queried "From your experience, what makes it easier (or harder) for EVS to clean your room?"

A combination of purposive and convenience sampling was used to identify subjects for interviews. Eligibility criteria included patients currently admitted on acute and LTC units and the ability to speak English. Charge nurses were asked to assist in identifying patients for potential interviews using their assessment of patient's availability, cognition, and aptitude. Patients were initially approached by nursing staff for permission to approach followed by research staff introducing the project and inviting participation; no compensation was provided.

Interviews were limited to day shift during the work week when RA staff were typically assigned and when patients are typically awake.

Interviews were conducted by two research team members (L.M., K.B.) with qualitative interview experience; L.M. performed ten interviews and K.B. performed five interviews. Interviews lasted 5-20 minutes with 10 minutes average; one interview ended prematurely when the recording device stopped, but initial recorded data was used in analysis. The interviews were audio recorded using encrypted recorders and transcribed verbatim. Electronic transcripts were managed and analyzed within Microsoft Word documents housed in a shared folder on a VA secure server.

We conducted a qualitative descriptive study using rapid qualitative inquiry (RQI) analysis.[77] The RQI analysis process occurred between November 2020 and January 2021. RQI design was selected to provide a rapid preliminary understanding of patient's perception of environmental cleaning to further inform findings of the mixed method study; patient interviews were limited to one VA site due to funding and timeline restraints, especially since this phase of the study occurred during the SARS-CoV-2 pandemic.

The 3-member RQI analysis team consisted of interdisciplinary research scientists with public health (K.B.), microbiology sciences (J.K.) and nursing and infection prevention (L.M.) backgrounds. Each team member attended two hours of RQI training.

The team used RQI techniques including structured templates, use of domains and matrix display (**see tools in Appendix**).[78, 79] The following coding process was used to maximize trustworthiness during the RQI analysis:

1. Development of the key domains (corresponding to each interview question) and a summary template to use with individual transcripts

2. Independent reading of each interview transcripts to achieve a deeper understanding of environmental cleaning in the work system as experienced by patients.
3. Independent line-by-line open coding of one of the transcripts by all coders to pilot the structured template followed by group consensus to:
    a. Compare consistency of text assignment to emerging codes
    b. Discuss and refine code definitions and descriptions using an iterative process.
    c. Apply final coding assignment.
4. Independent line-by-line coding of two additional transcripts by 3 coders using the structured templates followed by group consensus to:
    a. Compare consistency of text assignment to emerging codes
    b. Discuss and refine code definitions and descriptions using an iterative process.
    c. Apply final coding assignment.
5. Review, discuss, and refine code definitions and descriptions to develop a coding matrix display (**see Coding Matrix Display in Appendix**).
6. After consistency established, transcripts were divided and the remaining twelve transcripts were independently coded; transcripts 1 – 4 (L.M.), transcripts 5 – 8 (KB) and transcripts 9 – 12 (J.K.) followed by:
    a. Application of final code assignment using group consensus.
    b. Discussion of discrepancies using group agreement and consensus.
7. Review, discussion, and refinement of code assignment to SEIPS elements and emergent themes using group consensus.
8. Transfer of transcript summaries into a matrix. Matrix analysis[80] was initially used for domain specific matrices using all patient interviews. Later, matrices were used to display emergent themes and exemplar quotes across domains to look for overlapping themes and synthesize findings.

Trustworthiness and Rigor

Criteria for rigor in qualitative research (i.e., credibility, dependability, and confirmability) where followed to insure trustworthiness of the data during the data collection and analysis process.[75, 76] Credibility (confidence in truth of findings) was enhanced through the use of interviews with patients from different inpatient units; multiple perspectives revealed a more complete picture of the patient perspective of environmental cleaning. The coding process is outlined to maximize credibility and trustworthiness of coding. Dependability of findings (consistency of findings) was enhanced through use of a team of 3 coders for analysis. Two of the coders had minimal clinical experience, 2 coder was not involved in the development of the interview guide and 1 of the coders did not conduct interviews; this added to dependability of data because it limited the potential for coder's experience to influence the analysis. To support confirmability of the data, the coders created an audit trail by recording operational memo, thereby documenting the decisions they made throughout the analytic process.

QUANTITATIVE PLUS QUALITATIVE

Results of both data sets (quantitative and qualitative) were integrated using a convergent design[66] to explain and interpret findings and facilitate understanding of environmental cleaning practices, cleaning rates, and contextual factors within the work system. Qualitative content analysis of the interviews was used to further explain and interpret findings from the observations.

HUMAN SUBJECTS

Human subject review and approvals were obtained from the VA Central Institutional Review Board (CIRB 18-10) and local site Research and Development Committees for both observations of environmental cleaning and healthcare worker interviews; we received a waiver

of documentation of informed consent for both. Interviewees did complete VA Form 10-3203 (Consent for Use of Picture and/or Voice).

Human subject review and approvals were obtained from the University of Wisconsin-Madison Minimal Risk IRB (MR-2019-1207) and VA Research and Development Committee for patient interviews; the study was determined to be exempt. Interviewees did complete VA Form 10-3203 (Consent for Use of Picture and/or Voice) and HIPPA authorization. Patient interviews occurred during SARS-CoV-2 pandemic, so a risk assessment was performed outlining the risk mitigation plan prior to study initiation.

CHAPTER 6: RESULTS

QUANTITATIVE

From December 2018 to May 2019 trained RAs at each site conducted direct observations by shadowing EVS staff performing daily environmental cleaning of patient rooms. Quantitative results are grouped by unit of analysis, either by the cleaning rates per number of room observations (N=62) or by the cleaning rates per number of environmental surface observations (N=3602).

A surface was considered to be "cleaned" by any attempt to wipe a surface with a chemical disinfectant. The following data collected during daily cleaning characterize the cleaning process as: 1) two or more swipes (back-and-forth motion) were reported for 95% of observations, 2) 25% or more of the surface area was wiped cleaned in 93% of observations, and 3) cleaning wipes were changed sometimes or frequently (vs once or never) in 56% of the observations; the amount of surface disinfectant applied was missing for 72% of the observations and therefore could not be characterized.

Room Observation (N=62)

A total of 62 rooms (AC, N=35 and LTC, N=27) were observed during daily cleaning; the unit of analysis in this section is the total number of rooms observed. Descriptive statistics of the observations are presented in **Table 1.** EVS staff spent, on average, four more minutes performing daily cleaning activities in LTC compared to the AC setting. There were more observations of daily cleaning of isolation rooms in the LTC setting (19% vs. 6% in AC) which require EVS staff to wear personal protective equipment (PPE) such as gowns and/or gloves upon room entry and requires specialized cleaning procedures. Of note, less than half of the observations reported EVS staff performing hand hygiene upon room entry.

Surface Observation (N=3602)

During daily cleaning, EVS staff were observed cleaning a total of 3,602 surfaces (AC, = 2,013 and LTC, =1,589); the unit of analysis in this section is the total number of surfaces observed. Cleaning rates across settings (i.e., AC and LTC) and surface type (i.e., bathroom, bedroom, HTS, and RME) are described in **Table 2**. The overall cleaning rates for 'all room surfaces' during daily cleaning was low in both settings, rates were higher in LTC compared to AC. Cleaning rates for HTSs was higher in both settings compared to 'all surfaces'.

Multiple logistic regression analysis (**Table 3)** was used to measure the relationship between (Odds Ratio; OR) the observed variables and cleaning rates of all environmental surfaces. The surfaces associated with higher cleaning rates were bathroom surfaces, HTSs, and RME. Factors associated with lower cleaning rates were cleaning of semi-private patient rooms and rooms in AC. When analysis was stratified by whether the patient was in the room, cleaning rates increased for HTSs when the patient was absent from the room. The differences between cleaning rates of bathroom surfaces and RME, compared to bedroom surfaces, became less significant when the patient was absent from the room during the daily cleaning process. Of note, in AC nearly all (94%) of the cleaning observations occurred while the patient occupied the room while approximately half (48%) of the cleaning observations in LTC were done with patients present.

Table 4 shows the summary strategies of actual observed surface disinfection cleaning rates with various sampling strategies and frequency of sampling errors ($\leq$ 10% and 5%) to estimate the number of rooms needed to be observed to meet or exceed the mean compliance threshold.

QUALITATIVE

Healthcare Workers

Eighteen[71] interviews were conducted with EVS (N=11), Nursing (N=4), IPs (N=3). Themes describing environmental cleaning barriers and facilitators are organized by each of the SEIPS components.

Organization

The complexity of healthcare work systems is demonstrated by the number of emergent themes centered within the organizational element of the SEIPS framework. The organizational themes are outlined in **Table 5**, communication, staff education, organizational culture and leadership, teamwork, staffing, and professional value. Primarily, stakeholders report challenges for EVS staff recruitment and retention. EVS staffing issues subsequently impacted assignment consistency, cleaning practices, teamwork, and training. Other important organizational themes were communication, professional value and organizational culture and leadership.

The staffing challenges occurred across the human resource (HR) management continuum from staff recruitment and retention to staffing assignments. Respondents noted the regulatory and restrictive hiring processes within the VA specifically for hiring EVS staff and recognized the need for staffing solutions:

> *"(…) [Hiring is] a time-consuming, complicated quagmire of regulations…"* (EVS manager, Facility B).

> "*I just thank you guys for doing this research project. (…) It means a lot, especially we're struggling across the U.S. in this field, and I hope that this goes towards finding better ways to keep, recruit, and retain EVS staff and (…) I hope this is not a way to outsource housekeeping (…), but I really do hope that they take your research seriously and implement practices to come up with better ways to improve service"*. (EVS Manager, Facility B).

These HR difficulties lead to staffing turnover and assignment inconsistencies which can impact teamwork within the unit or department where cleaning occurs. Without consistent staff assignment, EVS staff felt unable to integrate into the healthcare team. Conversely, stakeholders

noted the power of teamwork in overcoming staffing barriers.

> *"…So, if you're moving from area to area a lot, sometimes if they don't know you, then sometimes they don't help you out."* (EVS Staff, Facility A)

> *"…we try to keep people in the same area, you know, instead of switching people (…) When they're in an area longer, they build up the lines of communication with the staff in there. They build up their ownership of that area…"* (EVS Manager, Facility A)

Stakeholders report understaffing has practice implications such as rushing through cleaning processes and perceptions that quality of cleaning practices may be compromised:

> *"…I think housekeepers are very understaffed, so they're rushed…"* (Infection Preventionist, Facility A).

> *"It's been going on since I've been here. Trying to cut the fat hog in the ass (…) I know where I can nip and tuck and still keep things within standard, but if that becomes common practice, things are gonna get missed. Quality control is gonna go down and something bad's gonna happen. But staffing is ALWAYS an issue."* (EVS Staff, Facility A).

Stakeholders believe undervaluing the EVS profession influences staffing turnover. One EVS manager (Facility B) provided a rationale for the high turnover as well as a potential solution to improving the professional value of EVS staff:

> *"…There are valid reasons that I lose staff. They get promotions because this is an entry-level, bottom, you can't get paid less than you can get paid here, you know?"*

> *"…we've [EVS] worked towards getting certifications for our housekeepers. There's a program called CHEST, Certified Healthcare Environmental Services Technician, we wanted to get all of our housekeepers certified with that program (…) CHEST, sets us aside from the janitor at the high school or Arby's or the 7-Eleven that we really want to be seen as Environmental Services Technicians instead of housekeeping in a hotel."*

Inadequate staffing levels can create training issues and training is critical for EVS staff performance as one EVS manager (Facility B) notes:

> *"So, staffing issues create training issues because if I don't have enough staff to go around and that shortchanges a new employee on the amount of time that they get trained without being put out on the floor independently."*

> *"…Our number one complaint used to be "I've never been trained," and that was a barrier for us holding people accountable for their standards of cleaning."*

Interviews revealed various training methods utilized to train EVS staff such as online training, training during staff meetings, peer-shadowing, train-the-trainer, hands-on training. Simulation (or hands-on) training methods were a preferred method of training as noted by one EVS manager (Facility A):

> *"…We also do hands-on training. Well, I believe hands-on is probably the most effective."*

Communication of environmental cleaning needs within the facilities was reportedly complex. Variations in communication methods were noted as well as the need for advanced interpersonal skills:

> *"So, there's kind of two methods by which we get notified [for cleaning]. One of 'em is nursing. Nursing'll call my supervisor and that's the most successful method. On the flipside of that option is nursing'll go straight to that bed, the person that's on the unit and that's generally very efficient. But sometimes my housekeepers don't have the best interpersonal relationship skills…"* (EVS Manager, Facility B).

> *"…They [EMS]can read the language and the atmosphere as to the flow and when things are gonna happen. They can plan their day around being able to read body language and signals, and that nursing communication board…"* (EVS Manager, Facility B).

Organizational culture and leadership were reported to be both facilitators and barriers to environmental cleaning. Some stakeholders perceived accessible leadership support as a facilitator while some staff reported perceived undervalued by the organization:

> *"…if there was something going on or if we needed more assistance, there's a supervisor we call and then the supervisor has a manager that we can also call both, Morning AND afternoon."* (Nurse Manager, Facility A).

> *"…sometimes I wish we had just maybe a little bit more say and working hand-in-hand, which I like doing. You know, I wish our input would be taken more, would be more valued, you know…"* (EVS staff, Facility A).

<u>Person</u>

Table 6 outlines key themes (i.e., knowledge, serving Veterans, and patient disruption) identified within the SEIPS element 'Person'. The study found many EVS staff were Veterans and highly motivated to serve fellow Veterans, especially to prevent them from acquiring infections. Although environmental cleaning was perceived to be important for patient safety, there was also a perception that cleaning may be disruptive.

> *"So, the environmental management department is the first-line of defense between organisms that are found in the environment and the staff and visitors and patients that use the environment"* (EVS Manager, Facility B).

> *"(…) sometimes you can do that [clean]and sometimes you can't because some patients don't want you in there." (*EVS Staff, Facility C).

EVS Staff understood the technical knowledge required for the position, especially understanding the different chemicals used. There was also acknowledgement of the complexity of the patients they serve:

> *"…but you know, you can have the fastest cart in the world, it's about how you use what's on that cart."* (Facility C).

> *"…When I started working in the hospice unit, I was SCARED, you know, and now you know, I've gotten more comfortable with it, but I think that would be a nice training that they could have."* (Facility B).

<u>Tools and Technology</u>

Themes were identified within the 'Tools and Technology' element (**Table 7**) included supply availability, use of audits and checklists, and having improved cleaning products). Staff noted having effective cleaning products, but sometimes in limited supply. There were several references to the implementation of supplies and equipment which improved the cleaning process.

> *"…the rag issue, which they try and try and try to solve and that just seems to be one of those things that is the same with the staffing…"* (EVS Staff, Facility B).

> *"He's [EVS] using a microfiber system for cleaning floors. I find that to be much more clean than when they used the old mops and they're more attuned to*

> *changing heads than they did with their mop heads…"* (Infection Preventionist, Facility A).

Most sites reported some form of monitoring (i.e., audits and/or checklists) of their cleaning process, however, there was variation in type and frequency. Audits and checklists were generally felt to be important and provide useful information.

> *"I think that it [audits] should be mandated across the country that environmental management reports data…"* (EVS Manager, Facility B).

> *"…I think that you're right on with needing a checklist for every room and a little bit more transparency on performance to make sure that we're--, you know, everything else has checklists, right?"* (Nurse Manager, Facility B)

Several staff mentioned that bed management systems could facilitate communication required for the cleaning process, but facilities reported lacking this technology:

> *"Other facilities have a fully functioning bed management system, meaning the ED knows when rooms are open…"* (Nurse Manager, Facility B).

Tasks

Several important themes were identified within the 'Task' element including the workload associated with patient movement, complexity of RME, prioritization of HTSs and presence of patients during cleaning (**Table 8**). Stakeholders reported that moving patients from one room to another occurred frequently for various reasons (e.g., isolation room or patient acuity) which greatly impacted workload.

> *"That [patient movement] takes away from their regular daily cleaning on everybody else on that unit because my person spent 90 minutes to make sure that one patient got closer to the nurse"* (EVS Manager, Facility B).

EVS staff were reportedly motivated to clean high-touch surfaces, they also found cleaning the room when the patient was present difficult:

> *"…But day shift, their primary task is doing daily cleanings and (…) they're supposed to hit the bathroom, high-touch areas."* (EVS Staff, Facility A)

> *"But, as far as the patient bed, you know, it's, while they're in it, it's hard [cleaning]. You know?"* (EVS Manager, Facility C).

Barriers to cleaning reusable medical equipment (RME) focused on ambiguity with responsibility for cleaning and equipment complexity:

> *"It depends on the equipment. There's certain things we clean and there's certain things that are assigned to certain people…"* (EVS Staff, Facility A)

> *"As far as if we turn those machines off or something or you know, do something wrong or if they lose information then (…) it's you guys have done something you shouldn't have"* (EVS Staff, Facility C)

Staff interviews did note the longer the patient was hospitalized the longer it took to clean their room, as one EVS staff stated,

> "*Yeah, if you put on the CLC, I mean, those guys have been there for months, some of 'em years and those take a LONG time to clean*" (Facility C).

Environment

Table 9 lists the themes identified within the element of 'Environment' including room design, semi-private rooms and types of furniture and finishes. Room design was important where private rooms were reported to be easier to clean and semi-private rooms more difficult to clean. However, small rooms and private rooms with multiple medical equipment were also challenging:

> *"…they're all single rooms, and you do have area, you have elbow room. You have area to move around to make sure that you get behind the beds or behind stands and that type of thing, you know…"* (EVS Staff, Facility A)

> *"I mean you get two patient beds (…) big chairs (…) trying to get in there and work around everything, it's challenging…"* (EVS Manager, Facility C).

> *"*There [patient room] too small*…when they pack that room full of IV poles, monitoring equipment and other equipment, it just makes it next to impossible to get into that room, clean it in an efficient manner."* (EVS Manager, Facility B).

Furniture and surface finishes were important and could either be considered a barrier to cleaning or facilitate cleaning:

> *"…I think our bathrooms have tile and grout, which makes it [cleaning] tough…"* (Nurse Manager, Facility B)

"…We need to have high quality, easy to clean, easy to maintain equipment. (…) you cannot skimp on cost…" (EVS Manager, Facility B).

Patient

A total of fifteen patients (Male N=15, White N=15) were interviewed; eleven in acute care, three in post-acute care and one pilot interview who had previous acute care hospitalization. Several themes emerged during patient interviews which provide insight into potential barriers and facilitators of environmental cleaning and disinfection (**Table 10**).

Domain 1 – 3: Knowledge, Expectation, Experience

Overlapping themes were identified regarding patients' knowledge of environmental cleaning and disinfection in healthcare and their expectations and experience for room cleanliness while hospitalized. Themes focused on elements of cleaning and disinfection such as type of cleaning and disinfection agent, frequency of cleaning and disinfection, and thoroughness of cleaning and disinfection. Patients were aware that cleaning and disinfection agents used in healthcare were different than household cleaning agents and effective for sanitizing the healthcare environment. There was awareness that cleaning, and disinfection occurred on a regular and frequent (daily and sometimes more often) basis. There was also desire for cleaning and disinfection to be thorough so all surfaces the patient may encounter are sanitized, especially for frequently handled equipment or surfaces. As one interviewee said, "*Anywhere where I would have the possibility of interacting with germs should be cleaned*."

Domain 4: EVS Qualities

When asked "If you were in charge of hiring a new EVS staff member, what qualities you would look for?" patients overwhelmingly articulated a desire for responsible and detail-oriented workers who possessed interpersonal skills (**Figure 4**) with one interviewee indicating "*If they're personable and a good multi-tasker so they can talk and clean at the same time.*" Many patients felt being personable, meaning someone who is comfortable talking and connecting with patients, was a desirable attribute. There was also camaraderie between patients who are Veterans and EVS staff who were also noted to be Veterans.

Domain 5: Teamwork

We asked patients about their experience with others involved in keeping a room clean: other healthcare workers (e.g., clinicians), visitors, and the patients themselves. Patients spoke of a "leave no trace" attitude, meaning members of their healthcare teams would pick up after themselves after patient care activities. Veterans commented that staff generally cleaned up after themselves and would assist if patients happened to spill or drop something. One interviewee mentioned health care workers being so busy juggling myriad tasks, they do not have time to clean up, but this was the only comment of this kind we recorded in our project. Patients also overwhelmingly noted their desire to want to pick up after themselves, expressing feelings like "*I feel uncomfortable being waited on. I'm just not that type of person. I try to keep my independence here*." Another said, "*Even in instances when they were not physically able, I will use the grabber if I drop something myself*."

Patients were asked about visitors' roles in cleaning and disinfection, however, many Veterans indicated they did not have visitors and thus could not comment on these roles. This lack of visitation could be related to the distances Veterans and their families live from the medical center or it could have been limited due to the ongoing COVID-19 pandemic.

Domain 6: Barriers and Facilitators

Key themes of "patient present in room" and "room clutter" emerged within the domains of barriers and facilitators (**Figure 5**). Patients identified a major barrier to effective cleaning and disinfection was the patient being in the room during the cleaning and disinfection process. Patients perceived when a room is occupied, the EVS staff may feel uncomfortable being observed by a patient or they may feel that they do not want to bother the patient. Patients mentioned the EVS staff may rush through cleaning procedures to prevent disrupting or bothering the patient. One patient commented, "*They don't want to bother you. But yet they still got to do their job, so they just kind of possibly just rush through it*." To facilitate cleaning and disinfection, patients suggested planning cleaning and disinfection schedules around patients' appointments – for example, scheduling a daily room cleaning and disinfection while a patient is out of the room for a scheduled x-ray. One Veteran suggested, "*Plan your cleaning with planned appointments…come in and clean when the patient is gone, alleviate a lot of that."* Patients also observed clutter being a barrier for effective cleaning and disinfection – for example, patients' personal belongings or medical supplies and equipment which would require EVS staff to move or maneuver around these items to effectively clean and disinfect.

Domain 7: Benefits and Drawbacks

Patients reported a clean environment – accomplished by effective environmental cleaning and disinfection – was beneficial to not only their physical health, but also their mental well-being (**Figure 6**). Patients emphasized the importance of cleaning and disinfection in preventing infections. One patient exclaimed, "*My god, you're in a hospital. [Room cleaning and disinfection] decreases the possibility of infection*."

In addition, patients reported that having a clean environment reduces stress and, as a result, promotes healing. As one patient stated here: "*If the place isn't clean, then it's not going to promote healing, physically or mentally.*" Patients were asked about any drawbacks to environmental cleaning and disinfection; however, they did not report any drawbacks and instead emphasized the importance of cleaning and disinfection to their physical and mental well-being while hospitalized.

Domain 8 and 9: Room Monitoring and Patient Feedback

The interviews yielded limited information regarding experience of routine room monitoring for cleanliness or providing feedback to staff about environmental cleaning and disinfection issues, therefore no themes emerged. In general, patients approved of or were supportive of some type of cleaning and disinfection monitoring as this patient noted: "*I think somebody should be checking. Otherwise, I think the quality of any work goes down if the work isn't being checked frequently*." The consensus was patients felt comfortable and routinely reported environmental cleaning and disinfection issues to staff, particularly nursing staff; "*They were doing their job. And I was doing my job by telling them it was there."*

QUANTITATIVE PLUS QUALITATIVE

A joint display[67] of quantitative and qualitative results is provided in **Table 10**, specifically focusing on themes associated with higher and lower cleaning rates.

HTS, RME and especially bathrooms are targeted and prioritized during daily cleaning

Targeting HTSs emerged as a theme during our qualitative analysis, as one Nurse Manager stated, "*The areas that are frequently handled, (…) so the handrails, things to that effect, are often frequently touched and they need to have a super amount of attention*" (Facility A). Bathrooms were especially prioritized during daily cleaning as an EVS staff noted, "*Well,*

daily clean is I go through (…). I mean I don't get to wipe down everything in there. But I make sure that the bathroom is taken care of (…)" (Facility C).

Daily cleaning is easier when the patient is absent from the room

An emergent theme was that rooms was easier to clean when the patient was not present during daily cleaning. One EVS staff stated: "*The Community Living Center (CLC), that's who I do most of my dealing[s] with. (…) For patients that have been there for a while, I'll ask 'em [certified nursing assistant CNA] if I can um just freshen the bed or something before, they remake it, because they clean, or they change their beds daily. (…) the CNAs will typically allow me to have, you know, those few minutes, 'cause they usually do it when the patient's not in their room (…) I can do that kind of thing up in the CLC. Give the patient a little bit of freshness on their actual bed*" (Facility B).

Daily cleaning is harder when the patient is present in the room.

Likewise, an equally important theme arose indicating having the patient in the room during daily cleaning was harder for staff. One EVS manager noted, "*If the patient's in the bed, we kinda have to skip the entire bed (…) the bathroom will still get a thorough cleaning*" (Facility B). EVS staff may also perceive cleaning of these bedroom surfaces as being disruptive to patients supported by following staff quote, "*Now the daily [cleaning], sometimes you can do that and sometimes you can't because some patients don't want you in there [the room]*" (EVS staff, Facility C).

Daily cleaning is harder (more challenging) in semi-private rooms

Interviews revealed a theme that staff found semi-private rooms harder to clean as an EVS manager stated: "(…) *I mean, you get two patient beds in there and then you get the big chairs for visitors in there, and then trying to get in there and work around everything, it's challenging*

sometimes (…)" (Facility C). Healthcare workers also noted the challenges of semi-private rooms as one Nurse Manager described the perceived infection risks for these types of rooms: "*Double rooms, obviously, is a huge challenge. It's a huge infection control challenge (…) we don't have enough staff EVS-wise [EVS staff] to clean the bathrooms after each person uses 'em*" (Facility B).

Various methods used to monitor the environmental cleaning process

Healthcare workers also described variation in how environmental cleaning was monitored across the three facilities. Use of fluorescence gel marking (FGM) for monitoring the cleaning process was referenced frequently as one Nurse Manager describes: "…*I know that housekeeping will come through and swab and light and do some checks and things like that. I've never seen them do that down here [in the CLC]. I've only heard of them doing it on the [AC] floor, or at their infection control meetings*." (Facility A) and an EVS manager said: "*So we do observations. We do fluorescent marking*." (Facility B). Participants also referenced various other methods for monitoring room cleaning, including: 1. Rounding: "*I do environment of care rounds to see if things are, you know, to see if there's issues (…) if things are dirty or not being cleaned*…" (Nurse Manager, Facility B); 2. Direct Observation: "*The trainer will come up and watch you once in a while.*" (EVS staff, Facility B); 3. Checklists: "*Well, they come by, and they have a checklist, and they always find something.*" (EVS staff, Facility C); or 4. Informal: "(…) *they [EVS staff] know that if I'm unhappy with something, I'm going to call [EVS department]. (…) So, it's like, 'You don't have to worry about that area, because if she [Nurse Manager] doesn't like something, she's going to let you know'*" (Nurse Manager, Facility A). Some respondents also noted their uncertainty regarding whether cleaning performance was routinely monitored, "*I guess [we monitor] by each other. We don't have one particular person*

that monitors." (Nurse, Facility A). And others questioned the consistency of monitoring methods: "*If you're asking, are they [EVS staff] monitored by the supervisory staff-- not consistently*…" (Nurse Manager, Facility A) and an EVS manager stated: "*So, it's [FGM] at the employee-level, so it's used as a training method*" (Facility B).

Table 1 Observation: Descriptive characteristics of environmental cleaning by room observation (N=62)

	AC N = 35 (%)	**LTC N = 27 (%)**	**Total N = 62 (%) *** *****Missing data not reported
Facility			
▪ A	5 (14%)	13 (48%)	18 (29%)
▪ B	6 (17%)	14 (52%)	20 (32%)
▪ C	24(69%)		24 (39%)
Isolation Precaution			
▪ Yes	2 (6%)	5 (19%)	7 (11%)
Type of room			
▪ Single Bed (private room)	28 (80%)	19 (70%)	47 (76%)
▪ Multi-Bed (semi-private room)	7 (20%)	8 (30%)	15 (24%)
Surface area			
▪ 1=>75%	23 (66%)	0 (0%)	23 (37%)
▪ 2=25-75%	10 (29%)	25 (93%)	35 (56%)
▪ 3=<25%	0 (0%)	1 (4%)	1 (2%)
Surface friction**			
▪ 1=>3 wipes	0 (0%)	6 (22%)	6 (10%)
▪ 2=2-3 wipes	33 (94%)	20 (74%)	53 (85%)
▪ 3=<2 wipes	0 (0%)	0 (0%)	0 (0%)
**Note: friction refers to 'back and forth' motion			
Surface wetness			
▪ 1=saturated	1 (3%)	0 (0%)	1 (2%)
▪ 2=wet/damp	34 (97%)	27 (100%)	61 (98%)
▪ 3=dry	0 (0%)	0 (0%)	0 (0%)
Patient in room			
• Yes	33 (94%)	13 (48%)	46 (74%)
• No	2 (6%)	14 (52%)	16 (26%)
Healthcare worker in room			
• Yes	14 (40%)	5 (18%)	19 (31%)
• No	21 (60%)	22 (82%)	43 (69%)
Visitor in room			
• Yes	5 (14%)	2 (8%)	7 (11%)
• No	28 (80%)	22 (81%)	50 (81%)
Interruptions (while cleaning)			
• Yes	7 (20%)	4 (15%)	11 (18%)
• No	26 (74%)	23 (85%)	49 (79%)
Surface clutter removed			
▪ Yes	2 (6%)	12 (44%)	14 (23%)
▪ No	26 (74%)	15 (56%)	41 (66%)
Disinfectant application method			
• Spray bottle	4 (11%)	8 (30%)	12 (19%)

• Wet cloth	29 (83%)	18 (67%)	47 (76%)
Number of cleaning wipes used • > 3 • 2-3 • 0-1	 5 (14%) 18 (51%) 10 (29%)	 5 (19%) 7 (26%) 14 (52%)	 10 (16%) 25 (40%) 24 (39%)
Mop method • Dry • Wet	 1 (3%) 30 (86%)	 2 (7%) 24 (89%)	 3 (5%) 54 (87%)
Mop material • Reusable cotton • Microfiber • Disposable synthetic	 23 (66%) 10 (29%) 0 (0%)	 0 (0%) 27 (100%) 0 (0%)	 23 (37%) 37 (60%) 0 (0%)
Cleaning wipe material • Reusable cotton • Microfiber • Disposable synthetic	 0 (0%) 10 (29%) 0 (0%)	 0 (0%) 27 (100%) 0 (0%)	 0 (0%) 37 (60%) 0 (0%)
Bedroom disinfectant • Quaternary ammonium • Sodium hypochlorite	 33 (94%) 0 (0%)	 27 (100%) 0 (0%)	 60 (97%) 0 (0%)
Bathroom disinfectant • Quaternary ammonium • Sodium hypochlorite • Quaternary plus Bleach	 29 (83%) 1 (3%) 3 (9%)	 21 (78%) 0 (0%) 6 (22%)	 50 (81%) 1 (2%) 9 (15%)
Hand Hygiene upon room entry • Yes • No	 14 (20%) 21 (80%)	 12 (44%) 15 (56%)	 26 (42%) 36 (58%)
PPE (glove and/or gown) • Yes • No	 10 (29%) 25 (71%)	 27 (100%) 0 (0%)	 37 (60%) 25 (40%)
	AC Mean (SD)	**LTC Mean (SD)**	**Total Mean (SD)**
Cleaning duration (minutes)	9.63 (3.40)	13.63 (3.40)	11.37 (3.90)

Table 2 Observation: Frequency of environmental surface cleaning rates by surface observation (N=3602)

	AC Mean (SD)	**LTC Mean (SD)**	**Total Mean (SD)**
Cleaning rates – all surfaces	0.27 (0.09)	0.42 (0.11)	33.69 (1.26)
Cleaning rates – HTSs	0.69 (0.12)	0.49 (0.14)	60.17 (1.63)
Surface	**AC N = 1571 (%)**	**LTC N = 1212 (%)**	**Total N = 2783 (%)**
Bedroom			
Bed controls	-	0.15	0.06
Bed frame	-	-	-
Head/foot boards	-	0.19	0.08
Bed rails	-	0.07	0.03
Bedside table	0.09	0.19	0.13
Built-in cabinets	0.29	0.67	0.45

Call button	-	0.04	0.02
Chair	-	0.48	0.21
Privacy curtain	-	-	-
Doorknob	0.34	0.96	0.61
Dresser	-	0.36	0.16
Light fixture	0.11	0.04	0.08
Floor	0.89	0.93	0.90
Light switch	0.09	0.48	0.26
Mattress	-	-	-
Medical gas	-	-	-
Pillow	-	-	-
Remote control	-	0.15	0.06
Sharps container	0.66	0.89	0.76
Sink & fixtures	0.85	0.89	0.87
Soap dispenser	0.23	0.89	0.52
Telephone	-	0.19	0.08
Television & housing	-	0.31	0.13
Tray table	0.20	0.52	0.34
Vents	-	0.41	0.18
Waste basket	0.03	0.37	0.18
Other	0.70	1.00	0.79
Bathroom			
Doorknob	0.46	0.93	0.66
Emergency pull cord	0.03	0.38	0.19
Floor	0.83	0.78	0.81
Handrails by toilet	0.89	0.81	0.85
Light switch	0.18	0.37	0.26
Mirrors	0.36	0.35	0.35
Shelves/ledges	0.30	0.44	0.37
Sink & fixtures	0.81	0.78	0.79
Shower floor	0.59	0.42	0.51
Shower curtain	-	-	-
Shower stall & fixtures	0.48	0.63	0.55
Shower walls	0.04	-	0.02
Soap dispensers	0.39	0.59	0.49
Toilet bedpan cleaner	0.83	-	0.76
Toilet flush handle	0.97	0.74	0.87
Toilet seat	0.94	0.85	0.90
Waste basket	0.03	0.33	0.17
Reusable Medical Equipment			
Bedpan, urinal	-	-	-
Commode	0.50	0.75	0.65
IV pole	0.07	0.55	0.20
Lift	-	-	-
Shower chair	0.46	0.53	0.49
Transfer belt	-	-	-

Walker	-	-	-
Wheelchair	-	-	-
Other	0.86	0.60	0.79

Table 3 Observation: Regression analysis evaluating effects of cleaning practices on cleaning rates using surface observations (N = 3602)

	Surfaces in AC N = 1571 OR (95% CI)	Surfaces in LTC N = 1212 OR (95% CI)	All Surfaces N = 2783 OR (95% CI)	All Surfaces Stratified by patient in room OR (95% CI)	
				Yes (N=2066)	**No (N=717)**
HTS (Y/N)	1.37 (1.07, 1.75)	1.78 (1.39, 2.28)	1.57 (1.32, 1.86)	1.51 (1.23, 1.86)	1.71 (1.24, 2.36)
Bathroom vs bedroom surface	5.17 (4.01, 6.67)	2.03 (1.58, 2.60)	3.23 (2.70, 3.85)	3.96 (3.20, 4.89)	1.97 (1.42, 2.74)
RME vs bedroom surface	1.99 (1.27, 3.13)	0.99 (0.60, 1.63)	1.40 (2.70, 3.85)	1.59 (1.07, 2.35)	1.063 (0.56, 2.01)
Multi-bed (semi-private) vs single-bed room (private)	2.57 (1.02, 6.49)	0.68 (0.43, 1.07)	0.71 (0.53, 0.97)	0.73 (0.49, 1.07)	0.26 (0.07, 0.93)
AC vs LTC	_	_	0.56 (0.42, 0.75)	0.52 (0.35, 0.78)	0.63 (0.30, 1.32)
Cleaning wipe utilization (≥ 2 vs ≤ 1)	2.00 (0.77, 5.16)	0.91 (0.66, 1.24)	0.68 (0.52, 0.88)	0.63 (0.44, 0.92)	0.88 (0.49, 1.57)
Surface wetness (saturated vs wet/damp)	4.71 (1.86, 11.96)	0.77 (0.50, 1.18)	1.07 (0.78, 1.47)	1.07 (0.71, 1.62)	0.95 (0.51, 1.77)
Surface wetness (dry vs wet/damp)	0.51 (0.23, 1.17)	NA	0.91 (0.46, 1.80)	0.91 (0.45, 1.85)	NA

Table 4 Observation: Summary statistics of actual observed cleaning rates, sampling error, and percentage of rooms with sampling error $\leq$ 10% and 5% using surface observations; **All Surfaces** and **High-touch Surfaces (HTS)**

	Actual Cleaning Rates	Sample Error		% with sampling error	% with sampling error
	Mean (SD)	Mean	SD	$\leq$ 10%	$\leq$ 5%
number of rooms needed to be observed to meet or exceed the mean cleaning rate threshold					
All Surfaces (N=2783)					
20 rooms		0.0153	0.0116	92	62.8
25 rooms	0.337	0.0128	0.0096	96.6	71.1
30 rooms	(0.126)	0.0099	0.0078	98.9	82.4
35 rooms		0.0086	0.0066	99.8	88.3
40 rooms		0.0062	0.0047	100	97.3
45 rooms		0.0042	0.0032	100	100
HTS (N=1029)					
20 rooms		0.0224	0.0175	84.7	54.4
25 rooms	0.602	0.0208	0.0151	88.7	54.8
30 rooms	(0.163)	0.0162	0.012	95.1	67.6
35 rooms		0.0147	0.0104	97.9	71.1

40 rooms		0.0123	0.0088	99.8	79.6
45 rooms		0.0104	0.0064	100	91.8

Table 5 HCW Interviews: Themes and Quotes within the 'Organization' Element

SEIPS element	Barriers and Facilitators	Theme	Quotes
Organization	Barriers	Communication	*"…and that's [patient room transfer] really what takes communication and coordination 'cause if you just blindly do what the nurses say and don't say [cleaning is less efficient]'…"* (**EVS Manager, Facility B).**
		Education/Training	*"…So, we have a lot of other cleaners and stuff [disinfectants and chemicals] and that's why I was commenting about the educational piece…"* (**EVS Manager, Facility B).**
		Organizational Culture and Leadership	*"You can bring it up [raise concerns]. It can fall on deaf ears."* (**EVS Staff, Facility B).**
		Teamwork	*"…The ones who stay in an area for a period of time, I think the staff values 'em more and they kinda take 'em on as part of the team, but because of the rotation business, they don't always have that, and so, I think the value is lost then."* (**Infection Preventionist, Facility A).**
		Staffing Challenges	*"I think they're continually going through recruitment and then turnover (…) and it primarily was opened only to Veterans…"* (**Infection Preventionist, Facility C).**
		Value	*"For one thing, we're, besides being in the lowest pay grade in the wage grade series, your supervisors pretty much don't respect you…"* (**EVS Staff, Facility B).**
Organization	Facilitators	Communication	"…we have new call light system out here where we'll put a room dirty light up so that they'll know the room is dirty (…) once the room is cleaned, the EMS person will turn the light off and go put a clean sticker on the door…So, it's a nice system." (**Nurse Manager, Facility B).**
		Education/Training	*"…They will call the housekeepers to meet up in a certain room to physically give us a demo, have one person visibly giving 'em--, us a demonstration, a hands-on like virtual, visual demonstration on how something's to be cleaned. That's what works best for me…"* (**EVS Staff, Facility A).**
		Organizational Culture and Leadership	*"We have regular monthly forums. Guys are at any time, more than welcome to make suggestions so, then he opens the floor at the end and then we have open door policy (…), you can walk in at any time and then tell us if there's a problem."* (**EVS Manager, Facility A).** *"The EMS management, myself, and others, we maintain frequent communication with the Pentad, and*

			that really brings us to the table…" (**EVS Manager, Facility B).**
		Teamwork	*"…There are places that really value their housekeeper and they take care of them, and I think those are the units that you find that they are the cleanest. When they [EVS] think they're part of the [unit] team then they work 'cause this is their home, their stomping ground, and I'll take care of it."* (**Infection Preventionist, Facility A).**
		Staffing	*See text*
		Value/Recognition	*"I think the recognition. A sense of a job well accomplished. A lot of staff will take ownership of an area and bring it up to their level (…) and then a continued driving motivation is just a word of praise here or there."* (**EVS Manager, Facility B).**

Table 6 HCW Interviews: Themes and Quotes within the 'Person' Element

Element	Barriers and Facilitators	Theme	Quotes
Person	Barriers	Patient disturbance	*See text*
		Knowledge/Experience	*"…But with the high turnover, I can't keep 'em in the one or two areas that they were trained in…"* (**EVS Manager, Facility B).**
Person	Facilitators	Serving patients and preventing infections	*"(…) I love being around the Vets, and sometimes you get to know the Vets. You build bonds, like the ones who have been here."* (**EVS Staff, Facility A).**
		Knowledge/Experience	*"We have all the tools we need to clean any kind of surface, just need to utilize the right cleaner."* (**EVS Staff, Facility A).**

Table 7 HCW Interviews: Themes and Quotes within the 'Tools/Technology' Element

Element	Barriers and Facilitators	Theme	Quotes
Tools and Technology	Barriers	Lack of bed management systems	*"They have no bed boards, no none of that and half the time they don't have an MSA so you gotta rely on the nurses and a lotta times it just, I mean, they're busy down there, but not always staffed right…"* (**EVS Staff, Facility A).**
		Cleaning audits not standardized	*"…but we monitor those monthly through Infection Control Committee. We look (…) for those high-touch areas to make sure they're being terminally cleaned through a fluorescent gel process."* (**Infection Preventionist, Facility A).**
		Supply availability	*"…logistics has been an issue since I've been here and it's just sometimes like, how many hours*

			I have to spend out of my work week, going to other areas and pilfering for basic supplies…" (**EVS Staff, Facility A).**
Tools and Technology	Facilitators	Checklists	*"…So, when we get new employees that we don't have time to hold their hand and go through every area, the minimal, the least we can do is print this, print this sheet out, this ward routine…"* (**EVS Manager, Facility B).**
		New technology and equipment	*"…The way they dilute their product, it is really a no-brainer. You walk over to the sink, you put the hose in your bucket, you hit the one button that says the soap, and turn on the water and it will mix it exactly at the right concentration…"* (**Infection Preventionist, Facility A).**

Table 8 HCW Interviews: Themes and Quotes within the 'Task' Element

Element	Barriers and Facilitators	Theme	Quotes
Tasks	Barriers	Patient movement	*"So, that [communication] we do very poorly here. We don't have a bed board, so it is face-to-face communication (…) we have to do what we call bed bingo because somebody has just had an infection and we have to move this one [patient], that one…"* (**EVS Manager, Facility A).** *"And it sometimes, it's a long series of chain reaction, so in order to get that one guy [patient] in front of the nurses' station (…) They're domino moves, and it compounds and multiplies the work on the housekeeper and it's really a stressor…"* (**EVS Manager, Facility B).**
		Patient presence	*"Well, it all depends. If they got the blankets all hanging down, you really can't pull their blankets up and get to the side rails..."* (**EVS Manager, Facility C).**
		RME complex and not standardized	*"You take the IV pumps and I put 'em in the dirty room over there. The nurses are supposed to do that, but sometimes they don't…"* (**EVS Staff, Facility C).** *"…But then the Alaris IV pumps we actually have to carry a bottle of isopropyl alcohol on our cart with a clean brush like a toothbrush almost, to clean the electrical diodes on the um IV pump…"* (**EVS Manager, Facility B).**
Tasks	Facilitators	High-touch surfaces prioritized	*"…We strictly do the low level, which would be the blood pressure cuff, beds, anything that would need to be touched…"* (**Nurse Manager, Facility A).**

		Patient absence	*"…if the patient's in the bed, we kinda have to skip the entire bed. If he's sitting in the chair next to the bed, it gives us an opportunity to handrails and stuff like that. The bathroom will still get a thorough cleaning…"* (**EVS Manager, Facility B).**

Table 9 HCW Interviews: Themes and Quotes within the 'Environment' Element

Element	Barriers and Facilitators	Theme	Quotes
Environment	Barriers	Design of room	*"…If you put a couple of things in that room and that's full. You really can't get in that room to wipe anything down, without moving half of that stuff (…) that's a big obstacle."* (**EVS Staff, Facility B).**
		Furniture and finishes	*"The tiles in the bathroom...I can mop a couple times, but sometimes they'll just like the surface, they just come back ten minutes later, and it doesn't even look like I mopped…"* (**EVS Staff, Facility A).** *"…Like um our infusion center, it's absolutely beautiful but the chairs that they picked are horrible to clean…"* (**Infection Preventionist, Facility A).**
		Semi-private rooms and shared bathrooms	*"…Pretty much every room is done the same and just, if there's a second person in there, it gives more apt for things to get missed…"* (**EVS Staff, Facility A).**
Environment	Facilitators	Design of room	*"Yes, especially the double patient, double-bedded rooms. It, our rooms, are NOT big enough."* (**EVS Manager, Facility C).**
		Furniture and finishes	*"…We had made a concerted effort to remove all of that high-labor type material from the facility and replace it with something that's easier to maintain and clean…"* (**EVS Manager, Facility B).**

Table 10 Patient Interviews: Visual Display of Domains, Themes and Quotes

Domain	**Theme**	**Quotes**
Knowledge, Expectation and Experience	Clean/Disinfection (cleaning and disinfection agent, frequency, thoroughness)	*"I don't know what they [EVS] use. I assume it's hospital quality, which I don't know what that means."* *"Wiping down stuff with alcohol and doing stuff like that . . .twice a day. "*

		"They're a little more thorough now with the [SARS-CoV-2] virus."
EVS Qualities	Responsible, Interpersonal and Camaraderie	*"I could tell you 50 people I have a lot of respect for but would never hire for a cleaning job. It's something you have to take seriously, especially now in the pandemic."* "Having some conversation with the patient makes the journey a little more comfortable on both ends." *"They seem to hire a lot of Veterans… you can actually bond with one old soldier to one younger soldier."* "*During my time in Service … it was, we're all brothers. We're in this together. Let's work like a team. And in our lives, we are all in this together. We're all a team, and we work together*."
Teamwork	"Leave no trace"	*"When I was in the hospital, they [providers and nurses] always kind of did pick up after themselves. That's their way of helping, I think."* *"So, I kind of keep my room in order… Because they're busy, and they've got, you know, I was just raised that way."* "*Well, I try to keep all my personal stuff, if I come here, I'll have either a backpack or an arm bag, and make sure all that is always attended to and put out of the way.*"
Barriers/Facilitators	Occupied room – Barrier Unoccupied room – Facilitator	*"They may feel that they don't want to be a bother to you, you know, that much of an inconvenience and so, they kind of hurry."* *"I'd say I have a feeling that if I wouldn't have been in the room, they'd do a better job."* *"It's easier for them if there isn't a patient in [the room] …it's hard to do any endeavor when you've got a complete stranger watching you."* *"If you want to do like a more patient-centered care, it might include the cleaning crew into it, say I'm scheduled for an x-ray, I come back from my x-ray and then the room is all clean and done."*

	Clutter – Barrier Declutter – Facilitator	*"Probably the gear you might have around, and I'm certain that they have to go around it and maybe move it or something."* *"Get it out of the way so they can sweep and mop and all that stuff underneath."*
Benefits/Drawbacks	Physical well-being	"*Oh, it [room cleaning and disinfection] keeps me healthy…so the cleaner the room, the less chance of something we didn't bring with us*."
	Mental well-being	"*I think having a clean room, a clean environment, gives a patient more rest, more freedom to think… I would say less stress in their body*."

Figure 4 Patient Interviews: Themes for the EVS Qualities Domain

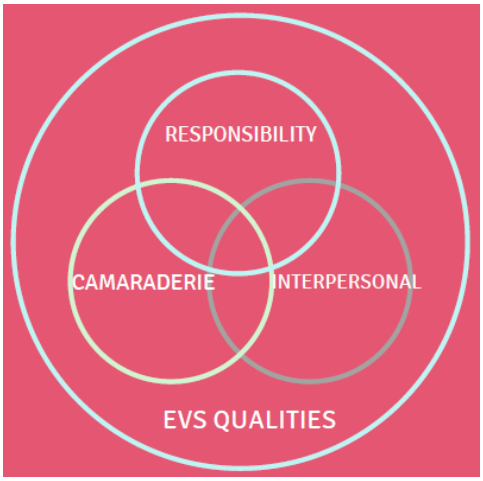


Figure 5 Patient Interviews: Themes for Barrier and Facilitator Domain

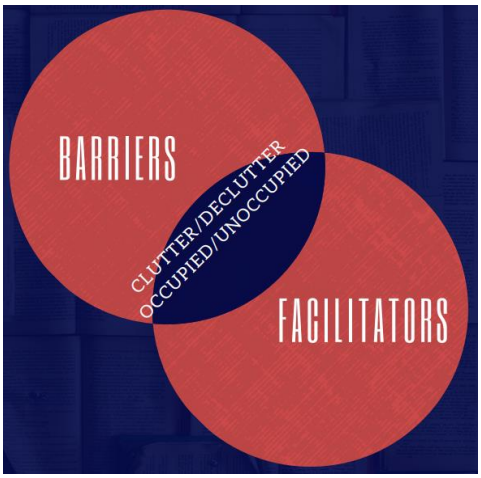


Figure 6 Patient Interviews: Themes for Benefit and Drawback Domain

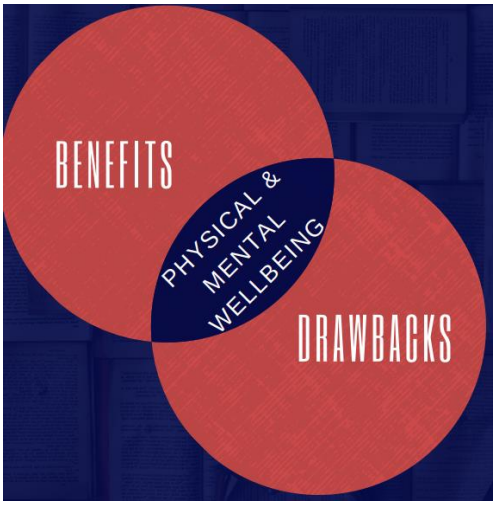


Table 11 Visual Joint Display Data Integration: Cleaning Observations (N=62) and Healthcare Worker Interviews (N=18)

Observation Variable (Quantitative)	**Findings**	**Interview Themes (Qualitative)**	**Quotes**
- HTS - Bathroom Surfaces - RME Surfaces	Higher Cleaning Rates	HTS, RME and especially bathrooms are targeted and prioritized during daily cleaning.	"The patients are always very glad to see me mopping the floors on a regular basis, cleaning the sinks, cleaning the high-touch areas (…)" (**EVS Staff, Facility A).** "We strictly do the low level, which would be the blood pressure cuff, beds, anything that would need to be touched (…)" (**Nurse Manager, Facility A).** "But day shift, their primary task is doing their daily cleanings. And they go through, they're supposed to hit the bathroom, high-touch areas." (**EVS Staff, Facility A).** "But all your high-touch is, you know, like your bathrooms, you know, sinks, knobs, toilet, flush handle, stuff, the handrails that's in the bathrooms (…) it's all that different stuff is considered a high-touch where the patients are constantly touching 'em." (**EVS Manager, Facility C).** "(…) another high-touch area is the toilet, toilet seat and the railing and the flushing handle behind that and the sink in the bathroom." (**EVS Staff, Facility A).**

- Patient not in room	Higher Cleaning Rates	Daily cleaning is easier when the patient is absent from the room.	"If he's [patient] sitting in the chair next to the bed, it gives us [EVS staff] an opportunity to do handrails and stuff like that." (**EVS Manager, Facility B).** "If they [patient] got the blankets all hanging down, you really can't pull their blankets up and get to the side rails. You know, the beds are REALLY gone through as when the patient's gone." (**EVS Manager, Facility C).**
- Patient in room	Lower Cleaning Rates	Daily cleaning is harder when the patient is present in the room.	"…that's [an] example [HTS], remote controls, although we don't really take that out of the patient's hand to clean that." (**EVS Staff, Facility B).** "The over-the-bed table, that normally doesn't get done 'cause it's piled high with patient belongings (…)" (**EVS Manager, Facility B).** "But, as far as the patient bed, you know, it's, while they're in it, it's kinda hard. You know?" (**EVS Manager, Facility C).**
- Semi-private patient rooms	Lower Cleaning Rates	Daily cleaning is harder in semi-private rooms.	"Shared bathrooms are just, I mean, I think that can be very problematic, even cleaning when… it's a two-person room. Trying to get in there and (…) there's a person in the bed and there might be a curtain, trying to take care of that and take care of the bathroom while there's still a patient (…)" (**EVS Staff, Facility A).**

CHAPTER 7. DISCUSSION AND CONCLUSION

DISCUSSION

Predictors of environmental cleaning rates

The overall cleaning rates during daily environmental cleaning and disinfection were low in acute and LTC settings within VA facilities. These cleaning rates were calculated using direct observation, which may be adversely affected and overestimate the rates due to the Hawthorne effect which inflates compliance rates when an observer is present.[81] However, cleaning of surfaces classified as 'high-touch' was significantly higher, which is similar to other published reports.[82 45]

To improve environmental cleaning, emphasis has been placed upon and guidance has been provided to prioritize cleaning of environmental surfaces in healthcare settings that have frequent hand contact – HTS.[24, 42, 83-86] This focus on HTSs has likely influenced facility policies, staff training and room monitoring and could explain the higher cleaning rates of HTSs observed in this study.

In addition to having observed overall low cleaning rates, the definition of cleaning used for the study was generously applied to include any surface that was attempted to be wiped with a disinfectant. To characterize the cleaning process, we observed specific cleaning processes to understand the extent of disinfectant application. We found that less than half of observations had disinfectant applied to an area greater than 75%, with most observations having only 2 – 3 swipes (back-and-forth motion) reported. Although guidance is given for the type of disinfectant to use on environmental surfaces and how long a disinfectant should remain on a surface for adequate disinfection (i.e., contact time),[87] little guidance is given to the characteristics of cleaning such as the amount of friction applied, amount of surface area or number of wipes. In 2018, a European Healthcare Cleaning Forum was held in which they defined five variables to be considered when performing environmental cleaning, including capable workforce, surface area

considerations, chemical disinfectant used, cleaning technique and equipment; however, cleaning technique was not defined.[88] A recent study evaluating a multi-modal environmental cleaning bundle included 'cleaning technique' as one of the bundle components that resulted in a significant improvement in cleaning performance.[89] Cleaning technique was defined as a physical process of cleaning including sequence, pressure and movement but the authors did not define these characteristics or measure staff compliance with these specific physical cleaning practices. We observed that cleaning wipes were changed more than once in at least half of the observations, but the remaining observations showed that cleaning wipes were changed once or never. Rutala and Weber (2019) recently outlined best practices for disinfection of environmental surfaces in healthcare and recommended using at least three cloths per room with up to 5 – 7 cloths as a typical number of cloths or wipes to be used.[45] Characteristics of these cleaning techniques need to be described and evaluated for meaningful translation into practice.

Use of a mixed methods design provided the opportunity to guide data analysis leading to an important study finding that patient presence in the room during daily cleaning impacts cleaning rates. Initial analysis of observations found cleaning rates were significantly lower in AC compared to LTC, but these data were difficult to interpret. Based on the emergence of the themes derived from interviews (i.e., rooms with patient presence are harder to clean and rooms without patient presence are easier to clean), data stratification by patient presence was added to the analysis. Once data were stratified by patient presence (i.e., present, or absent) in the room during daily cleaning, we found higher cleaning rates when the patient was not present in the room for daily cleaning. Since patients were present during cleaning in almost all observations in AC, a possible explanation for lower cleaning rates in AC is provided. The data stratification by patient presence allowed us to quantify previously reported themes in qualitative studies that

found HTSs in close proximity to the patient are more likely to be missed than other environmental surfaces[90] and EVS staff may avoid cleaning near patients so as not to disturb them.[91]

Our study found cleaning rates were significantly lower in semi-private patient rooms; semi-private rooms were observed in both AC and LTC units. A recent meta-analysis found significant benefit of private rooms for reducing HAIs and colonization.[92] Stiller et al. identified a relationship between higher square footage and HAIs, noting that there is more potential for surface contamination and higher likelihood of inadequate cleaning. Private patient rooms have been found to be easier to clean after discharge in comparison to larger and more heavily equipped (and occupied) semi-private patient rooms.[7, 92] Semi-private rooms were a key barrier identified in qualitative interviews with healthcare workers, supporting these quantitative findings.

Others have found clutter to be a barrier to cleaning,[50] especially in LTC,[93, 94] so our observations attempted to quantify whether clutter was removed prior to cleaning. Although our study did not find removal of clutter as an independent predictor for cleaning rates, the lack of removing clutter prior to cleaning was high in both settings. Staff interviews did note the longer the patient was hospitalized the longer it took to clean their room. Longer cleaning times were observed in LTC and this extra time may be due to having time to accumulate personal belongings (i.e., clutter) in this setting.

Our study found that FGM and direct observations were frequently cited as methods of monitoring (i.e., audit and feedback) environmental cleaning, although with various methodologies and consistency. Audit and feedback of healthcare practices is evidence-based and used commonly to improve care.[95] Monitoring of environmental cleaning has become a

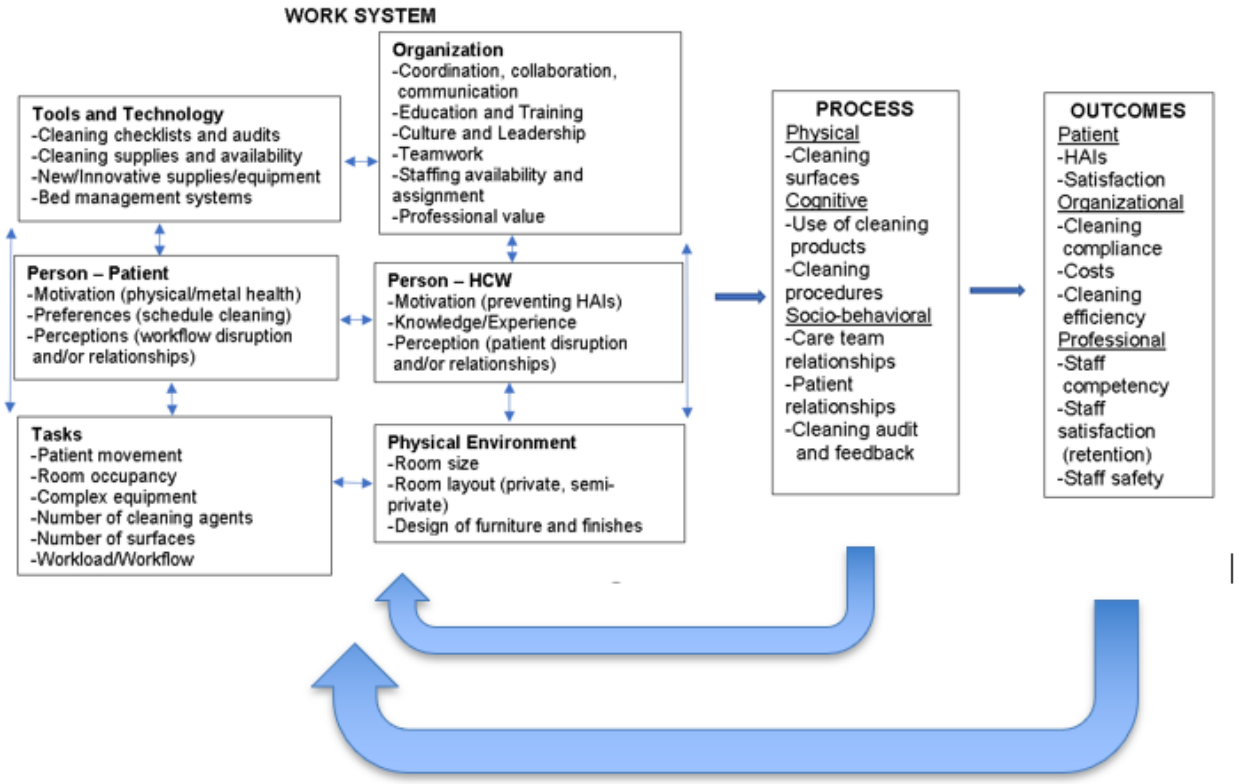
cornerstone of environmental cleaning programs. In addition, environmental cleaning monitoring is recommended in professional[41] and regulatory[96] guidelines. Monitoring of environmental cleaning can be done via microbial, non-microbial and visual observation.[41] Direct visual monitoring of cleaning practices can be achieved by assessing the amount of visual surface soiling that remains after a surface is cleaned or by a standardized evaluation of the cleaning process.[97] The accuracy of direct visual observation has been questioned[46] but most healthcare organizations in both national and international settings perform monitoring using direct observation.[97, 98] Direct observation provides an opportunity to assess the cleaning process, as opposed to being limited to surface 'cleanliness.'[99] The cost effectiveness benefits of visual inspection make it a preferred method for many healthcare facilities.[46, 100]

Our study provides an estimate for the number of observations, 20 rooms with 10% error, needed for accurately predicting cleaning rates of 60.2% for 'HTS'. Other recommendations have similar estimates; approximately 10-15 rooms with 20% error for less than 80% cleaning rate.[41, 97] Estimates using sampling error have been suggested for optimal environmental cleaning monitoring via FGM systems.[101, 102]

Work System Analysis

Our study identified important elements of the work system which could be barriers or facilitators to environmental cleaning within VA healthcare facilities. Based on these findings, we developed an adapted SEIPS model outlining essential work system components for environmental cleaning (**Figure 7**). One notable finding was the EVS staff, many of whom are

Figure 7. SEIPS 2.0 Model Adapted for Environmental Cleaning



Veterans were especially motivated to serve the Veteran population. They perceived their role to be critical in preventing infections, but they did not always perceive that the organization values them professionally. This is specifically related to being in an entry-level position with low pay. Similar results in feeling critical for patient outcomes yet not valued within the organization have been reported.[103] The authors previously reported findings from interviews with hospitalized Veterans and found many reported enjoying having fellow Veterans EVS staff to converse with and even had feelings of bonding and camaraderie, which may promote a healing environment.[104]

A central theme was the various staffing challenges reported by stakeholders. Hiring policies within the VA, particularly when hiring EVS staff, are legislated and beyond the scope of this manuscript. However, one VA reported a potentially real-world solution to EVS staff retention by attempting to transform the position from an entry-level to technician position

through certification; Certified Health Care Environmental Services Technician (CHEST). Peters et al.[88] reported findings from a conference with leading healthcare environmental scientist calling for investment within the EVS workforce: "They [healthcare organizations] must realize that being a hospital 'cleaner' is not a job but a profession…" The nursing profession has identified that the role of specialty certification is associated with improved patient outcomes, including reduced HAIs.[105] There is also evidence that infection preventionists' attainment of Infection Prevention and Control (CIC) certification is associated with improved care processes and HAI outcomes.[106, 107] Certification requirements can be used to reclassify VA positions to higher pay grades which may in-turn address professional value and retention and ultimately improve care and outcomes.

Stakeholders described that having consistent staffing assignments improved many aspects of the work system including communication, accountability, performance, and teamwork. Consistent assignment is a staffing model used in nursing homes to improve resident outcomes and while the evidence is varied, further study is warranted.[108, 109] Education and training of EVS staff was a key facilitator identified by stakeholders. Various methods were implemented to address staff training needs including interactive hands-on (or simulation) training, on-the-job training (peer coaching and train-the-trainer), and on-line computerized courses. Many respondents believed simulation training was extremely effective; the authors have reported these findings separately.[110]

Communication emerged as a challenge within the work system. Notification of EVS for room cleaning during admissions, transfers, and discharges (i.e., patient flow) was especially challenging. Although there were various communication methods used (e.g., nursing boards, light systems, phone calls or pagers, signs, etc.) many staff agreed that implementation of an

automated bed management system (BMS) could facilitate this process. Delays in patient flow can lead to poor patient outcomes and automated BMS have been found to improve patient throughput.[111]

Audit and feedback of environmental cleaning is a mainstay recommendation for infection prevention and control programs.[41] Most stakeholders reported some type of audit and feedback process, but it was highly variable in method and consistency. Audit and feedback of healthcare processes is associated with improvements in practice[95] and efforts to standardize this practice is critical.

An important theme was the concern that having a patient in the room during cleaning may be interpreted by staff as burdensome to patients. With patients in the room, staff may feel unnecessarily rushed, leading to hastened and less thorough cleaning. Previous qualitative studies have found staff reporting barriers to cleaning near patients to avoid disturbing them.[91] EVS staff also felt it was more difficult to do daily cleaning when someone was in the bed. The authors previously reported that cleaning surfaces were less likely to be cleaned when the patient was in the room during daily cleaning.[112] The VA has national guidance for environmental cleaning procedures, which includes a procedure for daily cleaning of occupied rooms.[37] However, detail is lacking on how to optimize cleaning around clutter, cleaning around the patient or cleaning in semi-private rooms. These may be opportunities for entry points for intervention such as simulation-based competency assessments.[113]

EVS staff were acutely aware of the barriers and facilitators of environmental cleaning within the context of the physical environment. EVS staff should be involved in the selection of healthcare furniture and finishes as well as in healthcare design (or redesign) of patient care areas

to ensure environmental cleaning is optimized. EVS involvement in healthcare design has been previously recommended.[93]

Patient Perspectives

The VA has prioritized patient satisfaction and routinely evaluates this through the VA Survey of Healthcare Experiences of Patients (SHEP).[114] However, SHEP focuses on the patient's perception of overall cleanliness, rather than on specific cleaning and disinfection processes or on patients' interactions with EVS personnel as we have evaluated here. Thus, our qualitative interviews provide a unique insight into the patient's perspective on environmental cleaning and disinfection and patient safety and well-being during their healthcare stay.

An important observation from the patient perspective was the concern that being in the room (or bed) during cleaning and disinfection activities may be interpreted by staff as being burdensome to patients and therefore staff may be unnecessarily rushed leading to hastened and less thorough cleaning and disinfection tasks. Our study corroborates previous qualitative studies reporting similar perceived barriers to cleaning and disinfection near patients to avoid disturbing them.[91]

Patients also described potential meaningful interventions that may lead to improved patient comfort and cleaning and disinfection effectiveness. Patients described options for having daily room cleaning and disinfection occur when they are outside of the room – for example, for scheduled imaging services – and reported their perception that this would be more comfortable for both the patients as well as the EVS staff performing the cleaning and disinfection.

Another surprising insight was the description of qualities of EVS staff important to patients. Patients expressed confidence in EVS staff's skilled work and noted "soft skills" as desirable attributes. EVS staff's interpersonal skills may provide some type of assurance or distraction during a time when patients may feel vulnerable due to illness and hospitalization. A

recent lay magazine exemplifies this sentiment in a report of a celebrity's (Ashley Judd) hospitalization experience and her thankfulness to hospital staff including EVS ("I loved the sweet spirit of the janitor who cleaned my room.")[115] The patients recognized the skilled labor involved in effective environmental cleaning and disinfection and were complimentary of EVS staff's intelligence and work ethic. At the same time, Veterans felt a need to participate in managing their own space by picking up after themselves.

At times, this Veteran (patient)-to-Veteran (EVS) interaction felt like casual relationships or camaraderie and sometimes feelings of bonding. Studies have found supportive relationships with fellow soldiers during combat (i.e., camaraderie) may be protective from psychological sequelae.[116] The VA is increasingly using Veteran peer networks, which use trust and camaraderie, to support health initiatives.[117] In fact, a member of our HAI Prevention Research PEER group participates in Veteran peer support health initiatives for substance abuse rehabilitation[118] and suicide prevention.[119] The fact that a Veteran has daily contact and camaraderie with a fellow Veteran through these environmental cleaning and disinfection procedures during a critical health event (hospitalization) could be a therapeutic interaction which supports the patient's physical and mental well-being during their time in the hospital.

Future studies should evaluate patient perceptions at a wider range of facilities and units – for example, patients in specialty units such as spinal cord injury units may have unique needs and/or barriers to effective and comfortable environmental cleaning and disinfection processes.

Engaging patients in the research process can lead to areas for improvement and development for patient-centered interventions. This study not only provides insight into the importance of environmental cleaning and disinfection from the patient perspective but also provides specific insight into potential access for interventions that are patient-centric: planning

cleaning and disinfection activities around patient preferences (e.g., being in or out of the room during cleaning, having specific procedures for handling cleaning and disinfection of rooms physically occupied by the patient, and a focus on interpersonal skills through hiring and training for EVS staff. Our findings that some patients felt uncomfortable with being in the room (or perceived EVS staff feeling uncomfortable with the patient in the room) during cleaning while others felt a camaraderie with fellow Veteran EVS staff during regular cleanings demonstrate the complexity involved in achieving patient-centered care. Patient-centered communication training can be provided to healthcare workers to facilitate skill development.[120] Thus, optimizing opportunities for members of the patient's care team to ask patients about their needs and wishes at admission and throughout their hospital stay could be considered to understand how environmental cleaning procedures could best be structured to meet a patient's wishes.

CONCLUSIONS

Environmental cleaning and disinfection are critical infection prevention and control evidence-based practices. While we observed overall low cleaning rates, higher rates were observed when cleaning HTSs, suggesting recent efforts prioritizing these surfaces have been widely implemented and sustained. Identification of patient presence as a barrier to environmental cleaning adds to our current knowledge of barriers to successful environmental cleaning, which may not have been fully characterized previously. Cleaning bundles have been recommended [45, 89, 121, 122] but do not address specific cleaning practices, especially how to overcome barriers to task completion. A recent randomized control trial tested a multi-modal cleaning bundle (i.e., optimizing product use and technique, staff training, audit and feedback and communication), which was successful in improving cleaning and reducing HAIs.[122] While the authors recognize the promise of these study results following implementation of a cleaning bundle, they note baseline cleaning compliance was low. In addition, multi-modal approaches

that implement enhanced cleaning simultaneously to other interventions make it difficult to attribute the direct individual effect of each component on outcomes (e.g., reduced HAIs). Standardizing and prioritizing task-specific environmental cleaning surfaces such as cleaning areas within immediate vicinity of occupied beds may be similarly amenable to practice improvement as was targeting HTSs. However further clinical interventional studies are needed to test whether standardized task-specific interventions are feasible and sustainable.

Our findings uncovered predictors of routine daily cleaning and contextual barriers and facilitators to cleaning of patient rooms prime for evaluation. Future research should evaluate interventions that target predictors of low cleaning compliance such as AC setting and semi-private rooms. Additional research is also needed to evaluate whether estimates for direct observation audit frequency (number of rooms observed) presented here are feasible and can optimize monitoring of cleaning processes.

A work system analysis using SEIPS, and qualitative interviews provided a unique insight into key stakeholder's perspective on environmental cleaning the entry points for intervention. Anderson et al. outlined a road map for applying human factors engineering concepts to improving the practice of infection prevention and control.[123] Key themes outlined in this narrative resonate in our study findings such as 1) improving feedback through simulation training and real-time feedback, 2) reducing inefficiencies by reducing design complexity and testing usability, 3) reducing cognitive workload through use of checklists, 4) improving communication through cues embedded in the workflow and 4) performing work analyses to understand barriers and facilitators to tasks. A large single-site observational study using human factors and systems engineering was recently reported in non-VA healthcare facility.[90] Similar to our findings, the authors identified several key work system factors such as type of unit, presence

of patient and interruptions as potential barriers. Clearly, more work needs to be done to improve work systems to optimize environmental cleaning. Interdisciplinary collaboration between researchers and healthcare clinical and ancillary staff is needed to develop and test systems-oriented, person-centered, and design-driven interventions which standardize environmental cleaning work system processes. Future research should evaluate individual work system elements, especially those designed to standardize cleaning practices that overcome barriers and incorporate best practices, to pilot feasibility and measure patient care processes and outcomes.

Finally, engaging Veteran patients in the research process identified environmental cleaning as a research priority in HAI prevention. Overall, our study highlighted Veteran patients' clear appreciation for environmental cleaning and disinfection as a major component of their care and healing within the VA inpatient setting. Patients reported the importance of a clean environment to their physical and mental well-being and identified suggestions for cleaning and disinfection procedures to enhance the patient experience and reduce stress. The qualities highlighted by patients as important for EVS staff – both technical skills such as cleaning and disinfection knowledge as well as "soft" skills such as work ethic, discipline, and personability – should be considered in EVS hiring, training, and retention programs given their importance to patients and as reported here, their recovery while receiving care at VA medical facilities.

Patients reported frequent contact with EVS staff. Among desired qualities of EVS staff, patients valued interpersonal skills which can facilitate patient education, patient preferences and peer relationships. Although evidence-based practices have been recommended,[45, 121] the recommendations do not address patient preferences and patient-centered practices. For example, tools to complement cleaning and disinfection schedules with patient care schedules could be developed and piloted to measure impacts on cleaning and disinfection effectiveness and patient,

provider, and EVS staff satisfaction. Hospital leadership should also consider regular formal or informal evaluations with patients to understand the effects of current cleaning and disinfection procedures on patient care and physical and mental well-being. Current patient surveys generally focus on overall satisfaction, however, as we found in the patient interviews, evaluating patient perceptions of environmental cleaning and disinfection procedures may elicit additional suggestions to improve the experience for patients beyond a more general perception of cleanliness. By addressing the preferences and practices which patients have identified that facilitate cleaning and disinfection and overcome barriers, environmental cleaning and disinfection procedures can become more patient-centric and potentially provide an even greater therapeutic benefit to patients.

STRENGTHS AND LIMITATIONS

This study has multiple contributions to the overall body of knowledge in understanding environmental cleaning in healthcare settings. First, this is the first multi-site mixed method study evaluating environmental cleaning within the VA. The mixed method design allowed us to quantify predictors of cleaning rates while providing the context to explain and interpret findings. Second, the study was also the first multi-site work system analysis in the VA to evaluate environmental cleaning; thus, providing a deeper understanding of the barriers and facilitators to environmental cleaning within the VA work system. Third, the engagement of patients in the research process was novel to understanding patient priorities for HAI prevention. Finally, the study is the first to evaluate Veteran perceptions of environmental cleaning and thus provides unique insight into potential patient-centered interventions for environmental cleaning important to patients.

There are several study limitations. The analysis was based on VA data and may not be generalizable to other populations, however the VA is the largest healthcare system in the U.S. with multiple opportunities for evaluation, implementation, and dissemination. In addition, the study methods are reproducible and can be evaluated in non-VA settings. The study design was focused on cleaning rates via direct observation, and therefore we did not assess other outcomes such as actual surface contamination or HAI outcomes. We also note the number of room cleaning observations was low, but the numbers of surfaces observed allowed us to generate additional analysis. Agreement analysis (i.e., interrater reliability) was not performed among observers using the environmental cleaning observation form. Observers did however utilize a standardized observation form, attended training, and received a training manual. Each observer performed a pilot observation followed by discussion with the research team to address questions and clarifications to data collection. Observers had the opportunity to clarify observations during weekly meetings and data completeness was assessed with each observation following data submission. Finally, we utilized RAs to conduct healthcare worker interviews; the RAs may lack experience in eliciting rich responses to interview questions. However, each RA received extensive training, performed a pilot interview with an experienced researcher, and followed a standardized interview guide including a list of question prompts.

REFERENCES

1. Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infect Control Hosp Epidemiol*. Feb 2011;32(2):101-14. doi:10.1086/657912
2. Klevens RM, Edwards JR, Richards CL, Jr., et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep*. Mar-Apr 2007;122(2):160-6. doi:10.1177/003335490712200205
3. Centers for Disease Control and Prevention. *Antibiotic resistance threats in the United States, 2013*. Centres for Disease Control and Prevention, U.S. Department of Health and Human Services; 2013.
4. Clancy CM. Getting to zero: new resources aim to reduce health care-associated infections. *Am J Med Qual*. Jul-Aug 2010;25(4):319-21. doi:10.1177/1062860610370395
5. Safdar N, Anderson DJ, Braun BI, et al. The evolving landscape of healthcare-associated infections: recent advances in prevention and a road map for research. *Infect Control Hosp Epidemiol*. May 2014;35(5):480-93. doi:10.1086/675821
6. Boyce JM. Environmental contamination makes an important contribution to hospital infection. *J Hosp Infect*. Jun 2007;65 Suppl 2:50-4. doi:10.1016/s0195-6701(07)60015-2
7. Martin, D., Dickey, L., Taylor, E., Conway, L., Myers, F., Bennett, D., Nichols, A., Wright, P. Using the health care physical environment to prevent and control infection: A Best Practice Guide to Help Healthcare Organizations Create Safe, Healing Environment. The Health Research & Educational Trust of the American Hospital Association, The Association for Health Care Environment, The American Society for Health Care Engineering, The Association for Professionals in Infection Control and Epidemiology, The Society of Hospital Medicine, and the University of Michigan, 2015.
8. McDonald LC, Gerding DN, Johnson S, et al. Clinical Practice Guidelines for Clostridium difficile Infection in Adults and Children: 2017 Update by the Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA). *Clinical Infectious Diseases*. 2018:cix1085-cix1085. doi:10.1093/cid/cix1085
9. Jain R, Kralovic SM, Evans ME, et al. Veterans Affairs initiative to prevent methicillin-resistant Staphylococcus aureus infections. *N Engl J Med*. Apr 14 2011;364(15):1419-30. doi:10.1056/NEJMoa1007474
10. Evans ME, Kralovic SM, Simbartl LA, Jain R, Roselle GA. Effect of a Clostridium difficile Infection Prevention Initiative in Veterans Affairs Acute Care Facilities. *Infect Control Hosp Epidemiol*. Jun 2016;37(6):720-2. doi:10.1017/ice.2016.27
11. Veterans Health Administration. Healthcare-associated infection (HAI) prevention practices related to multidrug resistant organisms (MDROs) in acute care settings needs assessment survey report. (2017).
12. Jagosh J, Macaulay AC, Pluye P, et al. Uncovering the benefits of participatory research: implications of a realist review for health research and practice. *Milbank Q*. Jun 2012;90(2):311-46. doi:10.1111/j.1468-0009.2012.00665.x
13. Hyde J WL, Fehling K, Whittle J, True G, Hamilton A, Gierisch JM, Ertl K, Fix G, Barker A, WehlerCJ, White B, Ritchie MF, Ono SS. *Strendthening Excellence IN Research through*

Veteran Engagement (SERVE): Toolkit for Veteran Engagement in Research (Version 1). 2018. https://www.hsrd.research.va.gov/for_researchers/serve/
14. Forsythe L, Heckert A, Margolis MK, Schrandt S, Frank L. Methods and impact of engagement in research, from theory to practice and back again: early findings from the Patient-Centered Outcomes Research Institute. *Qual Life Res*. Jan 2018;27(1):17-31. doi:10.1007/s11136-017-1581-x
15. Brys NA, Whittle J, Safdar N. Development of a veteran engagement toolkit for researchers. *J Comp Eff Res*. Jun 2018;7(6):595-602. doi:10.2217/cer-2017-0101
16. Dadich A, Wyer M. Patient Involvement in Healthcare-Associated Infection Research: A Lexical Review. *Infect Control Hosp Epidemiol*. Jun 2018;39(6):710-717. doi:10.1017/ice.2018.62
17. Brys N, Keating JA, Knobloch MJ, Safdar N. Engaging patients in health care epidemiology research: A case example. *Am J Infect Control*. Feb 2019;47(2):139-143. doi:10.1016/j.ajic.2018.08.013
18. Keating JA, Brys N, Knobloch MJ, Safdar N. Patients as stakeholders: Developing a patient-centered healthcare epidemiology research agenda. *Infect Control Hosp Epidemiol*. 2018:1389-1390. vol. 11.
19. Centers for Disease Control and Prevention. The 2019 National and State Healthcare-Associated Infections Progress Report. Centers for Disease Control and Prevention; 2020.
20. Agha Z, Lofgren RP, VanRuiswyk JV, Layde PM. Are patients at Veterans Affairs medical centers sicker? A comparative analysis of health status and medical resource use. *Arch Intern Med*. Nov 27 2000;160(21):3252-7. doi:10.1001/archinte.160.21.3252
21. Weber DJ, Anderson DJ, Sexton DJ, Rutala WA. Role of the environment in the transmission of Clostridium difficile in health care facilities. *Am J Infect Control*. May 2013;41(5 Suppl):S105-10. doi:10.1016/j.ajic.2012.12.009
22. Leas BF, Sullivan N, Han JH, Pegues DA, Kaczmarek JL, Umscheid CA. AHRQ Comparative Effectiveness Technical Briefs. *Environmental Cleaning for the Prevention of Healthcare-Associated Infections*. Agency for Healthcare Research and Quality (US); 2015.
23. Hota B. Contamination, disinfection, and cross-colonization: are hospital surfaces reservoirs for nosocomial infection? *Clin Infect Dis*. Oct 15 2004;39(8):1182-9. doi:10.1086/424667
24. Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. *Lancet Infect Dis*. Feb 2008;8(2):101-13. doi:10.1016/s1473-3099(07)70241-4
25. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol*. Jul 2011;32(7):687-99. doi:10.1086/660363
26. Anwar S. Multi-Drug Resistant Organisms within Biofilms on Dry Hospital Surfaces: Is this Worldwide? presented at: The Society for Healthcare Epidemiology of America; 2017; San Diego, CA.
27. Dancer SJ. Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. *Clinical microbiology reviews*. 2014;27(4):665-690. doi:10.1128/CMR.00020-14

28. Mitchell BG, Dancer SJ, Anderson M, Dehn E. Risk of organism acquisition from prior room occupants: a systematic review and meta-analysis. *J Hosp Infect*. Nov 2015;91(3):211-7. doi:10.1016/j.jhin.2015.08.005
29. White LF, Dancer SJ, Robertson C, McDonald J. Are hygiene standards useful in assessing infection risk? *Am J Infect Control*. Jun 2008;36(5):381-4. doi:10.1016/j.ajic.2007.10.015
30. Donskey CJ. Does improving surface cleaning and disinfection reduce health care-associated infections? *Am J Infect Control*. May 2013;41(5 Suppl):S12-9. doi:10.1016/j.ajic.2012.12.010
31. Sitzlar B, Deshpande A, Fertelli D, Kundrapu S, Sethi AK, Donskey CJ. An environmental disinfection odyssey: evaluation of sequential interventions to improve disinfection of Clostridium difficile isolation rooms. *Infect Control Hosp Epidemiol*. May 2013;34(5):459-65. doi:10.1086/670217
32. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med*. Dec 28 2006;355(26):2725-32. doi:10.1056/NEJMoa061115
33. Dubberke ER, Carling P, Carrico R, et al. Strategies to prevent Clostridium difficile infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol*. Sep 2014;35 Suppl 2:S48-65.
34. Doll M, Marra AR, Apisarnthanarak A, Al-Maani AS, Abbas S, Rosenthal VD. Prevention of Clostridioides difficile in hospitals: A position paper of the International Society for Infectious Diseases. *Int J Infect Dis*. Jan 2021;102:188-195. doi:10.1016/j.ijid.2020.10.039
35. Evans ME, Kralovic SM, Simbartl LA, et al. Veterans Affairs methicillin-resistant Staphylococcus aureus prevention initiative associated with a sustained reduction in transmissions and health care-associated infections. *Am J Infect Control*. Nov 2013;41(11):1093-5. doi:10.1016/j.ajic.2013.04.015
36. Evans ME, Simbartl LA, Kralovic SM, Jain R, Roselle GA. Clostridium difficile infections in Veterans Health Administration acute care facilities. *Infect Control Hosp Epidemiol*. Aug 2014;35(8):1037-42. doi:10.1086/677151
37. Veterans Health Administration. The Environmental Management Services: Sanitation Procedure Guide (2016).
38. Mitchell BG, Farrington A, Allen M, et al. Variation in hospital cleaning practice and process in Australian hospitals: A structured mapping exercise. *Infection, Disease & Health*. 2017/12/01/ 2017;22(4):195-202. doi:https://doi.org/10.1016/j.idh.2017.08.001
39. Yanke E, Moriarty H, Carayon P, Safdar N. A qualitative, interprofessional analysis of barriers to and facilitators of implementation of the Department of Veterans Affairs' Clostridium difficile prevention bundle using a human factors engineering approach. *Am J Infect Control*. Mar 2018;46(3):276-284. doi:10.1016/j.ajic.2017.08.027
40. Vaughn VM, Saint S, Greene MT, et al. Trends in Health Care-Associated Infection Prevention Practices in US Veterans Affairs Hospitals From 2005 to 2017. *JAMA Netw Open*. Feb 5 2020;3(2):e1920464. doi:10.1001/jamanetworkopen.2019.20464
41. Centers for Disease Control and Prevention. Options for Evaluating Environmental Cleaning (December 2010).

42. Sehulster L, Chinn RY. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep*. Jun 6 2003;52(Rr-10):1-42.
43. Siegel JD, Rhinehart E, Jackson M, Chiarello L. 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Health Care Settings. *Am J Infect Control*. Dec 2007;35(10 Suppl 2):S65-164. doi:10.1016/j.ajic.2007.10.007
44. Centers for Disease Control and Prevention. Management of Multidrug-Resistant Organisms in Healthcare Settings. 2006.
45. Rutala WA, Weber DJ. Best practices for disinfection of noncritical environmental surfaces and equipment in health care facilities: A bundle approach. *Am J Infect Control*. Jun 2019;47s:A96-a105. doi:10.1016/j.ajic.2019.01.014
46. Doll M, Stevens M, Bearman G. Environmental cleaning and disinfection of patient areas. *Int J Infect Dis*. Feb 2018;67:52-57. doi:10.1016/j.ijid.2017.10.014
47. Atsma F, Elwyn G, Westert G. Understanding unwarranted variation in clinical practice: a focus on network effects, reflective medicine and learning health systems. *Int J Qual Health Care*. Jun 4 2020;32(4):271-274. doi:10.1093/intqhc/mzaa023
48. Keating JA, Obasi C, McKinley L, et al. Building Implementation Science for Veterans Affairs Healthcare Associated Infection Prevention: VA Healthcare-Associated Infection Prevention Network (VHIN). *Infection Control & Hospital Epidemiology*. 2018:1-5. doi:10.1017/ice.2018.27
49. Veterans Health Administration. Healthcare-Associated Infection Prevention Practices Related to Multidrug-Resistant Organisms in Acute Care Settings Needs Assessment Survey Report, 2017.
50. Yanke E, Moriarty H, Carayon P, Safdar N. "The Invisible Staff": A Qualitative Analysis of Environmental Service Workers' Perceptions of the VA Clostridium difficile Prevention Bundle Using a Human Factors Engineering Approach. *J Patient Saf*. Jun 11 2018;doi:10.1097/pts.0000000000000500
51. Carayon P, Schoofs Hundt A, Karsh BT, et al. Work system design for patient safety: the SEIPS model. *Qual Saf Health Care*. Dec 2006;15 Suppl 1:i50-8. doi:10.1136/qshc.2005.015842
52. Carayon P. Sociotechnical systems approach to healthcare quality and patient safety. *Work (Reading, Mass)*. 2012;41 Suppl 1(0 1):3850-3854. doi:10.3233/WOR-2012-0091-3850
53. Holden RJ, Carayon P, Gurses AP, et al. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics*. 2013;56(11):1669-86. doi:10.1080/00140139.2013.838643
54. Musuuza JS, Roberts TJ, Hundt AS, et al. Implementing daily chlorhexidine gluconate treatment for the prevention of healthcare-associated infections in non-intensive care settings: A multiple case analysis. *PLoS One*. 2020;15(4):e0232062. doi:10.1371/journal.pone.0232062
55. Yanke E, Zellmer C, Van Hoof S, Moriarty H, Carayon P, Safdar N. Understanding the current state of infection prevention to prevent Clostridium difficile infection: a human factors and systems engineering approach. *Am J Infect Control*. Mar 1 2015;43(3):241-7. doi:10.1016/j.ajic.2014.11.026
56. Musuuza JS, Hundt AS, Carayon P, et al. Implementation of a Clostridioides difficile prevention bundle: Understanding common, unique, and conflicting work system barriers

and facilitators for subprocess design. *Infect Control Hosp Epidemiol*. Aug 2019;40(8):880-888. doi:10.1017/ice.2019.150
57. Knobloch MJ, Musuuza JS, McKinley L, et al. Implementing daily chlorhexidine gluconate (CHG) bathing in VA settings: The human factors engineering to prevent resistant organisms (HERO) project. *Am J Infect Control*. Dec 25 2020;doi:10.1016/j.ajic.2020.12.012
58. Carayon P, Wetterneck TB, Rivera-Rodriguez AJ, et al. Human factors systems approach to healthcare quality and patient safety. *Appl Ergon*. Jan 2014;45(1):14-25. doi:10.1016/j.apergo.2013.04.023
59. Jha AK, Orav EJ, Zheng J, Epstein AM. Patients' perception of hospital care in the United States. *N Engl J Med*. Oct 30 2008;359(18):1921-31. doi:10.1056/NEJMsa0804116
60. Quintana JM, Gonzalez N, Bilbao A, et al. Predictors of patient satisfaction with hospital health care. *BMC Health Serv Res*. Aug 16 2006;6:102. doi:10.1186/1472-6963-6-102
61. Schoenfelder T, Klewer J, Kugler J. Determinants of patient satisfaction: a study among 39 hospitals in an in-patient setting in Germany. *Int J Qual Health Care*. Oct 2011;23(5):503-9. doi:10.1093/intqhc/mzr038
62. Zimring C, Jacob JT, Denham ME, et al. The Role of Facility Design in Preventing the Transmission of Healthcare-Associated Infections: Background and Conceptual Framework. *HERD: Health Environments Research & Design Journal*. 2013/10/01 2013;7(1_suppl):18-30. doi:10.1177/19375867130070lS04
63. Suleyman G, Alangaden G, Bardossy AC. The Role of Environmental Contamination in the Transmission of Nosocomial Pathogens and Healthcare-Associated Infections. *Curr Infect Dis Rep*. Apr 27 2018;20(6):12. doi:10.1007/s11908-018-0620-2
64. Institute of Medicine Committee on Quality of Health Care in A. *Crossing the Quality Chasm: A New Health System for the 21st Century*. National Academies Press (US) Copyright 2001 by the National Academy of Sciences. All rights reserved.; 2001.
65. Creswell, J.W., Klassen, A.C., Plano-Clark, V.L., Smith, K.c Best practices for mixed methods research in health sciences. Office of Behavioral and Social Sciences: National Institute of Health; August 2011.
66. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. *Health Serv Res*. Dec 2013;48(6 Pt 2):2134-56. doi:10.1111/1475-6773.12117
67. Guetterman TC, Fetters MD, Creswell JW. Integrating Quantitative and Qualitative Results in Health Science Mixed Methods Research Through Joint Displays. *Ann Fam Med*. Nov 2015;13(6):554-61. doi:10.1370/afm.1865
68. Centers for Disease Control and Prevention. Environmental Checklist for Monitoring Cleaning (2010).
69. Dicicco-Bloom B, Crabtree BF. The qualitative research interview. *Med Educ*. Apr 2006;40(4):314-21. doi:10.1111/j.1365-2929.2006.02418.x
70. Marshall B, Cardon P, Poddar A, Fontenot R. Does sample size matter in qualitative interviews in IS research. Article. *Journal of Computer Information Systems*. Fall2013 2013;54(1):11-22. doi:10.1080/08874417.2013.11645667
71. Bengtsson M. How to plan and perform a qualitative study using content analysis. *NursingPlus Open*. 2016/01/01/ 2016;2:8-14. doi:https://doi.org/10.1016/j.npls.2016.01.001

72. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. Nov 2005;15(9):1277-88. doi:10.1177/1049732305276687
73. Elo S, Kyngas H. The qualitative content analysis process. *J Adv Nurs*. Apr 2008;62(1):107-15. doi:10.1111/j.1365-2648.2007.04569.x
74. Vaismoradi M, Turunen H, Bondas T. Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nurs Health Sci*. Sep 2013;15(3):398-405. doi:10.1111/nhs.12048
75. Elo S, Kääriäinen M, Kanste O, Pölkki T, Utriainen K, Kyngäs H. Qualitative Content Analysis: A Focus on Trustworthiness. *SAGE Open*. 2014/01/01 2014;4(1):2158244014522633. doi:10.1177/2158244014522633
76. Patton MQ. Enhancing the quality and credibility of qualitative analysis. *Health Serv Res*. Dec 1999;34(5 Pt 2):1189-208.
77. Beebe J. *Rapid assessment process : an introduction*. AltaMira Press; 2001.
78. Leslie M, Paradis E, Gropper MA, Reeves S, Kitto S. Applying ethnography to the study of context in healthcare quality and safety. *BMJ Qual Saf*. Feb 2014;23(2):99-105. doi:10.1136/bmjqs-2013-002335
79. Hamilton AB, Finley EP. Qualitative methods in implementation research: An introduction. *Psychiatry Res*. Oct 2019;280:112516. doi:10.1016/j.psychres.2019.112516
80. Averill JB. Matrix analysis as a complementary analytic strategy in qualitative inquiry. *Qual Health Res*. Jul 2002;12(6):855-66. doi:10.1177/104973230201200611
81. Chen LF, Vander Weg MW, Hofmann DA, Reisinger HS. The Hawthorne Effect in Infection Prevention and Epidemiology. *Infect Control Hosp Epidemiol*. Dec 2015;36(12):1444-50. doi:10.1017/ice.2015.216
82. Carling PC, Bartley JM. Evaluating hygienic cleaning in health care settings: what you do not know can harm your patients. *Am J Infect Control*. Jun 2010;38(5 Suppl 1):S41-50. doi:10.1016/j.ajic.2010.03.004
83. Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. A quantitative approach to defining "high-touch" surfaces in hospitals. *Infect Control Hosp Epidemiol*. Aug 2010;31(8):850-3. doi:10.1086/655016
84. Han JH, Sullivan N, Leas BF, Pegues DA, Kaczmarek JL, Umscheid CA. Cleaning Hospital Room Surfaces to Prevent Health Care-Associated Infections: A Technical Brief. *Ann Intern Med*. Oct 20 2015;163(8):598-607. doi:10.7326/m15-1192
85. Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. *BMC Med*. Jun 8 2009;7:28. doi:10.1186/1741-7015-7-28
86. Hess AS, Shardell M, Johnson JK, et al. A randomized controlled trial of enhanced cleaning to reduce contamination of healthcare worker gowns and gloves with multidrug-resistant bacteria. *Infect Control Hosp Epidemiol*. May 2013;34(5):487-93. doi:10.1086/670205
87. Centers for Disease Control and Prevention. Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008 (Updated 2018).
88. Peters A, Otter J, Moldovan A, Parneix P, Voss A, Pittet D. Keeping hospitals clean and safe without breaking the bank; summary of the Healthcare Cleaning Forum 2018. *Antimicrobial Resistance & Infection Control*. 2018/11/08 2018;7(1):132. doi:10.1186/s13756-018-0420-3

89. Allen M, Hall L, Halton K, Graves N. Improving hospital environmental hygiene with the use of a targeted multi-modal bundle strategy. *Infection, Disease & Health*. 2018/06/01/ 2018;23(2):107-113. doi:https://doi.org/10.1016/j.idh.2018.01.003
90. Xie A, Rock C, Hsu YJ, et al. Improving daily patient room cleaning: an observational study using a human factors and systems engineering approach. *IISE Trans Occup Ergon Hum Factors*. 2018;6(3-4):178-191. doi:10.1080/24725838.2018.1487348
91. Bernstein DA, Salsgiver E, Simon MS, et al. Understanding Barriers to Optimal Cleaning and Disinfection in Hospitals: A Knowledge, Attitudes, and Practices Survey of Environmental Services Workers. *Infect Control Hosp Epidemiol*. Dec 2016;37(12):1492-1495. doi:10.1017/ice.2016.206
92. Stiller A, Salm F, Bischoff P, Gastmeier P. Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. *Antimicrob Resist Infect Control*. 2016;5:51. doi:10.1186/s13756-016-0152-1
93. Van Tiem JM, Friberg JE, Cunningham Goedken C, et al. Environmental service workers as potential designers of infection control policy in long-term care settings. *Am J Infect Control*. Apr 2020;48(4):398-402. doi:10.1016/j.ajic.2020.01.014
94. Cullen D, Thomas Y. EOC-113 - The Impact of Clutter on Healthcare Acquired Infections in a Long-Term Acute Care Hospital. *American Journal of Infection Control*. 2018/06/01/ 2018;46(6, Supplement):S71. doi:https://doi.org/10.1016/j.ajic.2018.04.134
95. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. Jun 13 2012;(6):Cd000259. doi:10.1002/14651858.CD000259.pub3
96. Centers for Medicare & Medicaid Services. Nursing Home Enforcement (2016).
97. Carling PC, Bartley JM. Evaluating hygienic cleaning in health care settings: What you do not know can harm your patients. *American Journal of Infection Control*. 2010;38(5):S41-S50. doi:10.1016/j.ajic.2010.03.004
98. Kenters N, Gottlieb T, Hopman J, et al. An international survey of cleaning and disinfection practices in the healthcare environment. *J Hosp Infect*. Oct 2018;100(2):236-241. doi:10.1016/j.jhin.2018.05.008
99. Carling P. Methods for assessing the adequacy of practice and improving room disinfection. *Am J Infect Control*. May 2013;41(5 Suppl):S20-5. doi:10.1016/j.ajic.2013.01.003
100. Snyder GM, Holyoak AD, Leary KE, Sullivan BF, Davis RB, Wright SB. Effectiveness of visual inspection compared with non-microbiologic methods to determine the thoroughness of post-discharge cleaning. *Antimicrob Resist Infect Control*. Oct 2 2013;2(1):26. doi:10.1186/2047-2994-2-26
101. Rock C, Xie A, Andonian J, et al. Evaluation of environmental cleaning of patient rooms: Impact of different fluorescent gel markers. *Infect Control Hosp Epidemiol*. Jan 2019;40(1):100-102. doi:10.1017/ice.2018.287
102. Rock C, Small BA, Hsu YJ, et al. Evaluating accuracy of sampling strategies for fluorescent gel monitoring of patient room cleaning. *Infect Control Hosp Epidemiol*. Jul 2019;40(7):794-797. doi:10.1017/ice.2019.102
103. Tyan K, Cohen PA. Investing in Our First Line of Defense: Environmental Services Workers. *Ann Intern Med*. 2020:306-307. vol. 4.

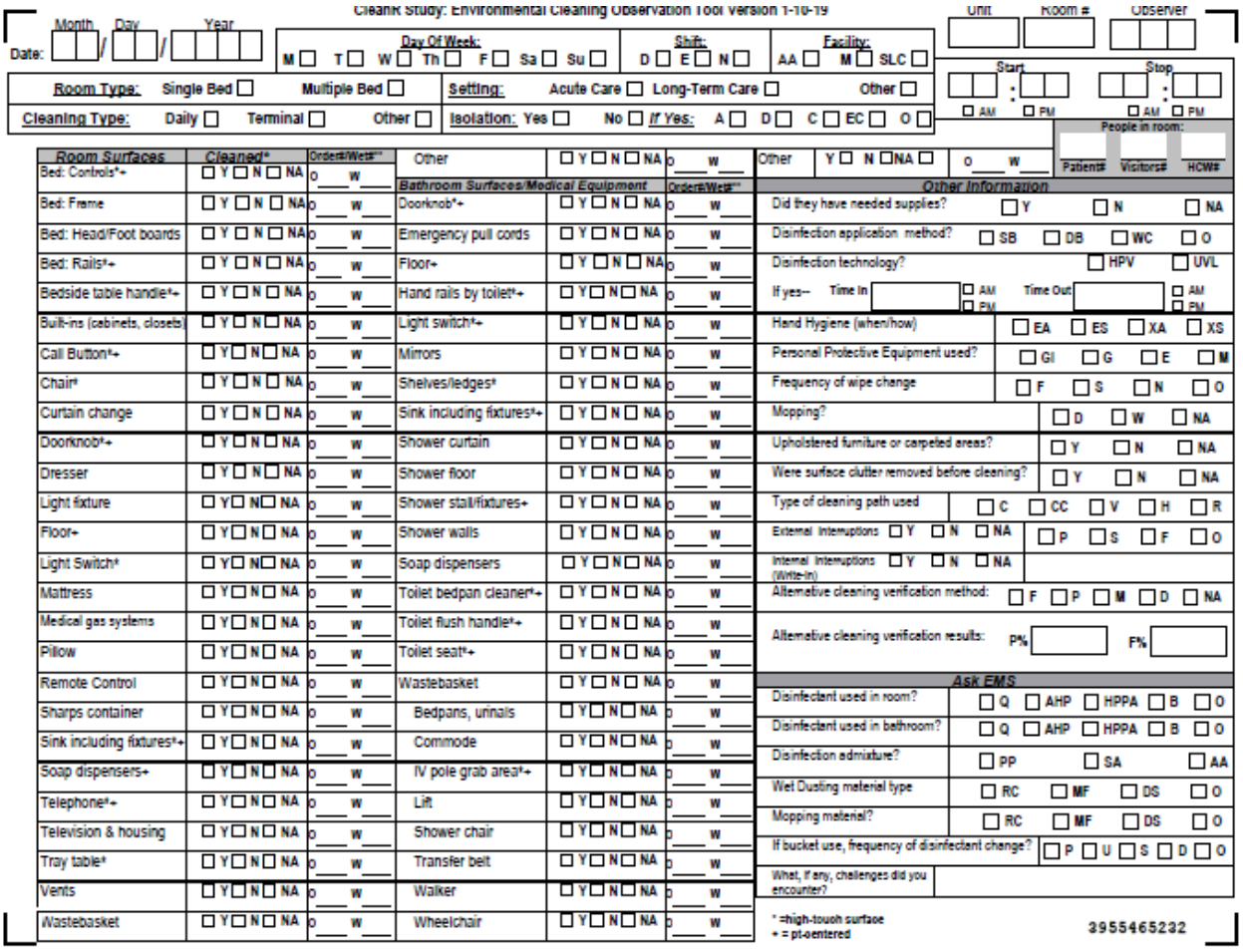
104. McKinley L, Baubie K, Bartel R, Flower M, Keating J, Safdar N. Engaging Veterans in Identifying Key Elements of Environmental Cleaning and Disinfection for Preventing Healthcare-Associated Infections: A Rapid Qualitative Inquiry of the Patient Perspective. *Journal of General Internal Medicine*. 2021;(under review)
105. Coelho P. Relationship Between Nurse Certification and Clinical Patient Outcomes: A Systematic Literature Review. *J Nurs Care Qual*. Jan/Mar 2020;35(1):E1-e5. doi:10.1097/ncq.0000000000000397
106. Pogorzelska M, Stone PW, Larson EL. Certification in infection control matters: Impact of infection control department characteristics and policies on rates of multidrug-resistant infections. *American Journal of Infection Control*. 2012;40(2):96-101. doi:10.1016/j.ajic.2011.10.002
107. Saint S, Greene MT, Olmsted RN, et al. Perceived strength of evidence supporting practices to prevent health care-associated infection: Results from a national survey of infection prevention personnel. *American Journal of Infection Control*. 2013;41(2):100-106. doi:10.1016/j.ajic.2012.10.007
108. Rahman A, Straker JK, Manning L. Staff assignment practices in nursing homes: review of the literature. *J Am Med Dir Assoc*. Jan 2009;10(1):4-10. doi:10.1016/j.jamda.2008.08.010
109. Roberts T, Nolet K, Bowers B. Consistent assignment of nursing staff to residents in nursing homes: a critical review of conceptual and methodological issues. *Gerontologist*. Jun 2015;55(3):434-47. doi:10.1093/geront/gnt101
110. Goedken C, McKinley L, Balkenende E, Hockett S, Reisinger H, Safdar N. Understanding barriers and facilitators to improve environmental cleaning practices: Perceptions from VA environmental services staff. presented at: 13th Annual Conference on the Science of Implementation and Dissemination in Health; 2020; Virtual - Online.
111. Tortorella F, Ukanowicz D, Douglas-Ntagha P, Ray R, Triller M. Improving bed turnover time with a bed management system. *J Nurs Adm*. Jan 2013;43(1):37-43. doi:10.1097/NNA.0b013e3182785fe7
112. McKinley L, Clore G, Balkenende E, et al. Evaluation of Daily Environmental Cleaning and Disinfection Practices in Acute and Long-Term Care Va Facilities: A Mixed Method Study. presented at: SHEA/CDC Decennial 6th International Conference on Healthcare Associated Infections; 2020; Virtual - Online.
113. Keddington AS, Moore J. Simulation as a Method of Competency Assessment Among Health Care Providers: A Systematic Review. *Nurs Educ Perspect*. Mar/Apr 2019;40(2):91-94. doi:10.1097/01.nep.0000000000000433
114. Cleary PD, Meterko M, Wright SM, Zaslavsky AM. Are comparisons of patient experiences across hospitals fair? A study in Veterans Health Administration hospitals. *Med Care*. Jul 2014;52(7):619-25. doi:10.1097/mlr.0000000000000144
115. Weisholtz, D. Naomi Judd says she will remove daughter Ashley's stitches after accident. TODAY Digital, 2021.
116. Nevarez MD, Yee HM, Waldinger RJ. Friendship in War: Camaraderie and Prevention of Posttraumatic Stress Disorder Prevention. *J Trauma Stress*. Oct 2017;30(5):512-520. doi:10.1002/jts.22224
117. Manning EP. A Veteran-Centric Model of Care: Crossing the Cultural Divide. *Ann Intern Med*. Dec 3 2019;171(11):843-844. doi:10.7326/m19-1264

118. Rizia R, Franco Z, Hooyer K, et al. Mobile Peer-Mentoring: An Approach to Make Veterans Seek Mental Health-Care Support a Normality. presented at: 10th International Conference on Collaborative Computing: Networking, Applications and Worksharing; 2014; Miami, Fl.
119. Monteith LL, Wendleton L, Bahraini NH, Matarazzo BB, Brimner G, Mohatt NV. Together With Veterans: VA National Strategy Alignment and Lessons Learned from Community-Based Suicide Prevention for Rural Veterans. *Suicide Life Threat Behav*. Jun 2020;50(3):588-600. doi:10.1111/sltb.12613
120. Braverman AM, Kunkel EJ, Katz L, et al. Do I Buy It? How AIDET™ Training Changes Residents' Values about Patient Care. *J Patient Exp*. May 2015;2(1):13-20. doi:10.1177/237437431500200104
121. Havill NL. Best practices in disinfection of noncritical surfaces in the health care setting: creating a bundle for success. *Am J Infect Control*. May 2013;41(5 Suppl):S26-30. doi:10.1016/j.ajic.2012.10.028
122. Mitchell BG, Hall L, White N, et al. An environmental cleaning bundle and health-care-associated infections in hospitals (REACH): a multicentre, randomised trial. *Lancet Infect Dis*. Apr 2019;19(4):410-418. doi:10.1016/s1473-3099(18)30714-x
123. Anderson J, Gosbee LL, Bessesen M, Williams L. Using human factors engineering to improve the effectiveness of infection prevention and control. *Crit Care Med*. Aug 2010;38(8 Suppl):S269-81. doi:10.1097/CCM.0b013e3181e6a058
124. World Health Organization. Guideline on Hand Hygiene in Health Care, 2009. Updated 2014.
125. Boyce JM. Hand hygiene compliance monitoring: current perspectives from the USA. *J Hosp Infect*. Oct 2008;70 Suppl 1:2-7. doi:10.1016/s0195-6701(08)60003-1
126. Bisantz, A.M., Drury, C.G. Applications of archival and observational data. In: Wilson, J.R., Corlett, N. (Eds.), Evaluation of Human Work. Boca Raton, FL: CRC Press; 2005.
127. Parsons HM. What Happened at Hawthorne?: New evidence suggests the Hawthorne effect resulted from operant reinforcement contingencies. *Science*. Mar 8 1974;183(4128):922-32. doi:10.1126/science.183.4128.922
128. Chou T. Environmental Services. In: Grota P, ed. *APIC Text Online of Infection Control and Epidemiology*. 2018.

APPENDICES

APPENIX A

Appendix A.1 Observation Form (Daily Environmental Cleaning)



CleanR Study: Environmental Cleaning Observation Tool Version 1-10-19

Date: Month / Day / Year

Day Of Week: M T W Th F Sa Su

Shift: D E N

Facility: AA M SLC

Unit | Room # | Observer

Start : AM PM

Stop : AM PM

Room Type: Single Bed Multiple Bed

Setting: Acute Care Long-Term Care Other

Cleaning Type: Daily Terminal Other

Isolation: Yes No *If Yes:* A D C EC O

People in room: Patient# Visitors# HCW#

Room Surfaces	Cleaned*	Orders#/Wet#**	Other		Orders#/Wet#**
Bed: Controls*+	Y N NA	o w	*Bathroom Surfaces/Medical Equipment*		
Bed: Frame	Y N NA	o w	Doorknob*+	Y N NA	o w
Bed: Head/Foot boards	Y N NA	o w	Emergency pull cords	Y N NA	o w
Bed: Rails*+	Y N NA	o w	Floor+	Y N NA	o w
Bedside table handle*+	Y N NA	o w	Hand rails by toilet*+	Y N NA	o w
Built-ins (cabinets, closets)	Y N NA	o w	Light switch*+	Y N NA	o w
Call Button*+	Y N NA	o w	Mirrors	Y N NA	o w
Chair*	Y N NA	o w	Shelves/ledges*	Y N NA	o w
Curtain change	Y N NA	o w	Sink including fixtures*+	Y N NA	o w
Doorknob*+	Y N NA	o w	Shower curtain	Y N NA	o w
Dresser	Y N NA	o w	Shower floor	Y N NA	o w
Light fixture	Y N NA	o w	Shower stall/fixtures+	Y N NA	o w
Floor+	Y N NA	o w	Shower walls	Y N NA	o w
Light Switch*	Y N NA	o w	Soap dispensers	Y N NA	o w
Mattress	Y N NA	o w	Toilet bedpan cleaner*+	Y N NA	o w
Medical gas systems	Y N NA	o w	Toilet flush handle*+	Y N NA	o w
Pillow	Y N NA	o w	Toilet seat*+	Y N NA	o w
Remote Control	Y N NA	o w	Wastebasket	Y N NA	o w
Sharps container	Y N NA	o w	Bedpans, urinals	Y N NA	o w
Sink including fixtures*+	Y N NA	o w	Commode	Y N NA	o w
Soap dispensers+	Y N NA	o w	IV pole grab area*+	Y N NA	o w
Telephone*+	Y N NA	o w	Lift	Y N NA	o w
Television & housing	Y N NA	o w	Shower chair	Y N NA	o w
Tray table*	Y N NA	o w	Transfer belt	Y N NA	o w
Vents	Y N NA	o w	Walker	Y N NA	o w
Wastebasket	Y N NA	o w	Wheelchair	Y N NA	o w
			Other	Y N NA	o w

Other Information

Did they have needed supplies?	Y N NA
Disinfection application method?	SB DB WC O
Disinfection technology?	HPV UVL
If yes-- Time In ☐AM ☐PM	Time Out ☐AM ☐PM
Hand Hygiene (when/how)	EA ES XA XS
Personal Protective Equipment used?	GI G E M
Frequency of wipe change	F S N O
Mopping?	D W NA
Upholstered furniture or carpeted areas?	Y N NA
Were surface clutter removed before cleaning?	Y N NA
Type of cleaning path used	C CC V H R
External Interruptions Y N NA	P S F O
Internal Interruptions (Write-In) Y N NA	
Alternative cleaning verification method:	F P M D NA
Alternative cleaning verification results:	P% F%

Ask EMS

Disinfectant used in room?	Q AHP HPPA B O
Disinfectant used in bathroom?	Q AHP HPPA B O
Disinfection admixture?	PP SA AA
Wet Dusting material type	RC MF DS O
Mopping material?	RC MF DS O
If bucket use, frequency of disinfectant change?	P U S D O
What, if any, challenges did you encounter?	

* =high-touch surface
\+ = pt-centered

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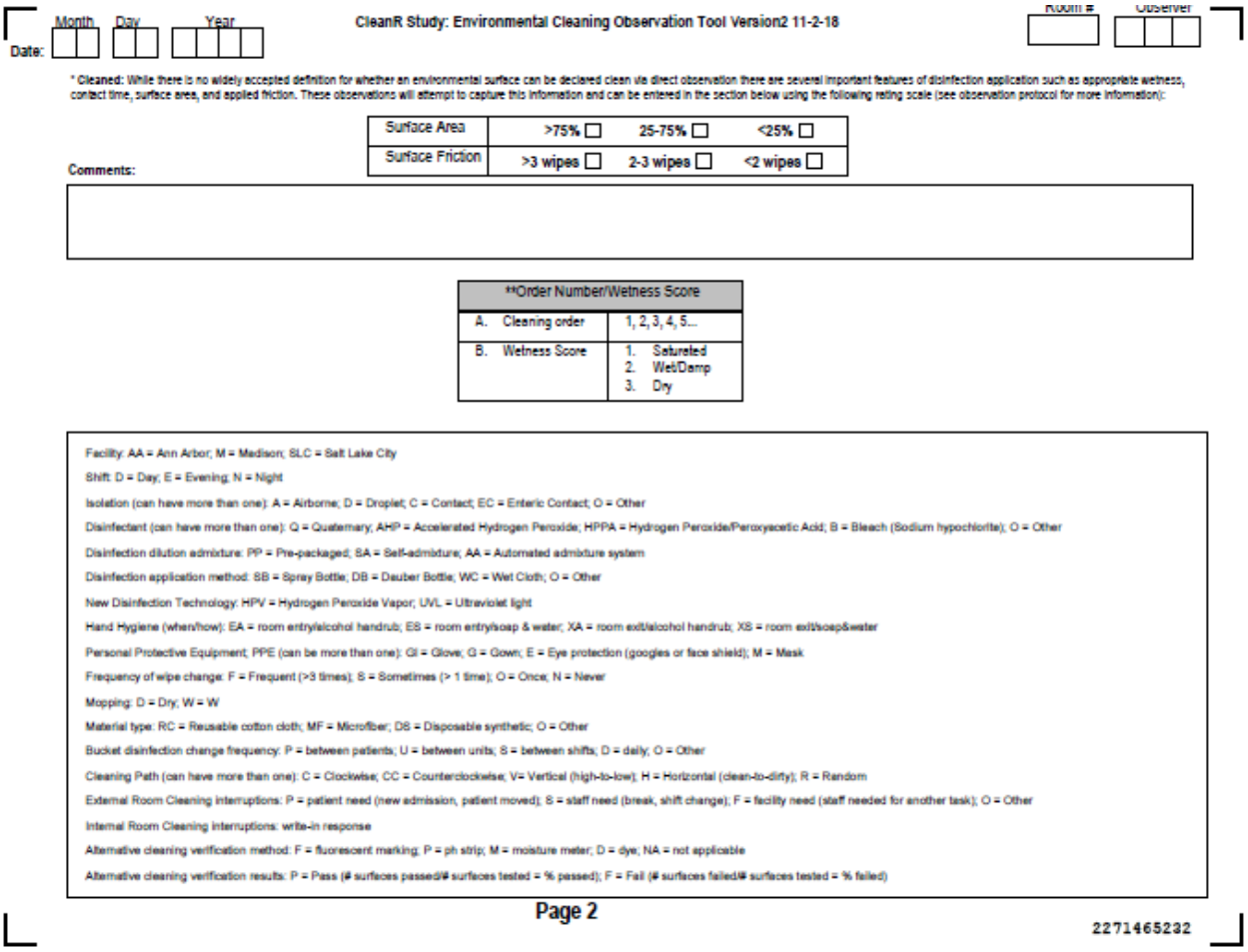

Date: Month Day Year

CleanR Study: Environmental Cleaning Observation Tool Version2 11-2-18

Room # Observer

* **Cleaned:** While there is no widely accepted definition for whether an environmental surface can be declared clean via direct observation there are several important features of disinfection application such as appropriate wetness, contact time, surface area, and applied friction. These observations will attempt to capture this information and can be entered in the section below using the following rating scale (see observation protocol for more information):

Surface Area	>75% ☐	25-75% ☐	<25% ☐
Surface Friction	>3 wipes ☐	2-3 wipes ☐	<2 wipes ☐

Comments:

**Order Number/Wetness Score	
A. Cleaning order	1, 2, 3, 4, 5...
B. Wetness Score	1. Saturated 2. Wet/Damp 3. Dry

Facility: AA = Ann Arbor; M = Madison; SLC = Salt Lake City

Shift: D = Day; E = Evening; N = Night

Isolation (can have more than one): A = Airborne; D = Droplet; C = Contact; EC = Enteric Contact; O = Other

Disinfectant (can have more than one): Q = Quaternary; AHP = Accelerated Hydrogen Peroxide; HPPA = Hydrogen Peroxide/Peroxyacetic Acid; B = Bleach (Sodium hypochlorite); O = Other

Disinfection dilution admixture: PP = Pre-packaged; SA = Self-admixture; AA = Automated admixture system

Disinfection application method: SB = Spray Bottle; DB = Dauber Bottle; WC = Wet Cloth; O = Other

New Disinfection Technology: HPV = Hydrogen Peroxide Vapor; UVL = Ultraviolet light

Hand Hygiene (when/how): EA = room entry/alcohol handrub; ES = room entry/soap & water; XA = room exit/alcohol handrub; XS = room exit/soap&water

Personal Protective Equipment; PPE (can be more than one): Gl = Glove; G = Gown; E = Eye protection (googles or face shield); M = Mask

Frequency of wipe change: F = Frequent (>3 times); S = Sometimes (> 1 time); O = Once; N = Never

Mopping: D = Dry; W = W

Material type: RC = Reusable cotton cloth; MF = Microfiber; DS = Disposable synthetic; O = Other

Bucket disinfection change frequency: P = between patients; U = between units; S = between shifts; D = daily; O = Other

Cleaning Path (can have more than one): C = Clockwise; CC = Counterclockwise; V= Vertical (high-to-low); H = Horizontal (clean-to-dirty); R = Random

External Room Cleaning interruptions: P = patient need (new admission, patient moved); S = staff need (break, shift change); F = facility need (staff needed for another task); O = Other

Internal Room Cleaning interruptions: write-in response

Alternative cleaning verification method: F = fluorescent marking; P = ph strip; M = moisture meter; D = dye; NA = not applicable

Alternative cleaning verification results: P = Pass (# surfaces passed/# surfaces tested = % passed); F = Fail (# surfaces failed/# surfaces tested = % failed)

Page 2

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Appendix A.2 Observation: Training Protocol

ENVIRONMENTAL CLEANING TO REDUCE C. DIFFICILE: CLEANR STUDY
PI: Nasia Safdar

Observation of Cleaning Procedures by Environmental Services StaffProtocol & Training Manual

Contributors: Linda McKinley[1,2], Catherine Shaughnessy[1,2], Nasia Safdar[1,2], Cassie Goedken 3

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Introduction

The objective of this training manual is to provide researchers or quality improvement managers with instructions to perform effective and consistent observations of environmental service staff's room cleaning activities. Because the environmental cleaning process requires multiple steps, we shall observe compliance with these stepsusing a standard data collection instrument/tool (**Appendix A**).

This manual focuses on observing the environmental cleaning process performed by environmental services in various patient care settings. All observers shall thoroughly read the manual and complete orientation prior to beginning data collection. Effectivelyconducting direct observation in a healthcare environment is a challenging undertakingand requires a significant amount of training.

Overview of Environmental Cleaning Observation

Contaminated surfaces in healthcare settings contribute to the transmission of pathogens including Clostridium difficile, Methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), gram-negative bacilli, and norovirus.[6, 21-25] Environmental cleaning that adequately disinfects surfaces is important for preventing transmission of these organisms and reducing healthcare-associated infections (HAIs). Successful environmental disinfection requires an effective disinfectant agent or technology able to reduce or eliminate pathogens.[30] However, disinfection products or technology alone are not sufficient to prevent HAI transmission. Effective environmental cleaning processes which involve consideration of human factors and work systems to ensure that cleaning tasks are performed consistently and with fidelity.

Direct Observations in Healthcare Settings

Healthcare organizations utilize auditing of care processes to assess, evaluate and improve patient outcomes. Audit and feedback is widely used as a strategy to improve professional practice in healthcare.[95] Audits in infection control are often performed usingdirect observation, e.g., monitoring hand hygiene practices of healthcare providers during the care of patients.[124, 125] The overall purpose of direct observation in the CleanR study is to understand the process of environmental cleaning.

Direct observation is an effective method for collecting real-time, naturalistic behavioral information about a specific job or process.[126] Observers should note the limitations of this methodology, including: 1) the observer may not always fully understand the tasks being performed, 2) physical barriers or busy work environments can interfere with and not allow the observer to gain an appropriate perspective and 3) the presence of the observer may influence the way the worker carries out his tasks. Theworker may become self-conscious of his/her work, spend more time on certain tasks or attempt to perform the activity being observed better than usual. This latter phenomenonis referred to as the Hawthorne effect;[127] the effect of the observer on the observed. The presence of the observer may disrupt the typical workflow (e.g., the movement and communication of the worker as they perform their work). Careful monitoring of one's observational procedures can help address these limitations.

Workers in healthcare are often moving during their work. To effectively observe the process, the observer must follow the worker and find an appropriate location to observedetails of the work being performed. The observer should be close enough to the workerto see details such as which surfaces are being cleaned and the order in which, the worker is progressing through the environmental cleaning process as well as an approximate of the surface area wiped, surface wetness, and number of wipes.
However, it is also very important that the observer minimize the intrusiveness of the observation. The observer should be in a position that does not interfere with the workflow. The observer may need to move around to continue to stay out of the way as the as EMS person moves through room cleaning process. Keeping an appropriate distance enables a more natural work environment for the study participant, which in turnprovides the observer with more accurate information. It requires practice for observers to learn how to strategically place themselves to allow for the collection of high-quality representative data. The observer should show respect for patient and family privacy during observations (see formal code of conduct section).

Observer Training
All observers must complete training prior to beginning research or quality improvement activities. Orientation will be project-specific and requires a full understanding rules of conduct, privacy and safety issues, human subjects and HIPAA training, and compliance with infection control practices such as hand hygiene, isolationand bloodborne pathogen training. Completion of the orientation ensures compliance with research and quality improvement policies and procedures of the university, Veterans Health Administration (VHA), local facility and other involved parties. Observertraining will commence after completing orientation.

Common Environmental Cleaning Terminology/Concepts/Principles
Cleaning – is the process for removal of visible soil (organic and inorganic)from objects and surfaces usually accomplished via water, detergents, and mechanical action (manually or mechanically).
Cleaning disinfection process – while there is no widely accepted definition for whether an environmental surface can be declared 'clean' or'disinfected' via direct observation there are several critical features that can be observed
Contact time – each disinfectant used will have the manufacturer's recommended contact time that the chemical should be in contact with the environmental surface for disinfection to occur; in lieu of manufacturer's guidance, follow recommendations from professionalallied health organizations.
Surface Area – disinfectant requires contact with all surface areasfor disinfection to occur.
Surface Friction – mechanical removal of visible soil and adequateapplication of disinfectant requires movement of the disinfection cleaning material with the environmental surface.
Wetness – disinfection should be applied with sufficiently saturatedmaterial so that the surface maintains wetness for the duration of the recommended contact time.
***Note**: Wipes used for cleaning should be changed frequently enough toassure proper saturation and avoid cross-contamination.*
Cleaning disinfection method (1-step vs 2-step) – Both cleaning anddisinfection are critical to effective environmental disinfection.

1-step method can be used when a disinfectant contains both adetergent for cleaning and disinfectant for disinfection.
2-step method should be used if the disinfectant does not contain adetergent; first step (cleaning with detergent) and second step (disinfection with disinfectant).
Cleaning material – there are several common materials used for cleaning
Reusable cloth – a porous material made from natural fiber (cotton)that can be laundered.
Microfiber – an absorbent material made from synthetic fiber(polyester-nylon blend) that can be reusable or disposable
Disposable synthetic – a disposable disinfectant wipe
***Note**: Wipes used for cleaning should be changed frequently enough toassure proper saturation and avoid cross-contamination.*
Cleaning Path – cleaning procedures usually progress in an orderedfashion. Common methods used are
Clean-to-Dirty (horizontal) – cleaning from the least soiled areas tothe most soiled areas
High-to-Low (vertical) – cleaning from high surfaces to low ones.
Clockwise/Counterclockwise – moving to the right or left aroundthe patient room
***Note**: Wipes used for cleaning should be changed frequently enough toassure proper saturation and avoid cross-contamination.*
Contamination – presence of organic soil that may contain pathogens onpatients or objects and surfaces.
Cross-contamination – the transfer of organic soil that may be harmfulfrom one person or object/surface to another.
***Note**: Wipes used for cleaning should be changed frequently enough toassure proper saturation and avoid cross-contamination.*
Disinfectant – chemical agents used for disinfecting healthcare surfacesand are divided into 3 categories (low-level, intermediate-level, and high-level); most environmental surfaces are cleaned with low- to intermediate-level disinfectants.
Liquid disinfectant (Quaternary, Phenolic, Hydrogen Peroxide, Hydrogen Peroxide plus Peroxyacetic Acid, or Sodium Hypochlorite)
Other disinfectant technologies (Hydrogen peroxide vapor orUltraviolet light)
Disinfection – is a process that eliminates many or all pathogenicmicroorganisms, except bacterial spores, on inanimate objects.
Disinfection admixture – chemical disinfectants require dilution with waterand this admixture can occur onsite (manual or mechanical) or by the manufacturer (pre-packaged).
High-dusting – when surfaces above shoulder level are dusted (e.g., vents, high cabinets, lights, curtain tracks); patients should not be present.
High-touch surfaces – environmental surfaces are commonly divided intotwo categories based on frequency they are likely to be touched and the associated risk of infection transmission. High-touch surfaces have a high degree of handling, so they need to be cleaned more frequently. Other surfaces may not need to be cleaned as frequently because they are touched less often.
Mopping – removal of dirt and debris from floors by one of two methods
Dry mopping – no use of water or detergent
Wet mopping – use of water and detergent or disinfectant
Noncritical environmental surfaces – the Spaulding classification systemis used in healthcare to categorize objects and surfaces based on the degree of risk for infection with their use (e.g., critical, semi-critical and non-critical). Environmental surfaces are considered noncritical;

noncritical items only have the potential to come into contact with intact skin or mucous membranes.

Quality monitoring (environmental cleaning compliance):

Direct Observation – use of human observers to monitor cleaningpractices

Fluorescent Markers – use of fluorescent products to mark high- touch areas prior to cleaning which can be evaluated after cleaningto see if the mark has been physically removed.

ATP (adenosine triphosphate) Bioluminescence – the measurementof organic ATP on surfaces using luciferase assay and luminometer.

Microbial Culture – measurement of microbial contamination onsurfaces.

Terminal Cleaning – thorough cleaning of a patient room followingdischarge.

Zones – patient rooms are commonly divided into two zones based on proximity to the patient. The patient zone consists of the patient and theirimmediate surroundings and can quickly become heavily soiled with the patient's flora; many high-touch surfaces are within the patient zone. The remaining areas in the room are considered the room zone.

Data Collection Tool

The data collection tool used described in this manual (**Appendix A**) was developed using multiple sources of information including the CDC guidelines for evaluating environmental cleaning and APIC Text.[41, 128] In **Appendix B** we define the items for each of the data collection instruments and provide specific instructions on how to collect data for each item. Observers should receive training prior to performing observations and be familiar with the content contained in the Appendices. Any concerns the new observer has regarding definitions and instruction clarity should be directed to the coordinating site (Iowa) research staff (Cassie) or primary site (Madison) research staff (Linda and Katie). **Appendix C provide surface images**

Conducting Observations

Observation Logistics

Patient care unit – the research team will identify the patient care areas where you will conduct observations. The research team will communicate with clinic staff (likely a combination of infection control, EMS, and nursing) toidentify these areas.

EMS staff – EMS staff assigned to the patient care area may be identified prior to observations so that the informed consent process can occur prior toobservations (see below protocol). The site PI (or their delegate) will contactthe EMS supervisor to determine best process for obtaining consent (e.g., atthe beginning of the shift or in the time period preceding observations).

Each site should strive for 24 total room observations that can be conductedin 2-4 hr. increments over a 2-mo period of time; at least 4 rooms per week. Sites conducting observations in both acute care and long-term care will require an additional 8 total room observations in acute care and 16 total room observations in long-term care (total of 24 room observation) using thestrategy above (2-4-hour increments over a 2-mo period). The number of observations will need to be reported weekly and provide details of barriers encountered if unable to obtain at least 4 observations per week.

Observation Protocol

Several important steps will be followed for each observation. Following is an outline ofthe procedure to be followed:

Be familiar with the definitions and concepts used in the observation formbefore observation.

Identifying rooms for observation will require communication and coordination

with environmental services and unit staff. If there is one environmental person assigned to the unit, you may be able shadow him/her during the observation period. If there are more than one staff performing cleaning, planout a schedule with the staff to get a variety of staff observations and type of
cleaning (e.g., terminal, daily, isolation, etc.). If the staff are called when needed, you will need to prearrange how you can be alerted (called, standby,etc.) and by whom (environmental or unit staff).
Provide the EMS staff who will be observed with the information sheet andprovide an explanation and opportunity to ask questions prior to the observation (**Appendix D**) including:
Consent EMS with the CIRB-approved observation informationsheet
Information emphasizing that the observation is about the process
of environmental cleaning rather than how well the staff member performs environmental cleaning. The staff member should know that no information identifying him or her is being collected.
Clarification that the observer will not interfere with the cleaning process in any way. No verbal communication by the observer willoccur once s/he enters the patient room.
Identify optimal observation location in the room, preferably with input fromstaff (**Appendix E**)
Complete the data collection instrument (**Appendix A**) while observing theprocess.
Conclude the observation by informing the EMS when the observation iscomplete and thanking them for their participation.
Immediately following conclusion of observation, review the data collection instrument and correct errors or fill in missing information. Add comments as needed, such as to explain any conflicting information. If necessary (i.e., formmessy), rewrite observation onto a new observation form.
Upload weekly observation data collection forms to SharePoint as one singlePDF document.
Participate in weekly research team conference calls.

Infection Prevention and Isolation[43]
Standard and Isolation Precautions must be taken to prevent the spread of disease in healthcare settings. Before an observation begins, after an observation ends and whenever the observer touches anything on the unit, the observer must practice proper hand hygiene. This must be done by either cleaning one's hands using the alcohol disinfectant located throughout the units, or by washing one's hands with soap and water. In addition, the use of personal protective equipment (PPE) such asgloves, gowns, masks, and eye protection may be required to protect from infections transmitted via common routes of transmission (airborne, droplet and contact).
Standard Precautions: The use of Standard Precautions in healthcare settings help prevent the spread of infections transmitted by contact with blood and body fluids. Gloves should be worn anytime contact with blood or body fluid is anticipated. Gowns, masks, and eye protection should be added if any splashing, splattering, or spraying of blood or body fluids is anticipated.Standard Precautions should be practiced for all patients regardless of Isolation Precautions. Since your only role is to observe and you will not perform any tasks that you will anticipate exposure to blood and body fluid, you only need to perform hand hygiene.
Isolation precautions: The use of Isolation Precautions in healthcare settings help prevent the spread of infections transmitted via Airborne, Droplet of Contact route. Depending on the type of isolation, one or more PPE (gloves, gowns, masks and/or eye protection) may be required to prevent infections transmitted via common routes of transmission. In addition to the standard

precautions, the observer might encounter patient rooms withisolation precautions and will be required to adhere to recommended isolationpractices. There are several different types of isolation precaution:

Contact Isolation Precautions: These are followed for infections that are spread by touching (contact) the patient or items in the patient's environment. Examples include patients infected with antibiotic-resistant bacteria such as Methicillin-resistant Staphylococcus aureus (MRSA) or Vancomycin - resistant Enterococci (VRE) or open wounds. *PPE required for contact precautions are gloves and gowns.*

Enteric Contact Precautions are a subcategory of contact precautions. These are followed in many healthcare facilities, particularly for patients who have diarrheal illness such as Clostridium *difficile* (C. difficile) or those with a rotavirus or norovirus infection. Theimportant consideration for the observer to remember is that enteric precautions are a type of contact precaution. Hand hygiene with soap and water should be followed upon room exit recommended for enteric contact isolation precautions. *PPE required for contact precautions are gloves and gowns.*

Droplet Isolation Precautions: These are followed for diseases that æspread via droplet route in tiny droplets caused by coughing and sneezing and includes pneumonia, influenza, whooping cough, bacterial meningitis, and other such diseases. *PPE required for droplet precautions are standard masks.*

Airborne Isolation Precautions: These are followed for diseases hatare spread via airborne route through respiratory droplets that become aerosolized when a person sneezes, coughs or exhales which become suspended in the air and includes tuberculosis, measles, chickenpox, etc. PPE required for airborne precautions is a special mask called N-95 respirator and unless you have been specifically fit-tested for this mask type, **we recommend that you do not do observations in airborne isolation rooms.**

Signage. If a patient has been placed on isolation precautions, there will be asign at the door to their room to remind visitors and HCWs which isolation precautions are needed. It is important that the observer looks for these signsbefore entering a patient's room. *If one notices that there is an "isolation precautions" sign on the door to the patient's room, the observer should follow the recommended practices reviewed during training.* EMS may recommend additional precautions, please follow guidance on what steps to take, such as which PPE and hygiene practices are required.

Code of Conduct and Dress Code

Observers must dress and behave professionally. The code of conduct is found in Appendix E.

Data Management

Observers will scan the completed observation forms and save image as one single PDF document. Upload the PDF document onto the secure VA SharePoint website. https://vaww.visn23.portal.va.gov/iow/SiteDirectory/CRIISP/Reisinger_VA-CDC_PBRN/CleanR_Study/Site Pages/Home.aspx

TELEform, a computerized data entry system that uses Optical Character Recognition (OCR) to read data collection forms, will be used to compile data for analysis. TELEform ensures accuracy and efficient data entry. Observers must write in CAPS using blue or black ink on the observation guide. In addition, observation forms must be printed directly from the PDF copy; observers must not use copier copies of the observation form. Observers should upload

observations onto SharePoint each week. Data will be processed by the Implementation Core and analyzed by the Data Core.
Appendix A – Observation Tool (see Figure X)
Appendix B – Observation Tool: Instructions for Use

The checklist has two major sections—the header and the main section. Items are defined below, beginning with the header items. For questions with **Y** (yes) and **N** (no) responses, the observer will X the box next to the appropriate response, based on what they observe. For situations where a given item is not applicable to the room, the observer will X **NA** (not applicable). The "Other Information" section contains additional abbreviations —these will be defined below.

HEADER

Date: The date when the observation is conducted. Record as mm/dd/yyyy.

Day of the week: The day of the week the observation occurs. The observer should check the corresponding day's abbreviation. For example, '**X**' M for Monday.

Shift: '**X**' the shift during which the observation occurred:

- D=day (7 AM-3 PM)
- E=evening (3 PM-11 PM)
- N=night (11 PM-7 AM)

Facility: The VA at which the observation occurred:

- AA=Ann Arbor
- M=Madison
- SLC=Salt Lake City

Unit and Room Number: Enter the unit and room number where the cleaning occurred. Forexample, 2A (Unit), 242 (Room)

Observer initials: Enter text. Note be consistent if you enter your middle initial always use your middle initial. For example, CCG

Room Type: Single bed vs. Multiple bed

Setting: Observers at all sites will conduct observations in Acute Care. Madison (and possibly Ann Arbor) will also select Long-Term Care.

People in Room: Enter the # of people in the room for each category (Patient, Visitor, HCW)

Cleaning Type: Select **Terminal** only if the patient has been discharged and no longer occupies the room. For all other cleanings, select **Daily**.

Isolation: Patients under isolation precautions will have signs on or near the door to their room.Mark 'Y' if the patient is under isolation, and 'N' if they are not. If isolation is marked, you must also '**X**' one of the following isolation precautions:

- A=airborne
- D=droplet
- C=contact
- EC=enteric contact (may also be known as "enhanced contact")
- O=other (may be Neutropenic sign or a combination of isolation) Note if you list other,you must indicate the type in the comments section.

Start/Stop Time: Record the time when EMS enter the room and when they exit, using AM/PM

MAIN SECTION

The main section can be further broken down into three parts:

1) List of common surfaces (Column 1 and 2) found in: **Patient Room**, **Bathroom**, andreusable (durable) **Medical Equipment**
    a. **Cleaning Order**: 1, 2, 3, 4, 5….
    b. **Cleaning Wetness score**: 1 = saturated; 2 = wet/damp; 3; dry

    NOTE: Saturated (1) = application of sufficient liquid chemical so that evaporation is prolonged allowing for recommended surface contact time (thoroughly soaked). Wet/damp (2) = application of insufficient liquid chemical sothat evaporation occurs quickly not allowing for recommended surface contact time (slightly wet). Dry (3) = application of insufficient liquid chemical so that there is little-to-no surface contact time (moisture free).
2) List of cleaning and disinfection processes (Column 3)
3) ASK EMS Section (Column 3)
    a. All questions, except for the last question, can be asked before or after cleaning.
    b. The last question "What, if any, challenges did you encounter?" should be asked ONLY following room cleaning.

NOTE: Definitions can be found on the back page of the observation

form Did they have supplies: Y = supplies on cart; N = supplies not on cart

(left area)

Disinfection application method: SB = Spray Bottle; DB = Dauber Bottle; WC = Wet Cloth; O
= Other [Note if other, list in comments section]

Note: Dauber bottle is a bottle with a dauber tip (like push-pull water bottle caps)

New Disinfection Technology: HPV = Hydrogen Peroxide Vapor; UVL = Ultraviolet

lightNote: indicate when machine placed in room and taken out of room (Time in/time

out)

Hand Hygiene: EA= room entry using alcohol handrub; ES = room entry using soap &

water;XA = room exit using alcohol handrub; XS = room exit using soap & water

Personal Protective Equipment: PPE (can be more than one): Gl = Glove; G = Gown; E =Eye protection (googles or face shield); M = Mask

Frequency of wipe change: F = Frequent (>3 times); S = Sometime (>1 time); O = Once; N =Never

Mopping Material: D = Dry; W = Wet

Upholstered furniture or carpeted areas: Y = present; N = not present

Surface clutter removed: Y = present and removed; N= present and not removed; NA = notpresent

Cleaning Path (can have more than one): C = Clockwise; CC = Counterclockwise; V =Vertical (High-to-low); H = Horizontal (clean to dirty); R = Random

Room Cleaning interruptions:

Note: You may ask and if unable to determine, leave blank

External Interruptions: Y, N, N/A P= patient need (new admission, patient moved), S = staffneed (break, shift change) F= facility need (staff needed for another task) O= other [Note if other, list in comments section]

Internal Interruptions: Y, N, N/A and then Write in response (e.g., clutter, need supplies)

Cleaned Surface Friction: 1 = > 3 wipes; 2 = 2-3 wipes; 3 = < 2 wipes

Cleaned Surface Area: 1 = > 75%; 2 = 25-75%; 3 = < 25%

Alternative cleaning verification method: F= fluorescent marking; P= ph strip; M = moisturemeter; D = dye; N/A = not applicable

Alternative cleaning verification results: P = Pass (# surfaces passed/# surfaces tested = %passed) F = Fail (# surfaces failed/#surfaces tested = % failed)

Disinfectant (can have more than one): Q = Quaternary; AHP = Accelerated Hydrogen Peroxide; HPPA = Hydrogen Peroxide/Peroxyacetic Acid; B = Bleach (Sodium hypochlorite); O = Other [Note if other, list in comments section]

Disinfection dilution admixture: PP = Pre-packaged; SA = Self-admixture; AA = Automatedadmixture system

Wet Dusting & Mopping Material Type: RC = Reusable cotton cloth; MF = Microfiber; DS =Disposable synthetic; O = Other [Note if other, list in comments section]

Bucket disinfection change frequency: P = between patients; U = between units; S =between shifts; D = daily; O = Other [Note if other, list in comments section]

Comments: This section will be **completed if 'Other' box is marked** and can also be used forany additional comments the observer would like to note. Keep in mind to be clear and concise when using the comments field.

Appendix C – Images of Common Environmental Surfaces (See Figure X)

Appendix D – Observation Information Sheet for EVS

INFORMATION SHEET FOR Developing a Bundled Approach to Environmental Cleaningto Prevent Transmission of HAIs

You are being asked to participate in a research study conducted by Dr. Nasia Safdar at the Madison VA Hospital in partnership with Dr. Heather Reisinger at the Iowa City VA Health CareSystem. We are conducting a research study to assess factors such as barriers and facilitators pertaining to the role of environmental cleaning to reduce healthcare-associated infections (HAIs). We are inviting you to participate in this study because you are involved with environmental cleaning at your facility. Your participation in this research study is voluntary. You may choose not to participate or leave the study at any time without penalty or loss of benefits to which you were otherwise entitled.

WHY IS THIS STUDY BEING DONE?

We are conducting a research study to evaluate barriers and facilitators to environmental cleaning at your facility. In order to understand current cleaning practices, we will performobservations of daily and terminal cleaning.

WHAT WILL HAPPEN IF I PARTICIPATE IN THIS STUDY?

If you agree to participate, a study team member will observe you as you clean a patient or resident's room. We do not anticipate that this will interfere with your regular cleaning activities. We will not collect your name or other personally identifiable information, and we will not be evaluating your performance.

ARE THERE ANY RISKS OR DISCOMFORTS?

There is a risk of loss of confidentiality, such as supervisors learning of your participation and of your responses. In addition, some people may experience psychologic discomfort at the idea of being observed.

ARE THERE ANY BENEFITS?

You will not benefit personally. However, we hope that others may benefit in the future from what we learn as a result of this study. You will not have any costs for being in this research study.

WHO WILL SEE MY INFORMATION?

The information collected for this study will be kept confidential with members of the study team.There are times when we might have to show your records to other people. For example, someone from the Office of Human Research Protections, the Government Accountability Office, the Office of the Inspector General, the VA Office of Research Oversight, the VA Central IRB, our local Research and Development Committee, and other study monitors may look at or copy portions of records that identify you.

WILL I RECEIVE ANY PAYMENT IF I PARTICIPATE IN THIS STUDY?

You will receive no payment for your participation.

WHO CAN I TALK TO ABOUT THE STUDY?

In the event of a research related injury, please immediately contact Nasia Safdar at 608-256-1901 x17007 or Nasia.Safdar@va.gov or Heather Reisinger at (319) 338-0581 x97715, (319) 530-7616, or heather.reisinger@va.gov. If you have any questions, comments or concerns about the research, please contact Heather Reisinger at (319) 338-0581 x97715, (319) 530- 7616, or heather.reisinger@va.gov, or Nasia Safdar at 608-256-1901 x17007 or Nasia.Safdar@va.gov. If you have questions about your rights as a study participant, or you want to make sure this is a valid VA study, you may contact the VA Central Institutional ReviewBoard (IRB) toll free at 1-877-254-3130.

Appendix E – Script for Observers in Patient Rooms

Purpose: Observers should explicitly tell EMS they will be followed into the patient room to observe cleaning processes, not individual personnel practices. Observers should verbally explain to the patient and/or their family members their role/what is being observed and collected (see script below). The observer should tell the patient and/or family they may decline to have the observer enter the room and may ask the observer to leave at any time.

Consent Script for EMS personnel: Give and go over the EMS Informational Sheet (Appendix C)"We want to accurately record the cleaning process and therefore will be following you into patient rooms. Ensure you have the participant's consent prior to entering the room for the observation. Tell them that, although the observations will not be directed towards them, they can refuse at any time to have the observer in the room."

Script for Patient/Visitor: "I'm from the research office and am observing the room cleaning process. Is it okay with you if I enter your room? It is completely voluntary, and you can ask meto leave at any time."

Appendix F – Formal Code of Conduct for Observers in Healthcare Settings

Observers should be aware of the unique nature of healthcare environments. It is important to establish a set of standards for observers to protect the privacy of the patients, their families and other study participants. The research team realizes their presence could potentially be distracting to the normal workflow. Abiding by a code of conduct increases the likelihood of a positive experience for all and a continued collaborative spirit between researchers and clinicians.

1. All observers entering clinical areas of healthcare organizations must document their vaccination status. Please ensure your facility employee/occupational health office has a record of your vaccination status.
2. All observers must complete facility HIPAA and IRB Human Subjects Training modules.A copy of completion certificates should be given to the project manager.
3. All information collected during the observation is confidential. Although patient- or staff-identifiable data are generally not collected, observers may be exposed to identifiable data and sensitive conversations. All elements of the observation are to be

kept confidential.

   a. Do not record any personally identifiable information of the patient or staff (e.g.,names or birthdates).

4. If the observer knows a patient personally, the observer will temporarily discontinue the observation and leave the room while any discussions regarding their healthcare occurs.
5. All observers must obtain and wear an ID badge at all times, per the healthcare organization's requirements.
6. Most observation sessions should be pre-scheduled through informational activities described in the protocol. Always introduce yourself and re-explain what you will bedoing, giving the participant a copy of the Information Sheet, as per the protocol.
   a. Explain that you will never interrupt patient care or cleaning activities.
   b. Explain that you will speak to the staff only when it is clear that you are notinterrupting the workflow.
   c. Remind the staff to let you know if you are asking questions at an inopportunetime so you can refrain from interrupting.
   d. Let the staff know that you will stay as physically-out-of-the-way as possible but still enable yourself to collect necessary data. Let the staff know that they can tellyou to move locations.
   e. Let the staff know they can cancel or postpone the observation if they feeluncomfortable or that it impedes patient care or cleaning activities.
   f. It is OK to show the staff the notes that you are taking. Sometimes this helps torelieve any concerns associated with being observed.
7. At no time are you allowed to participate in the care of the patient or cleaning activities while observing. Although a staff person may ask you to hold something or participate asa way of being nice or engaging, you must politely refuse their request; You may say "I'm not allowed to assist you with this, but I can ask a nurse to help you". If there is a patient or staff emergency, you are not obliged to help and should use your judgment. If you touch anything, promptly wash your hands. If you are exposed to blood or body fluids at any time, stop the observation and thoroughly wash the exposed area. Consult the site PI immediately and follow local policy for blood and body fluid exposures.
8. Observers may witness patients and healthcare professionals sharing personal/sensitive information or performing personal/sensitive physical exams and procedures. Patients may be in various stages of undress, which may fluster him/her or the observer. Following are some general guidelines:
   a. Avoid direct eye contact with the patient or the healthcare professionals that youare observing. Watch your body language. Avoid shaking your head, making

faces, or reacting visibly to anything said by the clinician or patient.

b. Be aware that taking notes during sensitive times may cause the patient or healthcare professional to worry about what you are recording. It is OK to periodically stop taking notes and later record what was observed during sensitive times.

c. Many rooms have curtains that may be pulled to shield the patient bed in the room from the doorway. Consider stepping into the doorway behind the curtain ifthese situations arise; since the observation focus is on room cleaning these situations should be rare. Alternatively, you may turn your back or turn your bodyaway during this time or just exit the room. Patients appreciate observers proactively taking this action.

d. The staff and/or patient may ask you to step out of the room or away from the observation during this time and call you back when they are finished. Always respect their requests.

Note: if you have a break in your observation indicate this on in the comments field on the observation form. Any break in observation should result in aborting the observation

9. Observers may encounter situations that are disturbing to them or make them feel uncomfortable or ill. It is acceptable to end the observation or step away momentarily if this occurs. For example, you may see blood or needles or hear disturbing noises from equipment or patients in pain or distress. Even if these have not bothered you in the past, there may be circumstances in which they bother you. Here are some tips to avoidfeeling ill:

    a. Eat and drink before the observation to ensure that you are well hydrated. This will protect against a dramatic vagal response (feeling faint, nauseated, queasy, and/or jittery).

    b. Do not overdress for observations. Feeling warm can exaggerate any sick response.

    c. If you begin to feel sick, immediately remove yourself from the situation. If you are dizzy and feel like you may pass out, sit down, on the floor if needed, or leanagainst something. Use your notepad to fan yourself; get something cold to drink.

    d. Do not restart the observation until you feel “normal”.

10. You may encounter patients that are in isolation. This means that they have a conditionthat could be harmful to others if transferred or that they are vulnerable to illness due toa compromised immune system. Isolation precautions must be followed for any study that necessitates the observer to follow staff into the room of a patient in isolation. You will be trained on the procedures to follow for isolation. At no time

should you enter the room of a patient who is in respiratory isolation requiring an N95 mask. [See page X ofthe protocol.]

11. If you are pregnant or have another health condition that may be affected by observing in the healthcare setting, please talk to your study PI about the potential for exposure to conditions that may affect your health or pregnancy and precautions one should take to avoid this.
12. Observers must follow the local dress code.
13. If observers are concerned about anything they observe in the clinical setting (such as threats to patient safety or unethical behavior), the concern should be shared with the PI as soon as possible after the end of the observation. The PI will provide guidance.

APPENDIX B

Appendix B.1 Interview Guide: EVS Staff

CleanR Study: Environmental Cleaning Interview Guide Version2 8-10-18

Interview guide for individual or group interviews: ENVIRONMENTAL SERVICES PROFESSIONALS

Introduction: You are being asked to participate in this interview discussion to understand and learn from your experience, specifically the role you play in environmental cleaning to reduce healthcare-associated infections (HAIs).

Questions (based on SIEPS Conceptual Framework):

I. Person

1. For Environmental Services Professionals: Tell me about environmental cleaning practices are important for infection prevention?
   Follow-up/Probes/Prompts:
   - What do you know about the 2-step cleaning process (or why is both cleaning and disinfection steps needed)?
   - Describe which cleaners, disinfectants, and/or combination products you use routinely? Describe how you know when to use each product? What disinfectant contact time(s) do you observe?
   - Describe differences between daily vs. terminal/discharge vs. isolation cleaning.
   - When performing daily cleaning, what is meant by high-touch areas?
   - Describe how reusable medical equipment (RME) are cleaned between patients?

2. For Environmental Services Professionals: Do you believe environmental cleaning reduces transmission of infections? Why/why not?
   Follow-up/Probes/Prompts:
   - Compared to other infection prevention activities such as hand hygiene and isolation precautions, how important is environmental cleaning in reducing infections?
   - How is infection data provided to you? Could that be improved? Describe any problems with infections at your facility?

3. For Environmental Services Professionals: Do you feel your role in reducing the spread of hospital-acquired infections is valued?
   Follow-up/Probes/Prompts:
   - Who values your role? Why or why not? Could this be improved in your facility?
   - What do you think are important characteristics of personnel responsible for effective environmental cleaning?
   - In your experience, what motivates (such as doing a good job, taking care of veterans, job expectation, etc.) environmental services staff and why?

- If you see staff education and training as important, what methods (such as onsite training, on-the-job training, attending a conference or off-site training) have been effective for you or your coworkers and how/why? [list methods]

Organization

1. For Environmental Services Professionals: Describe steps (if any) your facility has taken to prioritize environmental cleaning to reduce infections?
   Follow-up/Probes/Prompts:
   - Describe how the organization provides training? Describe any training issues?
   - Do you believe your cleaning policies/procedures match your practice?
   - Do you believe you have enough staff? Describe any staffing issues?
   - Describe the organizational service line where you report? Describe any benefits/problems with this organizational structure.
   - Within your facility or department, are there opportunities to discuss ideas to improve cleaning practices?

2. For Environmental Services Professionals: How are various members of the patient care team (doctors, RNs, nursing assistants, patient transport, food service and environmental services) involved in ensuring environmental cleaning occurs between patients?
   Follow-up/Probes/Prompts:
   - Describe any cleaning schedules? How is cleaning frequency decided?
   - How are you informed about which rooms need to be cleaned and how is that communicated? How is room cleaning tracked?
   - Describe how responsibilities are shared?
   - How could this be improved?

II. Tools/Technology

1. For Environmental Services Professionals: What are the important tools (e.g., cleaning equipment, supplies or products) necessary for implementing effective environmental cleaning?
   Follow-up/Probes/Prompts:
   - Do you believe you have adequate equipment/supplies? Describe any equipment/supply issues?
   - Is cleaning performance routinely monitored (e.g., observation, fluorescent marking, ATP monitoring, culture)? Do you get feedback on individual or departmental performance? Could that be improved?

III. Tasks

1. For Environmental Services Professionals: What do you see as key factors influencing your ability to perform environmental cleaning tasks?
   Follow-up/Probes/Prompts
   - Do you use carts to transport your supplies for cleaning? Describe how these carts facilitate or cause barriers with your cleaning tasks? How can this be improved?
   - Do you utilize task checklists and is that documented?

IV. Environment

1. For Environmental Services Professionals: Can you think of any physical characteristics (different surface material, room layout, shared rooms, or bathrooms) of the environment that may impact environmental cleaning?
   Follow-up/Probes/Prompts
   - Describe problems with the physical layout of patient rooms or units?
   - Describe problems with the different surface material?
   - Are you physically comfortable (temperature, use of PPE) while cleaning?

We've covered a lot of material, but you are the expert in this area and know what environmental cleaning is like in this hospital. Do you have any other comments you would like to share that would help us understand environmental cleaning here?

Appendix B.2 Interview Guide: Other Healthcare Workers

CleanR Study: Environmental Cleaning Interview Guide Version2 8-10-18

Interview guide for individual or group interviews: Other Facility Stakeholders (Infection Preventionist, Managers, Organizational Leaders)

Introduction: You are being asked to participate in this interview discussion to understand and learn from your experience, specifically the role you play in environmental cleaning to reduce healthcare-associated infections (HAIs).

Questions (based on SIEPS Conceptual Framework):

V. Person

1. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): What do you know about which environmental cleaning practices are important for infection prevention?

Follow-up/Probes/Prompts:
- Besides environmental services, which healthcare professionals are involved in environmental cleaning? Describe their role?
- What types of cleaning products are routinely available? What disinfectant contact time(s) are observed?
- For daily cleaning, what is meant by high-touch areas?
- Describe how reusable medical equipment (RME) are cleaned between patients?

2. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): Do you believe environmental cleaning reduces transmission of infections? Why/why not?

Follow-up/Probes/Prompts:
- Compared to other infection prevention activities such as hand hygiene and isolation precautions, how important is environmental cleaning in reducing infections?

- How is infection data provided to you? Could that be improved? Describe any problems with infections at your facility?

3. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): Do you believe staff who perform environmental cleaning are valued?
Follow-up/Probes/Prompts:
- Who values their role? Why or why not? Could this be improved?
- What do you think are important characteristics of personnel responsible for effective environmental cleaning?
- In your experience, what motivates (such as doing a good job, taking care of veterans, job expectation, etc.) staff and why?
- If you see staff education and training as important, what methods (such as onsite training, on-the-job training, attending a conference or off-site training) have been effective for your staff and how/why? [list methods]

VI. Organization

1. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): Describe steps (if any) your facility has taken to prioritize environmental cleaning to reduce infections?

Follow-up/Probes/Prompts:
- Describe how the organization provides training? Describe any training issues?
- Do you believe your cleaning policies/procedures match your practice?
- Do you believe you have enough staff? Describe any staffing issues?
- Describe where environmental cleaning staff fall organizationally? Describe any benefits/problems with this organizational structure.
- Within your facility, are there opportunities to discuss ideas to improve cleaning practices?

2. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): How are various members of the patient care team (doctors, RNs, nursing assistants, patient transport, food service, and environmental services) involved in ensuring environmental cleaning occurs between patients?

Follow-up/Probes/Prompts:
- Describe any cleaning schedules? How is cleaning frequency decided?
- How are staff informed about which rooms need to be cleaned and how is that communicated? How is room cleaning tracked?
- Describe how responsibilities are shared?
- How could this be improved?

VII. Tools/Technology

1. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): What are the important tools (e.g., cleaning equipment, supplies or products) necessary for implementing effective environmental cleaning?

Follow-up/Probes/Prompts:
- Do you believe you have adequate equipment/supplies? Describe any equipment/supply issues?

- Is cleaning performance routinely monitored (e.g., observation, fluorescent marking, ATP monitoring, culture)? Do you get feedback on individual or departmental performance? Could that be improved?

VIII. Tasks

1. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders): What do you see as key factors influencing your staff's ability to perform environmental cleaning tasks?

Follow-up/Probes/Prompts

- Does environmental service staff use carts to transport cleaning supplies? Describe how these carts may facilitate or cause barriers with cleaning tasks? How can this be improved?
- Do you utilize task checklists and is that documented?

IX. Environment

1. For Other Facility Stakeholders (Infection Preventionists, Managers, Organizational Leaders):

Follow-up/Probes/Prompts:

- Describe problems with the physical layout of patient rooms or units?
- Describe problems with the different surface material?

We've covered a lot of material, but you are the expert in this area and know what environmental cleaning is like in this hospital. Do you have any other comments you would like to share that would help us understand environmental cleaning here?

Appendix B.3 Healthcare Worker Interviews: Coding Matrix

1 Other cleaning	3	Task
2 Hand hygiene	5	Task
3 Environment	0	
3.1 Acute Care/Hospital	5	Environment
3.2 CLC	5	Environment
3.3 CBOC	1	Environment
4 Open Codes	0	
4.1 Change in Practice	17	Organization
4.2 Gold Star	25	Data pull
4.3 Bathroom surfaces	20	Task
4.4 Physical characteristics of room	13	Environment
4.5 Cleaning Preferences	11	Person
4.6 Facilitator	41	Data pull
4.7 Physical comfort	4	Environment
4.8 Prioritizing	18	Person
4.9 Teamwork	50	Organization
4.10 Uncertainty	10	Person/Org
4.11 Policy and Procedure	25	Organization
4.12 Purpose	16	Person/Org
4.13 Motivation	19	Person/Org
4.13.1 Reward	1	Organization
4.14 EMS Characteristics	21	Person
4.15 Recommendations	24	Organization/Pers
4.15 Recommendations	24	Organization/Person
4.16 Education and Training	23	Person/Organization
4.17 Infection data feedback	8	Organization
4.18 Value in work	22	Organization/Person
4.19 Infection belief	25	Person
4.20 Barrier	66	Data pull
4.21 Lack of standardization	40	Organization
4.22 Daily clean	21	Task
4.23 Workload	31	Task/Organization
4.24 Disinfection Effectiveness	5	Person/Tools
4.25 Workflow	26	Task
4.26 Contact Time	11	Task
4.27 Terminal Cleaning	37	Task
4.28 Equipment Surfaces	14	Task
4.29 High-Touch Surfaces	17	Task
4.30 Other Surfaces	27	Task
4.31 Two-Step Cleaning Process	12	Task
4.32 Cleaning Products	36	Tool
4.33 Supplies	40	Tool
4.34 Isolation	28	Environment/Task
4.35 Knowledge	40	Person/Organization
4.36 Communication	71	Organization/Pers
5 Organization	7	Org
5.1 Resources	6	Org
5.2 Infection data	5	Org
5.3 Structure	8	Org
5.4 Leadership	42	Org
5.5 Staffing	26	Org
5.6 Culture	32	Org
5.7 Monitoring of cleaning process	19	Org
5.7.1 Monitoring data feedback	5	Org
5.8 Accountability	13	Org
6 Person	0	
6.1 Infection Control Team	7	Org/Person
6.2 Visitor	8	Person
6.3 Nurses	43	Person
6.4 Patient	48	Person
6.5 Other Heathcare Worker	39	Person
6.6 EMS Staff	62	Person
6.6.1 Veterans	4	Person
7 Task	20	Task
8 Tools/Technology	0	
8.1 UV cleaning system	5	Tools
8.2 Checklist	9	Tools

APPENDIX C

Appendix C.1 RQI: Patient Interview Guide

1. How is cleaning a hospital room different from cleaning in your home?
2. What are your expectations for room cleanliness in terms of being neat and cleaned for removal of germs?
    a. What are your expectations for neatness such as clean linens, emptying trash, removing clutter and dusting?
    b. What are your expectations for cleaning and sanitation/disinfection of surfaces (such as bed, toilets, sink, countertops, and floors) and medical equipment (such as blood pressure cuff and other monitoring equipment, wheelchairs, and other assistance devices, etc.)?
3. What has been your experience with hospital room cleaning during your present (or prior) hospitalization?
4. From your experience, what makes it easier for healthcare workers to clean your room.?
5. From your experience, what makes it harder for healthcare workers to clean your room?
6. From your experience, what are important qualities of the hospital cleaning staff?
7. From your experience, how do the clinical staff such as doctors and nurses, help in the room cleaning process?
8. From your experience, how do you help in the room cleaning process?
9. From your experience, how do your visitors help in the room cleaning process?
10. What do you think are the benefits of room cleaning?
11. What are the drawbacks or problems that occur because of room cleaning?
12. How do you feel about healthcare workers regularly checking how well your room is cleaned?
13. How do you feel about providing feedback to healthcare workers about your room cleanliness?

Appendix C.2 RQI: Domains based on Interview Questions

Interview Question	Domain	SEIPS
1. How is cleaning a hospital room different from cleaning in your home?	Patient/Resident room cleanliness knowledge	Person/Knowledge
2. What are your expectations for room cleanliness in terms of being neat and cleaned for removal of germs?	Patient/Resident room cleanliness expectation	Person/Preferences
3. What has been your experience with hospital room cleaning during	Patient/Resident room cleanliness experience	Person (or Organization)/Experience

your present (or prior) hospitalization?		
4. From your experience, what makes it easier for healthcare workers to clean your room.?	Patient/Resident room cleanliness facilitators	Facilitators
5. From your experience, what makes it harder for healthcare workers to clean your room?	Patient/Resident room cleanliness barriers	Barriers
6. From your experience, what are important qualities of the hospital cleaning staff?	EMS staff desired qualities	Person/EMS characteristics
7. From your experience, how do the clinical staff such as doctors and nurses, help in the room cleaning process?	Patient/Resident room cleaning teamwork	Organization/Teamwork or Org Culture
8. From your experience, how do you help in the room cleaning process?	Patient Engagement	Person
9. From your experience, how do your visitors help in the room cleaning process?	Family Engagement	Person
10. What do you think are the benefits of room cleaning?	Patient/Resident room cleanliness benefits	Person/Knowledge or Infection Belief
11. What are the drawbacks or problems that occur because of room cleaning?	Patient/Resident room cleanliness drawbacks	Person/Knowledge
12. How do you feel about healthcare workers regularly checking how well your room is cleaned?	Patient/Resident room cleanliness monitoring	Organization/Monitoring Cleaning

13. How do you feel about providing feedback to healthcare workers about your room cleanliness?	Patient/Resident room cleanliness feedback communication	Person/Communication

Appendix C.3 RQI: Transcript Summary Template

Domain: Patient/Resident Room Cleanliness Knowledge

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Quotes:

Domain: Patient/Resident Room Cleanliness Expectation

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Quotes:

Domain: Patient/Resident Room Cleanliness Experience

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-
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Quotes:

Domain: Patient/Resident Room Cleanliness Facilitators

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-
-

Quotes:

Domain: Patient/Resident Room Cleanliness Barriers

-
-
-

Quotes:

Domain: EMS Staff Desired Qualities

-
-
-

Quotes:

Domain: Patient/Resident Room Cleaning Teamwork

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-
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Quotes:
Domain: Patient/Family Engagement

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-
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Quotes:
Domain: Patient/Resident Room Cleanliness Benefits

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-
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Quotes:
Domain: Patient/Resident Room Cleanliness Drawbacks

-
-
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Quotes:
Domain: Patient/Resident Room Cleanliness Monitoring

-
-
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Quotes:
Domain: Patient/Resident Room Cleanliness Feedback Communication

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-
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Quotes:
Domain: Other

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-
-

Quotes:

Appendix C.4 RQI: Coding Matrix Display

Domain	Code(s)/Theme(s)	Definition	Comment(s)

Patient/Resident Room Cleaning			
Domain 1 Knowledge (Home vs Hospital)	-Chemical Disinfection -All surface cleaning -Trained EMS -Interrupt disease transmission -Frequency	-Cleaning agent used for chemical disinfection (special, different, sterile) -All surfaces (high-touch, equipment, bathroom, horizontal) need to be cleaned or disinfection cleaning process (detail, different, intensity) -Trained cleaning personnel (EMS); Appreciate/other people -Cleaning /Disinfection important for preventing disease transmission -more frequent cleaning	
Domain 2 Expectation (in hospital)	-Chemical disinfection -All surface cleaning -Size -Clutter -VA system	-Cleaning and chemical disinfection so surfaces are clean (vs. just looking clean) - All surfaces cleaned all surfaces (high-touch, equipment, bathroom, horizontal) -Big room vs small rooms -Stress and Clutter; perceptions of cleanliness or ease of cleaning -Neg (bureaucracy, Vet might expect large VA system	

	-Other cleaning tasks	might have problems) Pos (expect better care at VA) Comparing VA and nonVA (private) -Changing sheets and removing garbage, dusting	
Domain 3 Experience (during hospitalization)	-Hinderance/Burden -EMS rushed -COVID pandemic -Clean Hospitals -Cleaned daily	-Burden/ in way of EVS/EVS burden/in way of patient; inconvenient or awkward -EMS are in a hurry or rushed - more thorough cleaning during covid -Hospital rooms consistently clean -Patient rooms should have daily cleaning	
Domain 4 Facilitator(s)	-Unoccupied room -Better Planning -Comradery -Adequate facilities -Staffing	-Easier to clean when patient not in room -Room cleaning needs better planning (e.g., during patient appt) -Vets grateful for healthcare, especially staff that are Vets and staff grateful to Vets -Keeping rooms modern and updated -Staff readily available or consistent	
Domain 5 Barrier(s)	-Occupied room -EMS rushed -Communication problems	-Harder to clean when patient in room -EMS rushed/hurry -miscommunication or no communicating including awkward interactions	

	-Do not disturb -Inadequate facilities -Staffing -Interruptions	-Patients are sick and grumpy and may not want to be disturbed -Worn facilities /small and cluttered rooms -Different staff observed (not consistent) Emergency (called away), too many staff (leave room)	
Domain 6 EMS Qualities	-Interpersonal skills -Empathy /Compassion -Detail-oriented -Responsible -Physical qualities - Camaraderie	-Personable (converse with patient) -Compassionate -Efficient, effective, multi-tasker, -Work ethic, intelligence, responsible, disciplined, team player -young, strong - Patient relationship with staff (fellow veteran) that is conducive to healing	
Domain 7 HCW teamwork	-Leave no mess behind/no trace -Team responsibility	-Clean up after themselves -More than cleaning up after self, perform cleaning tasks	
Domain 8 Patient/Family Engagement	-Leave no mess behind -Patient feedback	-Patient/visitor clean up after themselves -Patient alert EVS to what needs cleaning or is missed	
Domain 9 Benefits	-Physical wellbeing -Mental wellbeing	-Less risk of infections when clean -less stressed when clean	
Domain 10 Drawbacks	-Hinderance/Burden -Scheduling	-Inconvenient to patient	

		-needs to be planned with patient	
Domain 11 Monitoring	-Support monitoring -Indifference to monitoring	-Support cleaning monitoring (if makes sure job is done) -Indifferent to cleaning monitoring as long as job is done	
Domain 12 Feedback	-Supportive; feedback without fear, feedback as caring -Loss of independence	-Support patient feedback; patient should feel comfortable giving feedback/ staff should care how patient feels about environment -Feels embarrassing	

APPENDIX D: Veteran Narrative on Participatory Research

Title: The Veterans Engaged in Education and Research Infection Prevention Project: My 'Research' Life, My Story

Note: This narrative was transcribed from an oral interview with the Veteran. The text has been lightly edited for clarity, and he has read and approved this written narrative of his comments.

My involvement in Veteran research began about ten to fifteen years ago through researchers at the Medical College of Wisconsin (MCW) and the Milwaukee VA. They were interested in Dryhootch of America, where I served as Co-founder and Director of Community Programs and Peer Coordinator. We partnered in the Dryhootch Partners for Veteran Health – Veteran Centered Research and Action project to support mental health initiatives. I am an Army Veteran in recovery, and my passion for the past fifteen years has been working on Veterans' issues and helping Veterans in their journey of transition to living a productive life, especially at points when they may not think they can. I'm also involved in some other peer support programs supporting suicide prevention (Captain John D. Mason Peer Support Program, the Growing Rural Outreach through Veteran Engagement 'GROVE' project and Assessing Social and Community Environments with National Data 'ASCEND').

I became involved with the University of Wisconsin – Madison (UW) and Madison VA Infection Prevention 'Patients (and Veterans) Engaged in Education and Research' (PEER) group about five years ago. Although I have not personally experienced a healthcare-associated infection (HAI), I've known some veterans who have gotten those infections while in the hospital, so I see these are things my fellow Veterans must deal with. I was immediately interested because if there is any way we can improve the lives of our Veterans, or my brothers and sisters, coming in and out of the hospital, it is worth doing.

From the very first meeting with the Infection Prevention PEER group, I learned of the devastating effects of HAIs and the research on trying to prevent these infections, and I got hooked and wanted to be involved. Having the PEER group face-to-face meetings helped get to know the team and I really felt that the team and the researchers were interested in my opinions. I never felt that any of what I said would be dismissed. In one of my first meetings, I specifically recall focusing our discussion on the cleanliness of the hospital environment and concern that things might not get cleaned in the patient room.

And now, that is what I have since primarily been directly involved in – the CleanR (Cleaning to Reduce *C. difficile*) study to understand environmental cleaning within the VA. In addition to my involvement in having this research group prioritize this research subject, since the CleanR study has been funded I've been able to participate by reviewing and trialing the interview questions that were developed for the patient interviews. I was able to provide feedback on the questions [to make them] easier to understand and more Veteran-friendly. I've been told that my initial trial interview guided some revisions of the questions.

I've also been told that my feedback guided some of the data analysis for data collected during cleaning observations, specifically the issue of patients feeling they may be getting in the way

during the cleaning process. I remember bringing this up: the fact that on the staff-side, they feel uncomfortable of doing a good job [thereby disturbing the patient] but on the Veteran-side, if they knew what's going on [why EVS staff were there] they'd let them do whatever is needed to do, especially if it's for their own personal safety and the risk of possibly getting an infection.

I really hope that this study moves forward to the point where the staff can learn to clean rooms utilizing lessons learned from this study so they can clean better. For example, they may cover more of the surfaces that they probably don't do as well, or maybe even miss just because of that feeling that they don't want to bother this patient. Yet, if this patient in the room is told why [cleaning staff] are coming in and doing what they're doing, they would be more than happy to allow them to do that and relieve [staff's] worry about bothering [the patient]. I have been thinking a lot about the Veterans who work at the hospital as environmental cleaning staff and how they might benefit from peer support to help them navigate caring for their fellow Veteran while they go about their job of cleaning the hospital room. They could learn to be interactive with the patient in the room while they're doing cleaning and making sure the patients are safe and talking about why what they are doing is important.

I am very grateful to be part of the PEER group. Every project I've participated in has opened my mind to how I think about research. I would like to find a way for this important work to be more accessible to other Veterans and the public and hopefully more sustainable. Interestingly, I feel my involvement with the PEER group prepared me for COVID and the importance of measures like hand washing that are important to prevent serious infections. My hope is that I can continue to work with this PEER group and maybe begin focusing on other directions of infection prevention. In the end, it's about the health and wellbeing of our Veterans.