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Original Article

Using a human-factors engineering approach to evaluate environmental cleaning in Veterans' Affairs acute and long-term care facilities: A qualitative analysis

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Abstract

Background: Environmental cleaning is important in the interruption of pathogen transmission. Although prevention initiatives have targeted environmental cleaning, practice variations exist and compliance is low. Evaluation of human factors influencing variations in cleaning practices can be valuable in developing interventions to standardized practices. We conducted a work-system analysis using a human-factors engineering (HFE) framework to identify barriers and facilitators to environmental cleaning practices in acute and long-term care settings within the Veterans' Affairs health system.

Methods: We conducted a qualitative study with key stakeholders at 3 VA facilities. We analyzed transcripts for thematic content and mapped themes to the HFE framework.

Results: Staffing consistency was felt to improve cleaning practices and teamwork. We found that many environmental management service (EMS) staff were veterans who were motivated to serve fellow veterans, especially to prevent infections. However, hiring veterans comes with regulatory hurdles that affect staffing. Sites reported some form of monitoring their cleaning process, but there was variation in method and frequency. The EMS workload was affected by whether rooms were occupied by patients or were semiprivate rooms; both were reportedly more difficult to clean. Room design and surface finishes were identified as important to cleaning efficiency.

Conclusion: HFE work analysis identified barriers and facilitators to environmental cleaning. These findings highlight intervention entry points that may facilitate standardized work practices. There is a need to develop task-specific procedures such as cleaning occupied beds and semiprivate rooms. Future research should evaluate interventions that address these determinants of environmental cleaning.

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The healthcare physical environment is a significant reservoir of pathogens.[1–3] Environmental cleaning and disinfection is critical to interrupting the transmission of these pathogens.[4] Despite initiatives that have targeted environmental cleaning,[5] cleaning compliance is still low.[6] Low practice compliance may partially be explained by practice variation.[7] In a recent evaluation of infection prevention practices across the Veterans' Affairs health system, significant variation in cleaning was identified.[8] A recent review of healthcare cleaning strategies highlighted the human factors in the manual cleaning process and the need for work-system evaluation to understand contextual determinants (ie, barriers and facilitators) of environmental cleaning.[9]
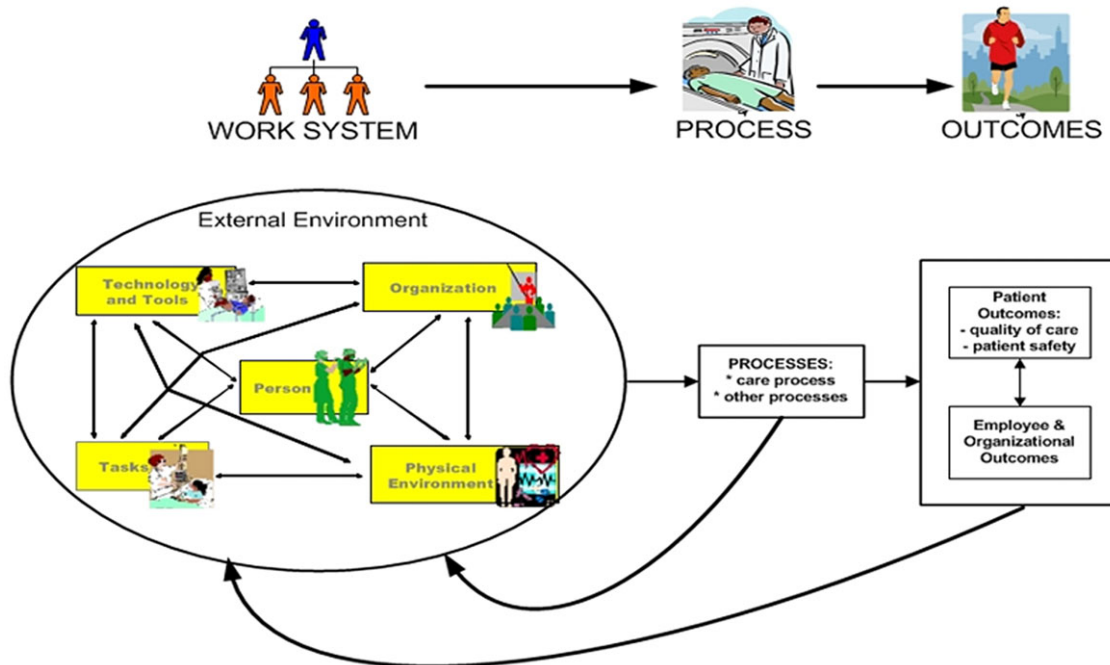
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A human-factors engineering (HFE) framework, the Systems Engineering Initiative for Patient Safety (SEIPS) model,[10–12] has been used extensively in health care as a road map for work system analysis, including its application for understanding processes for infection prevention (Fig. 1).[13,14]

The SEIPS model focuses on 5 interacting components of the work system: organization, person, tools and technology, tasks, and environment. Interactions of these components can affect care processes such as environmental cleaning practices in healthcare as well as subsequent outcomes such as poor cleaning compliance, pathogen transmission and healthcare-associated infections (HAIs).

An HFE-focused work-system analysis provides a means to understanding the contextual determinants of environmental cleaning processes, which could improve the fidelity of the processes through identifying key entry points for interventions. We conducted a comprehensive work-system analysis using the SEIPS model to identify determinants of cleaning practices within the VA.

Figure 1. Systems engineering initiative for patient safety model.

Methods

We conducted a qualitative study[15,16] using semistructured interviews with key stakeholders including environmental management service (EMS), nursing, and infection preventionists (IPs) at VA facilities across 3 acute-care settings and 2 long-term care settings between January and June 2019. We interviewed 18 participants using interview guides developed by the research team. The interview questions focused around the 5 work-system components of the SEIPS model within the context of cleaning processes (eg, healthcare worker's knowledge; knowledge as an element within the 'person' component of cleaning) was assessed by asking "How is cleaning important for infection prevention?" (see the Interview Guide in the Supplementary Material online).

Interviews were conducted by trained research staff at each site who received ~10 hours of didactic training on qualitative interviewing. Interviews lasted 45 minutes on average and were audiorecorded using encrypted recorders and were transcribed verbatim. The qualitative team used MAXQDA software (VERBI Software, Berlin, Germany) to manage and analyze electronic transcripts.

Transcripts were analyzed for thematic content and were then mapped to the SEIPS work-system components. Analysis was conducted by an interdisciplinary team including trained social scientists with backgrounds in anthropology, public health, nursing, and infection control. The initial inductive coding 56% of the transcripts occurred via group consensus. This process involved individuals reading and coding transcripts independently with final coding assigned after group consensus.[16] Through an iterative process of discussion and code definition refinement, a comprehensive codebook was developed. The remaining transcripts (44%) were coded by pairs following a similar method of initial independent coding followed by paired consensus.[16] Discrepancies continued to be discussed within the larger group to reach agreement and consensus. The team first focused on inductive codes, which were later mapped onto domains of the

SEIPS framework. This unconstrained coding process allowed the team to later align themes congruent with the SEIPS constructs and allowed for the emergence of themes that may have been disparate from the framework. The team found that the codes aligned well with the SEIPS domains; however, there was overlap between domains (ie, codes could be mapped to >1 domain). The mapping of inductive codes within the SEIPS domains is provided in the Results section along with exemplar quotes.

Human-subject review

Human-subject review and approvals were sought from the VA Central Institutional Review Board (CIRB 18-10) and local site research and development committees. We received a waiver of documentation of informed consent for the interviews.

Results

All 18 interviews were conducted with 11 EMS managers and staff, 4 nurse managers and staff, and 3 IPs.[17] Several themes were identified as determinants of environmental cleaning.

Organization

Most of the emergent themes centered within the organization component of the SEIPS framework, which are outlined in Table 1. Primarily, stakeholders reported challenges to EMS staff recruitment and retention that greatly affected assignment consistency, cleaning practices, teamwork, and training. Other important organization themes were communication, professional value and organizational culture, and leadership.

The staffing challenges occurred across the continuum from recruitment to retention. Respondents noted that regulatory and restrictive hiring processes within the VA for hiring EMS staff led to staffing challenges. Specifically, laws governing specific positions (eg, housekeeping aids) of government employees restrict hiring to veterans, which have limited the applicant pool.

Table 1. Themes and Exemplar Quotes within the *Organization* Component

SEIPS component	Barriers and Facilitators	Theme	Participant 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]' (…)." (EMS manager, facility B) "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 (…)." (EMS 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 [too many cleaners can be a barrier to cleaning] (…)." (EMS manager, facility B) "(…) 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."
		Organizational culture and leadership	"(…) 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…" (EMS staff, facility A)
		Team member consistency	"(…) 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" (EMS Staff, Facility A). "(…) 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 housekeepers are very understaffed, so they're rushed (…)." (Infection preventionist, facility A) "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 (…)." (EMS staff, facility B) "(…) 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?" (EMS manager, facility B)
Organization	Facilitators	Education/Training	"(…) We also do hands-on training. Well, I believe hands-on is probably the most effective." (EMS manager, facility A) "(…) 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 (…)." (EMS staff, facility A) "Training occurs annually and quarterly, as noted before. If one person did the training of new people and review for the older guys, then the rooms would be cleaned in the same way – a routine would be developed. When we move from unit to unit, we can take the routine with us and add those things for that unit." (EMS 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." (EMS manager, facility A) "The EMS management, myself, and others, we maintain frequent communication with the Pentad, [VA leadership] and that really brings us to the table (…)." (EMS manager, facility B) "(…) 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).
		Team member consistency	"(…) 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 [EMS] 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 Results: Organization section
		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." (EMS manager, facility B)
		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) "(…) They [EMS staff] can read the language and the atmosphere [on the patient unit] as to the flow and when things are gonna happen [admissions, transfers, and discharges]. They can plan their day around being able to read body language and signals [of the nursing staff], and that nursing communication board (…)." (EMS manager, facility B)

Table 2. Themes and Exemplar Quotes within the *Person* Component

Component	Barriers and Facilitators	Theme	Participant Quotes
Person	Barriers	Patient disturbance	See Results: Person section
		Knowledge/Experience	"(…) But with the high turnover, I can't keep 'em in the one or two areas that they were trained in (…)." (EMS manager, facility B)
Person	Facilitators	Serving patients	"(…) I love being around the vets, and sometimes you get to know the Vets. You build bonds, like the ones who have been here." (EMS staff, facility A)
		Preventing infections	"So, in our breakroom we have a little (…) quote that's up on the wall. (…) that says, 'One good housekeeping aide will do more to prevent the spread of infection than 12 doctors,' so we truly believe that, and we try to reinforce that with our staff (…) How well they do their job is critical to the patient's outcome. (EMS manager, facility B)
		Knowledge/Experience	"We have all the tools we need to clean any kind of surface, just need to utilize the right cleaner." (EMS staff, facility A)

According to 5 US Code 3310, a 2013 law that governs Title 5 government employees, housekeeping aid positions are restricted to veteran hires.[18] In 2022, 5 US Code 3310 was amended to allow nonveteran hires when veteran eligibles are not available.

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

These hiring difficulties led to low staffing and assignment inconsistencies that affect teamwork within the area where cleaning occurs. Without consistent staff assignment, EMS staff felt unable to integrate into the healthcare team. Stakeholders also noted the power of staffing consistency.

> "(…) 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 (…)." (EMS manager, facility A)

Stakeholders reported that understaffing had practice implications, such as rushing through cleaning processes, and that perceptions, including quality of cleaning practices, may be compromised:

> "Things are gonna get missed. Quality control is gonna go down and something bad's gonna happen. But staffing is ALWAYS an issue." (EMS staff, facility A)

Inadequate staffing levels can also create training issues, and training is critical for EMS staff performance, as one EMS manager (facility B) noted:

> "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."

EMS staff education and training lacked standardization. Interviews revealed various training methods such as online training, training during staff meetings, peer shadowing, train-the-trainer activities, and hands-on training. Facilitators reported by interviewees largely centered around preferred training methods and best practices to improve training. Simulation (or hands-on) methods and train-the-trainer methods were preferred approaches to training:

> "In training (…) new ones [EMS staff], I like to pair 'em up with a real good housekeeper that's been here for quite a while and work side by side with 'em. That hands-on training is probably your best. (…)." (EMS manager, facility B)

The interviews highlighted several best practices for optimizing standardized training:

> "(…) We converted a housekeeping aide position to a GSI [VA pay scale] training specialist, and she solely dedicated to training for housekeeping personnel." (EMS manager, facility B)

Person

Multiple people are involved in the work process for environmental cleaning. Overlap of these processes has been described in other SEIPS components such as the communication (ie, organization component) required for room cleaning. Table 2 outlines key themes identified within the person component. Many EMS staff were veterans who were highly motivated to serve fellow veterans, especially to prevent them from acquiring infections. Although cleaning was perceived to be important for patient safety, there was also a perception that cleaning may be disruptive to patients.

> "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." (EMS manager, facility B)

And

> "(…) sometimes you can do that [clean] and sometimes you can't because some patients don't want you in there." (EMS staff, facility C)

EMS staff understood the technical knowledge required for the position, especially understanding the multitude of chemicals used. There was also acknowledgement of the need to understand the intricacy of 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)

And

> "(…) 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)

Tools and technology

Themes identified within the tools and technology SEIPS component (Table 3) included having effective cleaning products, but sometimes these products and/or equipment were in limited supply. Staff noted on several occasions that the introduction of new products, supplies, and/or equipment improved the cleaning process.

Table 3. Themes and Exemplar Quotes within the *Tools/Technology* Component

Component	Barriers and Facilitators	Theme	Participant 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 Medical Support Assistant] 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 (. . .)."* (EMS staff, facility A)
		Cleaning audits not standardized across facilities	*"(. . .) 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) When asked whether cleaning was routinely monitored, an infection preventionist (facility C) stated: *"No, I would say it's [cleaning monitoring] randomly."*
		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 (. . .)."* (EMS staff, facility A)
Tools and Technology	Facilitators	Checklists	*"(. . .) 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) *"(. . .) 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 (. . .)."* (EMS 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)

"(. . .) The rag issue [limited supplies], 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 (. . .)." (EMS staff, facility B)

And

"He's [EMS] 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)

Interviewees at most sites reported some form of monitoring (ie, 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 to provide useful information.

"I think that it [audits] should be mandated across the country that environmental management reports data (. . .)." (EMS manager, facility B)

Several staff mentioned that automated bed management systems (BMSs) could facilitate communication required for efficient notification and management of room cleaning, but some facilities lacked 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 component of the SEIPS framework (Table 4). Stakeholders reported that moving patients from one room to another occurred frequently for various reasons (eg, isolation or patient acuity) which greatly affected 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." (EMS manager, facility B)

EMS staff were reportedly motivated to clean high-touch surfaces but also found that cleaning the room with the patient present in the room was difficult:

"(. . .) But day shift, their primary task is doing daily cleanings and (. . .) they're supposed to hit the bathroom, high-touch areas." (EMS staff, facility A)

And

"But, as far as the patient bed, you know, it's, while they're in it, it's hard [cleaning]. You know?" (EMS manager, facility C)

Another theme included challenges with cleaning reusable medical equipment (RME) such as ambiguity regarding who was responsible for cleaning (ie, EMS or the end user) and cleaning complex or delicate equipment:

"It depends on the equipment. There's certain things we clean and there's certain things that are assigned to certain people (. . .)." (EMS staff, facility A)

Environment

Table 5 lists the themes identified within the SEIPS environment component. Room design was important when semiprivate rooms were reported to be harder to clean than private rooms. However, small private rooms with multiple medical equipment were also challenging:

"I mean you get two patient beds (. . .) big chairs (. . .) trying to get in there and work around everything, it's challenging (. . .)." (EMS manager, facility C)

And

"They're [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." (EMS manager, facility B)

Table 4. Themes and Exemplar Quotes within the *Task* Component

Component	Barriers and Facilitators	Theme	Participant 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 (…)." (EMS 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 (…)." (EMS 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 (…)" (EMS Manager, Facility C)
		Reusable medical equipment, complex and not standardized	"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." (EMS staff, facility C) "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 (…)." (EMS 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 (…)." (EMS, 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 (…)." (EMS manager, facility B)

Table 5. Themes and Exemplar Quotes within the *Environment* Component

Component	Barriers and Facilitators	Theme	Participant 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." (EMS staff, facility B) "Yes, especially the double patient, double-bedded rooms. It, our rooms, are NOT big enough." (EMS manager, facility C)
		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 (…)." (EMS 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)
		Semiprivate 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 (…)." (EMS staff, facility A)
Environment	Facilitators	Design of room	"(…) 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 um or behind stands and that type of thing (…)." (EMS staff, facility A)
		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 (…)." (EMS manager, facility B)

Furniture and surface finishes were important and could be considered a barrier to or facilitator of cleaning:

"(…) I think our bathrooms have tile and grout, which makes [cleaning] it tough (…)." (Nurse manager, facility B)

And

"(…) We need to have high quality, easy to clean, easy to maintain equipment. (…) you cannot skimp on cost (…)." (EMS manager, facility B)

Adapted SEIPS model for environmental cleaning

Our study identified important components of the work system that could be barriers or facilitators to environmental cleaning. Based on these findings, we developed a SEIPS model outlining essential work-system components for cleaning (Fig. 2). The adapted SEIPS model can be used when evaluating the status of facility or unit-level cleaning program or processes to elicit comprehensive feedback from stakeholders and to provide specific actionable entry points for improvement efforts.
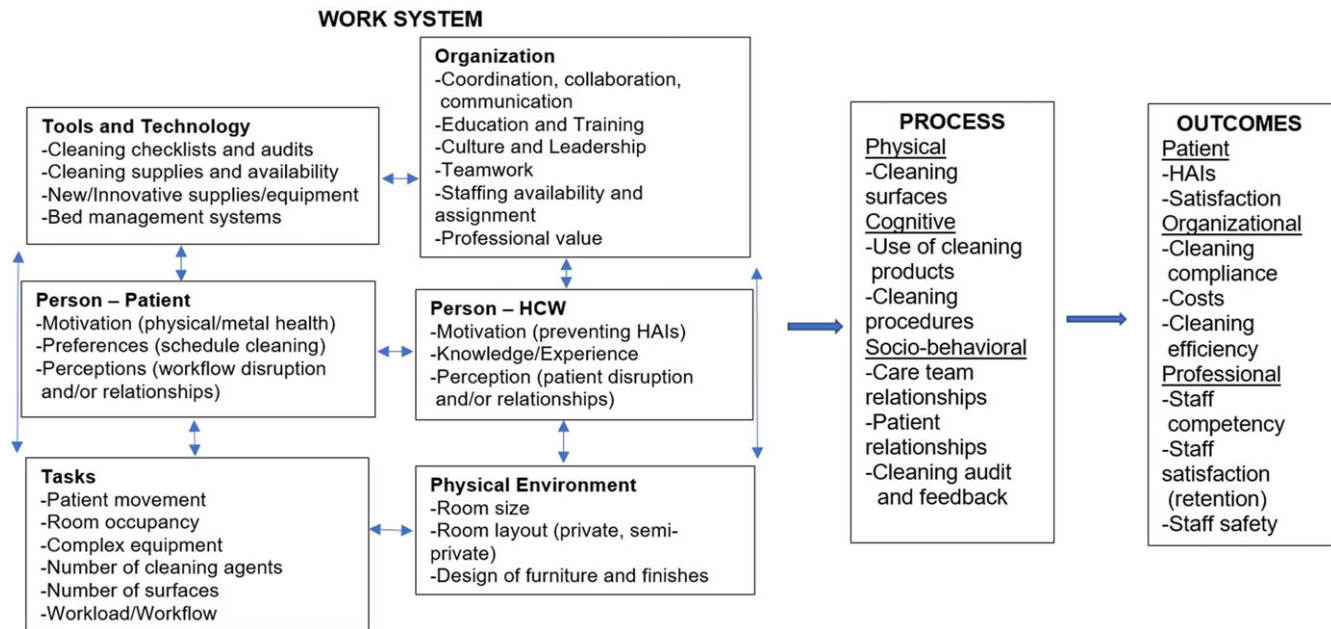
Figure 2. SEIPS 2.0 model adapted for environmental cleaning.

Discussion

In this study, we identified several work-system facilitators of and barriers to environmental cleaning. One notable finding was that EMS staff, many of whom are veterans, were especially motivated to serve the veteran population. We previously reported findings from interviews with hospitalized veterans, and many reported enjoying having fellow veterans EMS staff to converse with and even had feelings of bonding and camaraderie, which may promote a healing environment.[18] Our team also identified the need create a work environment for EMS staff to be viewed as a valued member of the healthcare team and potential ways for healthcare organizations to improve EMS work climate.[19]

A central theme was the staffing challenges reported by stakeholders, which affected assignment consistency, cleaning practices, teamwork, and training. Hiring policies within the VA, particularly when hiring EMS staff, are legislated and thus are beyond the scope of this manuscript. However, investing in EMS staff once employed may be a viable solution and has been previously proposed by providing or incentivizing specialized certification.[20,21] The nursing profession has identified the role of specialty certification and improved patient outcomes, including reducing HAIs.[22] Evidence shows that certification of healthcare professionals who infection prevention and control (ie, CIC) results in improved care processes and HAI outcomes.[23,24] 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 reported that 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 although the evidence varies, further study is warrented.[25] Education and training of EMS 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 (eg, peer

coaching and train-the-trainer activities), and online computerized courses. Many respondents believed that simulation training was extremely effective, and we have reported these findings separately.[26]

Communication emerged as a challenge within the work system. Notification of EMS for room cleaning during admissions, transfers, and discharges (ie, patient throughput) was especially challenging. Although various communication methods were used (eg, nursing boards, light systems, phone calls or pagers, signs, etc), many staff agreed that implementation of an automated BMS could facilitate this process. Delays in patient flow can lead to poor patient outcomes, and automated BMS have improved patient throughput.[27]

Audit and feedback of environmental cleaning is a mainstay recommendation for infection prevention and control programs.[28] Most stakeholders reported some type of audit and feedback in place, but it was highly variable in method and consistency. Audit and feedback of healthcare processes is associated with improvements in practice,[29] and efforts to standardize this practice are critical.

Another important theme was the concern that having a patient in the room during cleaning may be interpreted by staff as disruptive to patients. EMS staff may feel unnecessarily rushed or may avoid cleaning all together, leading to less thorough cleaning or low compliance. Previous qualitative studies have reported this barrier to cleaning, as staff report circumventing cleaning near patients to avoid disturbing them.[30] EMS staff also felt that it was more difficult to do daily cleaning when someone was in the bed. We have previously reported that surfaces were less likely to be cleaned when the patient was in the room during daily cleaning.[32] Although the VA has national guidance for environmental cleaning procedures, which includes a procedure for daily cleaning for occupied rooms,[31] detail is lacking on how to optimize cleaning around patient care articles and belongings (ie, clutter) that can prevent easy access to environmental surfaces. We previously reported the presence of clutter in both acute-care and LTC

settings; the presence of clutter was particularly prevalent in LTC settings.[32] These findings may represent opportunities for interventions such as simulation-based competency assessments.[33]

EMS staff were acutely aware of the determinants of environmental cleaning within the context of the physical environment. EMS staff should be involved in the selection of healthcare furniture and finishings as well as healthcare design (or redesign) of patient care areas to ensure that cleaning is optimized. EMS involvement in healthcare design has been recommended previously.[34]

This human-factors analysis (ie, HFE) of environmental cleaning provides multiple opportunities for interventions. The use of HFE has long been recommended[35] to advance patient safety because it uses the understanding of human performance in complex systems to target and develop interventions. The SEIPS model, which integrates HFE principles and has been adapted for environmental cleaning by another group,[36] highlights multiple intervention entry points to consider. There is recent interest in collaborative efforts of HFE (understanding of human performance in complex systems) and quality improvement (knowledge of complex systems to make changes) to address sustainability of patient safety interventions.[37] Findings from these studies can be used to evaluate interventions in real-world settings such as future quality improvement or implementation science initiatives that address staffing issues through professional recognition and staff training.

The study is the first multisite human-centered work-system analysis of environmental cleaning within VA acute and long-term care. The study findings are limited to a descriptive analysis, but identification of multiple points of entry for intervention have been identified for future study. And although the results are not generalizable to non-VA settings, the VA is the largest healthcare system in the United States, and many of the themes identified will resonate in non-VA healthcare settings.

In conclusion, a work-system analysis using SEIPS identified common determinants of environmental cleaning processes, which provide multiple entry points for interventions. Incorporating cleaning practices that address the determinants identified here may facilitate more standardized cleaning of environmental surfaces. Interdisciplinary collaboration between researchers, especially those with HFE, quality improvement and/or implementation science expertise and healthcare clinical and ancillary staff is needed to develop and test interventions that are systems oriented, person centered, and design driven to standardize environmental cleaning work-system processes. A recent report by our group demonstrated the use of SEIPS to evaluate an antimicrobial stewardship intervention to reduce fluoroquinolone prescriptions in intensive care units.[38] Successful implementation strategies utilized in this project mirrored those identified to be important in our study: leadership, communication, education, and feedback. Future research should evaluate similar implementation or quality initiatives utilizing these strategies when targeting individual work-system components of cleaning, especially those designed to standardize processes that overcome barriers and incorporate best practices.

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