American Journal of Infection Control 49 (2021) 919–927

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

State of the Science Review

Factors associated with environmental service worker cleaning practices in health care settings: A systematic review of the literature

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Key Words:
Health care-associated infection
Cleaning staff
Environmental disinfection
Infection control
Training
Feedback

Introduction: Health care-associated infections can be reduced through better environmental disinfection practices. Central to effective disinfection is the environmental service worker (ESW). The aim of this systematic literature review was to identify factors associated with the disinfection practices of ESWs in health care settings.

Methods: A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses principles. Ten online databases and search engines were selected for the review of English-language studies published between 2000 and 2019.

Results: Thirty-one (31) eligible studies were identified. Environmental disinfection was associated with many factors (eg, knowledge, perceptions) as well as ESW exposure to education/training sessions. When education/training was combined with performance evaluation/feedback, significant improvement in ESW disinfection practices was reported.

Conclusions: To sustain improvements in disinfection practices, education/training sessions need to be continuous. The long-term commitment of an organization is also essential for continuous improvement in disinfection outcomes. While knowledge transfer is critical for behavior change, education/training also needs to focus on the skills and perceptions of ESWs. Future studies need to use a randomized controlled design with larger sample sizes to determine a true effect.

Health care-associated infections (HAIs), a complication of the health care system, are clearly linked to high morbidity, mortality, and costs.[1] For many years, reducing the number and burden of HAIs has been a priority of public health agencies in the United States,[2,3] and while progress has been made, a substantial burden from HAIs, including surgical site infection, and central-line and catheter-associated blood stream infections, persists.

Many HAIs involve microorganisms transmitted person-to-person via direct and indirect contact, such as methicillin-resistant *Streptococcus aureus, Clostridioides difficile,* and vancomycin-resistant *Enterococcus*, among others.[2,4] In direct contact transmission, microorganisms are transmitted directly from one colonized person to a susceptible person, whereas indirect contact transmission involves a contaminated intermediate object (or fomite), such as the hands of a health care worker, a medical device, or an environmental surface. Indirect contact transmission can be protracted, as some microorganisms persist in the environment for days or weeks.[5-8] Environmental disinfection may reduce indirect contact transmission of HAIs as it aims to remove infectious agents from fomites in the health care environment.[9]

While environmental disinfection appears to be a relatively simple task, disinfection is in fact a complex process resulting from individual, organizational, and work environment factors.[10] Central to effective disinfection is the environmental service worker (ESW).[11,12] Numerous studies have demonstrated that disinfection may be ineffective or inconsistent,[5,13-15] but there is less knowledge about factors associated with ESW disinfection practices. The aim of this systematic literature review was to identify factors associated with the disinfection practices of ESWs in health care settings. The 2

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Funding/support: This work was partially supported by a grant (R01 HS025987-03) from the Agency for Healthcare Research and Quality.
Conflicts of interest: None to report.

https://doi.org/10.1016/j.ajic.2021.01.001
0196-6553/

research questions informing the review were: (1) What factors are reported to be associated with good environmental disinfection practices? (2) What factors are reported to be associated with poor environmental disinfection practices? The long-term goal of this review is to inform interventions and future research to improve environmental disinfection.

METHODS

Search strategy

A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses principles. Peer-reviewed articles published in English between January 2000 and August 2019 were included in the search. The selected online databases and search engines were—Academic OneFile, Academic Search Complete, Agricola, CAB Abstract Archives, CINAHL Plus with Full Text, Food Science and Technology, MEDLINE with Full Text, PubMed, Science Direct, and Web of Science Core Collection. The following combination of search terms was used—("*Service worker*" OR "*Custodial worker*" OR "*Janitorial worker*" OR "*Caretaker*" OR "*Housekeeper*" OR "*Environmental service worker*" OR "*Cleaner*" OR "*Cleaning personnel*") AND ("*Knowledge*" OR "*Behavior*" OR "*Training*" OR "*Education*" OR "*Awareness*" OR "*Perception*" OR "*Attitudes*" OR "*Opinion*" OR "*Beliefs*" OR "*Barriers*") AND "*Cleaning.*" Since Science Direct does not have a similar input option for search words, search word combination was entered into the advanced search option as—Find articles with these terms—("*Knowledge*" OR "*Behavior*" OR "*Training*" OR "*Education*" OR "*Perception*" OR "*Attitudes*" OR "*Opinion*" OR "*Beliefs*" OR "*Barriers*"). Title, abstract, or author-specified keywords—("*Service worker*" OR "*Custodial worker*" OR "*Janitorial worker*" OR "*Caretaker*" OR "*Housekeeper*" OR "*Environmental service worker*" OR "*Cleaning personnel*") AND "*Cleaning.*" For all databases except for Web of Science Core Collection, the abstract option was used to input the search keywords. For Web of Science Core Collection, because of not having an abstract option, the *topic* option was used under basic search.

Study selection

All citations yielded from the initial search were saved to Legacy RefWorks (RefWorks LLC, MD), and duplicate articles were eliminated. Then, the title and abstract of each remaining article was independently screened by 2 researchers, using 3 eligibility criteria: (1) peer-reviewed, (2) published in English, and (3) environmental disinfection studied in health care systems in the United States and other developed countries. Review articles were excluded. The focus on developed countries was motivated by the wide variety of resources and quality of health care systems globally.

Full texts were retrieved when the title and abstract met all 3 eligibility criteria. Reference lists of review articles and retrieved full texts were hand searched to identify additional articles for screening. Two independent reviewers analyzed all full text articles and categorized them as either an intervention or an observational study.

Quality assessment

The Downs and Black checklist was used to evaluate study quality (Downs and Black). This checklist is designed to be used with randomized and nonrandomized studies and includes 27 items categorized into 5 topics: reporting, external validity, internal validity—bias, internal validity—confounding, and power, with the highest score being 28. Two researchers independently rated each item for each article (yes = 1, no = 0, unable to determine = 0 or not applicable) and reconciled differences through discussion. Because all items are not applicable to all studies, the quality score was reported as the percentage of applicable items that were met, rather than the total score.

RESULTS

Literature search strategy and selection

The initial search yielded 1,125 articles, and records identified through other sources yielded 8 additional articles. The duplicate removal function in Legacy RefWorks removed 218 duplicate articles, resulting in 915 articles (Fig 1). Title and abstract screening excluded 877 articles. Among the remaining 38 articles, 5 were determined irrelevant and were removed. The reference lists of the remaining 33 articles were hand searched, and 26 additional articles were identified, and hand searching yielded 4 additional articles. A total of 63 articles received full-text review. After full-text review, 32 articles were removed based on our 3 eligibility criteria—articles not related to disinfection (n = 19), conducted in a developing country (n = 4), reviews (n = 3), incorrect setting (n = 2), abstract only (n = 2), publication year (n = 1), and a brief report explaining fluorescent markers (n = 1). A total of 31 articles were included in our study.

Quality assessment

The average quality percentages for observational and intervention studies were 50.37% and 52.02%, respectively (range from 26.67% to 77.78% in all studies; Supplementary Material 1). Studies consistently reported their: hypothesis, aim, or objective; main outcomes; main findings, and use of data dredging. Intervention studies generally lacked control groups, blinding, and long-term follow up after the intervention ceased. Only 3 of the 31 studies (9.7%) included a power analysis.[16-18]

Study characteristics

Articles were designated observational (n = 9) or intervention (n = 22) studies. Articles were published between 2006 and 2019. Studies were conducted in the United States (n = 20), Canada (n = 5), Australia (n = 4), or the United Kingdom (n = 2). The studies were conducted in hospitals (n = 23), medical centers (n = 7), or nursing homes (n = 1). Among the intervention studies, 17 (77%) reported the duration of the study, which ranged from 6 weeks to 8 years. Study sample sizes varied widely, with observational studies including 6-327 ESWs and intervention studies including 1-36 health care sites. In observational studies, tools used to collect data from ESWs included: paper surveys (n = 2),[19,20] online survey (n = 1),[15] interviews (n = 3),[21-23] focus groups (n = 1),[24] and direct observations of ESWs (n = 2).[25,26] Among the intervention studies, 4 used surveys to collect data from ESWs.[27-30] All intervention studies assessed surface cleanliness using: fluorescent markers (n = 11), microbial assessments (n = 10), or ATP bioluminescence assays (n = 2). Nine (41%) intervention studies measured change in infection rates.

All interventions were education and/or training programs directly targeting ESWs. Delivery methods included: presentations (n = 1),[14] instruction booklets (n = 1),[27] photographs (n =1),[31] checklists (n = 1),[32] online education modules (n = 1),[33] demonstrations (n = 6),[13,14,18,27,29,32] and not described (n = 11). The most frequently covered topics in the trainings were: importance of environmental disinfection (n = 12), importance of disinfecting frequently touched objects (n = 7), and transmission of health care-associated pathogens and infections (n = 6). Opportunities for providing feedback during the intervention was reported as a motivational strategy in many studies to improve performance. In 7 studies, results about disinfection effectiveness were provided to ESWs before the intervention; in 15 studies, the feedback was provided at different stages of the study (eg, several times

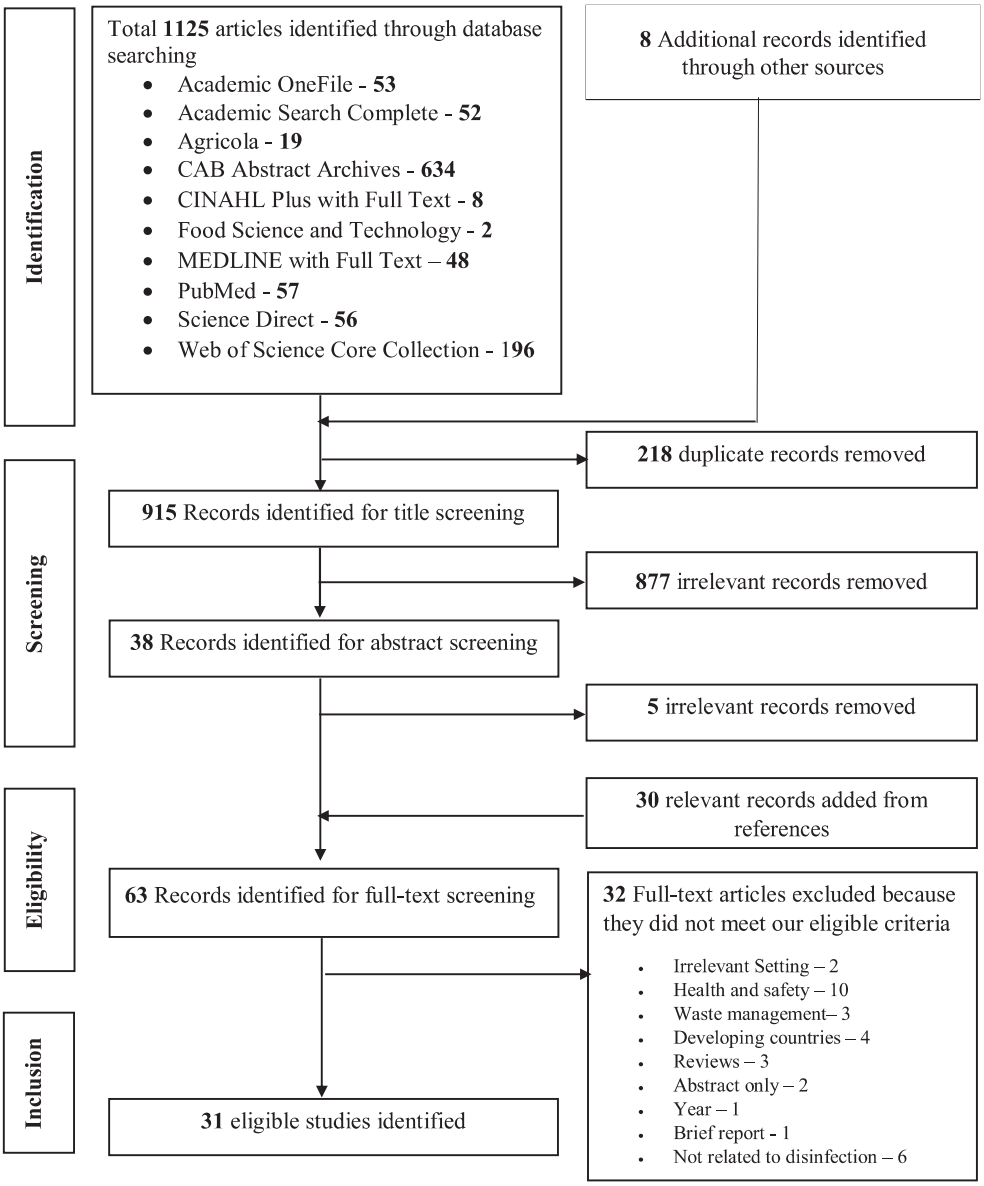

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart describing the results of the literature search procedure.

during the intervention period or after the intervention). After providing feedback, additional education was provided in 3 of these studies.[14,34,35] Four interventions were skill based and focused on how to implement a disinfection practice or procedure.[14,32,36,37] Two studies used a crossover design.[16,38] Four studies used a "bundle" of activities,[17,27,29,35] such as training, technique, product, audit, and communication. Three studies conducted question/answer sessions,[5,14,28] and 2 presented real-time solutions to problems.[5,14]

Study data extraction

Results extracted from each article were categorized into demographic/facility characteristics, individual factors, and outcome measures. They are presented in Table 1.

Observational studies

Demographic characteristics of participating ESWs were reported in 8 of 9 observational studies.[15,19-24,26] Only 3 studies reported facility characteristics,[15,22,26] such as type or size of the facility. Six studies reported ESWs had received training,[15,19,21-24] with more than 80% of the ESWs in 3 of these studies agreeing they received the required training to do their job.[15,19,21] The content, methods, and frequency of ESW trainings, however, was not clearly reported in most studies.

Knowledge. Gaps in ESW knowledge were observed across 2 broad content areas—disinfection and knowledge about pathogens. Knowledge gaps related to disinfection identified in specific studies included: correct use of a one-step disinfectant,[20] correct use of UV light disinfectant devices,[15] and disinfectant contact time.[19] Gaps related to knowledge about pathogens included: inability to correctly identify common pathogens spread via contaminated surfaces.[19] When asked, ESWs reported interest in regular classes or more training.[15,20]

Attitudes and perceptions. Six observational studies assessed ESW attitudes and perceptions,[15,19-21,23,24] and found that while ESWs perceived themselves as having low social status and providing little value to the organization, the vast majority perceived that their work

Table 1
Definition of variables

Variables		Definition
Demographic/facility characteristics		Demographic characteristics include individual attributes of the ESW, such as years of experience, age, gender, language, and received trainings.[71]
		Facility characteristics refer to physical attributes, such as type of facility, number of wards, and number of beds.[71]
Individual factors	Cognitive	Cognitive factors center around the knowledge gained by ESWs, such as theories, facts, or interactions, that learned in the past, recall or recognized and apply to regular situations in workplace.[72]
	Affective	Affective factors refer to intellectual experiences, emotions, or degree of acceptance or rejection, such as personal values, feelings, appreciation, enthusiasm, and motivation.[73]
	Behavior	Behavioral factors center around activities performed by the ESW. These practices include identification of tasks, developing methods, organizing and allocating responsibilities, and coordinating activities.[74]
Outcome measures		The outcome measures are those measurements used to evaluate the effect of the intervention.[75]

was very important in keeping patients safe and preventing infections.[15,19,20] ESWs take pride in their work and satisfaction with the quality of their disinfection practices.[20,21,24] Some ESWs perceived safety concerns in their work from cleaning/disinfection chemicals,[15,23] and from getting an infection at work.[15,24]

Beliefs and opinions. Beliefs and opinions about the ESW occupation were measured in 5 studies.[15,19-22] When asked, most ESWs reported that they could request help or advice from their managers or co-workers, but ESWs were more likely to report that their views were listened to rather than asked for.[21] The percentage of ESWs that reported being given respect and appreciation for their work or to be trusted in their work, varied among studies.[15,20,21] When asked, more than half of participating ESWs reported receiving useful feedback,[15,21] or expressed willingness to participate in a performance evaluation/feedback program, if it would not affect their job evaluation.[19]

Perceived barriers. In 7 studies ESWs reported a variety of barriers they faced while disinfecting surfaces.[15,19-21,23,24,26] Few reported barriers associated with resources, such as a shortage of disinfection supplies.[19,26] In one study, ESWs expressed a preference for a one-step disinfectant,[24] but challenges to using a one-step disinfectant were reported in another study.[20] Interruptions were reported as a barrier in 3 studies, where interruptions included disturbances by individuals (patients, family members, co-workers, etc) and from lack of resources.[15,24,26] Nearly 30% of respondents in 2 studies reported insufficient time to complete their tasks,[15,19] and ESWs in these studies also reported communication problems, such as notice when rooms were ready for disinfection, and lack of clarity about disinfection responsibilities. Time pressure was linked to understaffing,[23] the need for rapid room turnover,[24] and ad hoc disinfection requests.[21] Disinfection around the patients was reported to be affected by clutter,[15] and patient need for conversation.[21]

Practices. Disinfection practices of ESWs were measured in 5 studies.[15,22,24–26] Two studies reported the duration of room disinfection, which was longer for discharge disinfection and rooms of patients on contact isolation.[22,26] A variety of disinfection methods was reported among facilities for disinfecting of high-touch surfaces in nursing homes, though all ESWs used cleaning carts that contained multiple cleaning/disinfecting products and tools.[22] With respect to the disinfection process, Xie et al found that a "local disinfection" pattern was less effective than clockwise/counterclockwise, horizontal/vertical, or random disinfection patterns.[26] Saeb et al reported that the facilities studied followed a "5 and 7 steps" routine, which includes emptying trash, disinfecting horizontal surfaces, spot cleaning walls, dust-mopping floors, and disinfecting the commode.[22] The use of alcohol-based hand sanitizers among ESWs after disinfecting *C difficile* isolation rooms was examined in 2 studies, and while one study found ESWs to understand the limitations of this product,[24] the other study found 63% of ESWs used this product.[15]

Intervention studies

Participation of ESWs. All interventions studied directly targeted ESWs (ie, education/training, feedback related to environmental disinfection), though one study limited training to ESWs dedicated to disinfecting "gray zones" in the hospital ward.[38] Only 4 studies engaged ESWs in the research in other ways, specifically through surveys.[27-30] Two studies conducted both pre- and postsurveys, examining change over time.[27,29] In contrast, Matlow et al administered a survey in conjunction with focus groups.[28] In one study, a written survey was administered, but the results were not reported.[30] Only one study reported including an ESW in the study team.[27]

Knowledge. The 2 studies with pre- and postintervention surveys focused mostly on knowledge related to disease prevention.[27,29] In general, they found ESW knowledge to be high before the intervention and to remain high after the intervention. Significant improvement was seen in the identification of frequently touched surfaces.[27,29] One study found no improvement in knowledge of disinfectant contact time.[27]

Beliefs and opinions. Beliefs and opinions about the ESW occupation were measured in 3 intervention studies.[27-29] Focus groups performed in one study identified the theme of "me/us versus them" affecting many levels of workplace interactions—among ESWs, between shifts, among job classifications, and with patients; but which could be improved through more positive feedback.[28] Exemplar quotes for these themes emphasized aspects of work load and poor work performance by others. The 2 studies that included pre- and postintervention surveys did not find a lot of change with respect to attitude, beliefs, or opinions.[27,29] Allen et al, however, reported improvement in ESW opinions of hospital support for new methods to improve hospital hygiene and hospital investment in ESW hygiene training and associated resources.[27] Mitchell et al found that more than half of responding ESWs agreed that they felt supported, appreciated, and listened to, yet the majority of ESWs agreed or felt neutral about the statement "I feel overwhelmed by work demands." The vast majority of ESWs agreed that they like getting feedback about their work.[29] When asked, ESWs expressed pride in their work, and an interest and expectation in doing a good job.[28,29]

Outcome measures. Effectiveness of environmental disinfection was the main outcome for the intervention studies, except for one study that measured change in ESWs' knowledge and attitudes.[29] Various data collection methods were used to measure effective disinfection, including fluorescent markers (n = 11), microbial assessments (n = 10), and ATP bioluminescence assays (n = 2)[14,44] with 2 studies using 2 measures.[37,39] All studies assessed disinfection effectiveness on frequently touched objects (FTOs), but the frequently touched objects assessed varied among studies. Two studies directly observed ESWs disinfection.[32,40]

Nine studies also measured the change in infection rate, including HAIs caused by methicillin-resistant *Staphylococcus aureus* (n = 5), vancomycin-resistant *Enterococcus* (n = 5), *C difficile* (n = 5),

Staphylococcus aureus (n = 1), methicillin-sensitive *Staphylococcus aureus* (n = 1), and multiple drug-resistant *Klebsiella* species (n = 1). Five studies measured infections from more than one microorganism.[16,17,27,36,38] The infection rate was measured using microbial cultures in 4 studies,[16,18,33,41] and 5 reported using hospital surveillance data.[17,27,35,36,38]

Factors associated with environmental disinfection

The authors of all studies reported interventions had a significant positive effect on environmental disinfection practices (Table 2). The common factor associated with better practices in all studies was education/training.[5,13,14,16-18,27-42] The sustainability of the intervention effect, however, was not assessed in most studies. For example, Murphy et al found that when face-to-face education was not provided for ESWs in the washout period, the overall effectiveness of disinfection significantly reduced in 1 of the 2 participating hospitals, indicating normal operations and interactions with infection prevention personnel were insufficient to maintain the improved practices.[30]

Besides education/training, performance evaluation with feedback was the most influential factor associated with improved environmental disinfection.[5,13,14,17,18,29-42] Seven studies included a preintervention performance evaluation to ESWs, while 15 provided performance evaluation at multiple times during the intervention or after the intervention. Other interventions that had positive impacts on disinfection effectiveness included: assigning some ESWs special duties, such as to disinfect frequently touched surfaces[16,32] or gray zones,[38] requiring approval from a supervisor or infection prevention personnel before the room could be occupied by the next patient,[32] notifying ESWs of monitoring in advance,[14,39] and direct supervision during disinfection.[40]

Among the 9 studies that measured infection rates as an outcome, 7 reported a significant reduction in at least one infection measured. The 2 studies that did not find a change in infection rates did observe a significant improvement in disinfection.[18,27] There are many possible explanations for observing improved disinfection but not infection rates, including: transmission through surfaces that were not targeted in the intervention, insufficient disinfection[18], and even transmission through other routes.

DISCUSSION

The aim of this systematic literature review was to identify factors associated with the disinfection practices of ESWs in health care settings with the intent that findings can inform disinfection practices in health care settings. Well-designed and properly executed studies are needed to reliably build the evidence base about environmental disinfection. However, not all evidence is of equal quality. If the quality of evidence is not considered, inaccurate conclusions could be drawn that lead to ineffective practices.[43] A wide array of quality assessment tools is available to evaluate the quality of evidence in health care studies.[44] The Downs and Black checklist, which we used, was chosen because it was designed to assess the quality of both randomized and nonrandomized studies.[45] By grading the quality of each study, researchers not only summarize the evidence but rate its strength.[46]

The intervention studies reviewed generally lacked control groups and blinding of participants, reducing confidence that the intervention caused the outcome. Many reviewed observation and intervention studies involved a small number of ESWs at one or a few sites, limiting the generalizability of results, particularly given the contribution of individual, organizational, and work environmental factors that affect disinfection practices. Power calculations were rare among the intervention studies, but they are important to ensure an optimal sample size to detect a meaningful effect. While presumably most studies were intended to provide lasting change in the facility, only Dumigan et al articulated a guiding quality improvement framework.[14] Overall, the reviewed intervention studies lacked rigor, which when considered with the short duration of most studies, suggest that the evidence is weak about the sustainable impact of education/training interventions. Nonetheless, the reviewed studies identified many shared themes about the experience of being an ESW.

Only one reviewed study was conducted in a long-term care facility, all others were conducted in hospitals. Long-term care facilities have been reported to pay considerably less attention in disinfection than hospitals,[47] perhaps because of limited staff, insufficient infection prevention education, and staff perception of isolation and contact precautions.[48] In fact, as of 2020, only 29 US states require staff training on infection control practices (unpublished data). The lack of information about disinfection practices and effectiveness in long-term care facilities is a key gap in the literature, highlighted by the high burden of HAIs associated with indirect contact transmission in these facilities.[49,50]

Qualitative data collection procedures, such as focus groups, were only used in one observational study and one intervention study; other studies utilized surveys. These methodological approaches trade off between nuance in understanding the experience, attitudes, and beliefs among ESWs and sample size.[51,52] A mixed methods approach could provide a more holistic understanding of environmental disinfection. A participatory research framework could also be valuable to understand the experience of ESWs and improve disinfection effectiveness. Allen et al included one ESW on their study team,[27] but true participatory research provides a role for ESWs to develop the research question and intervention. The pride expressed by ESWs in their work, as well as self-reported interest in education/training, and feedback suggests that given workload accommodations, ESWs are likely to be interested in participatory research to improve disinfection effectiveness.

Education/training was the basis for all intervention studies and focused on improving the technical skill and knowledge of ESWs (eg, procedural knowledge[53]). While procedural knowledge is important for effective disinfection, it does not address many of the barriers identified by ESWs, such as high work demands,[29] "me/us versus them,"[28] interruptions, low status or value for ESWs,[15,19,20] and lack of communication.[15,19] These barriers suggest that training should address organizational and work environment factors, as well as intrapersonal and interpersonal skills of ESWs. Even in a skills-focused field like environmental service, leadership, self-management, conflict resolution, communication, emotional intelligence, and other "soft-skills" are necessary to perform the job effectively.[54]

The most reliable method to assess disinfection effectiveness is the reduction of pathogens measured before and after disinfection. Microbial assessments are challenging though, which is why they are not used more frequently. There are financial and administrative constraints, along with the need for readily accessible laboratory facilities and qualified individuals, typically limiting their usage to outbreak investigations, policy evaluations, or research studies.[55] On the other hand, nonmicrobial methods also have limitations. ATP bioluminescence is low in sensitivity and specificity and fluorescent markers are incapable of assessing bioburden.[56] Under ideal circumstances both microbial and nonmicrobial methods should be used to assess disinfection effectiveness.[37,39]

Many observational and intervention studies measured conceptual knowledge (ie, concepts, facts, and theories)[53] related to infection prevention. Such knowledge—the "why"—has been shown important in adult education. Many ESWs may not be able to understand advanced microbiology,[57] so information in some areas (eg, pathogens) should be simple. For example, rather than giving detailed descriptions of what pathogens are, the focus should be on

Table 2
Factors reported across 31 studies associated with the study outcome measures

		Author/Date	Individual factors					Outcome measures		Intervention		Effect of intervention to outcomes
			Cognitive	Affective			Behavior					
			Knowledge	Attitudes and perceptions	Beliefs and opinions	Perceived barriers	Practices	Infections rate	Effectiveness of environmental disinfection	Training/ education	Performance evaluation and feedback	
Observational studies	1	Bernstein et al, 2016[15]		SD	SD	SD						
	2	Boyce et al, 2010[25]					SD		SD			
	3	Jeanes et al, 2012[21]										
	4	Jennings et al, 2013[19]										
	5	Pedersen et al, 2018[20]										
	6	Saeb et al, 2017[22]					SD					
	7	Xie et al, 2018[26]				+/–	+/–		+/–			
	8	Yanke et al, 2018[24]										
	9	Zuberi et al, 2011[23]										
Total studies reported				1	1	2	3		2			
Interventional studies	1	Allen et al, 2018[27]	+		SD/ NSD			NSD	+	+		+
	2	Boyce et al, 2009[39]							+	+	+	+
	3	Carling et al, 2008[13]							+	+	+[IN]	+
	4	Carling et al, 2010[34]							+	+	+	+
	5	Dancer et al, 2009[16]						+	+	+		+
	6	Datta et al, 2011[36]						+	+[IN]	+	+[IN]	+
	7	Dumigan et al, 2010[14]							+	+	+[IN]	+
	8	Eckstein et al, 2007[5]							+	+	+[IN]	+
	9	Goodman et al, 2008[37]							+	+	+[IN]	+
	10	Guerrero et al, 2013[40]							+	+	+[IN]	+
	11	Hayden et al, 2006[41]						+	+	+	+[IN]	+
	12	Hota et al, 2009[42]							+	+	+[IN]	+
	13	Matlow et al, 2012[28]			NSD				+	+		+
	14	Mitchell et al, 2018[29]	SD/NSD		SD/NSD					+	SD/NSD	+
	15	Mitchell et al, 2019[17]						+/NSD	+	+	+[IN]	+
	16	Murphy et al, 2011[30]							+/–	+	+[IN]	+
	17	Ragan et al, 2012[31]							+	+	+[IN]	+
	18	Ray et al, 2017[18]						NSD	+	+	+[IN]	+
	19	Semret et al, 2016[38]						+/NSD		+	+[IN]	+
	20	Sitzlar et al, 2013[32]							+	+	+[IN]	+
	21	Smith et al, 2016[33]						+		+	+[IN]	+
	22	Watson et al, 2016[35]						+		+	+[IN]	+
Total studies reported			2		3			9	18	22	19	22

NOTE.
+ Significantly positive relationship reported in the factor/outcome measure.
– Significantly negative relationship reported in the factor/outcome measure.
+/– Both significantly positive and negative relationship reported for the same factor/outcome, in different events.
+/NSD Both significantly positive relationship and no significant difference reported for the same factor/outcome in different events.
SD Significant difference reported in the factor/outcome measure (not reported positive or negative).
NSD No significant difference reported in the factor/outcome measures.
SD/NSD Both significant difference and no significant difference reported for the same factor/outcome, in different events.
+[IN] Indirectly stating a significant positive relationship (reported as part of the intervention).

Table 3
Summary of key findings

		Key findings
Individual factors	Knowledge	• Gaps - correct use of a one-step disinfectant and UV light disinfectant devices - disinfectant contact time - identification of frequently touched surfaces
	Attitudes and perceptions	• Environmental service workers recognized their importance • Proud and satisfied with work • Concern safety over cleaning/disinfection chemicals and becoming infected
	Beliefs and opinions	• Respect, appreciation, and being trusted varied among studies • Received useful feedback and willing to participate such programs • "Me/us versus them" affected workplace interactions • Overwhelmed by work demands
	Perceived barriers	• Shortage of cleaning/disinfection supplies • Interruptions (by patients, family members, co-workers, etc) • Insufficient time • Patient clutter and patient disturbances
	Practices	• Duration of disinfection longer for discharge disinfection and rooms of patients on contact isolation • Disinfection methods and instructions varied
Outcome measures		• All but one intervention studies measured effectiveness of environmental disinfection • Nine studies measured change in infection rates
Factors associated with environmental disinfection		• Education/training coupled with performance evaluation/feedback improved environmental disinfection practices

how these pathogens can spread in hospital environments and what procedures ESWs can implement to prevent the spread of pathogens. Moreover, procedural knowledge (ie, techniques, skills, and procedures needed to "do" things)[53] can only be assessed through direct observations.[58] However, despite the value of direct observations, only 2 intervention studies included it in ESWs disinfection.[32,40]

All intervention studies provided limited information about the guiding theory of education or learning used as the underpinning of the intervention, if one was used at all. The interventions targeted adult learners (ie, ESWs), therefore, study investigators could draw from the robust literature about adult education and learning theory. Adult learning theories address various learning styles and encourage engagement in the learning process through real-life scenarios as a means to optimize training outcomes.[59,60] Several studies reported on-the-job training by peer demonstration. This approach, while understandingly useful and cost/time effective, has the potential to propagate incorrect practices so its use should be closely monitored.[61] No matter which training approach is used, it is important to provide ongoing feedback to ESWs.[62] Nearly all intervention studies evaluated the ESW performance and gave feedback in different stages. This performance evaluation/feedback process encourages employees to strive for continuous self-improvement, helps to detect performance gaps, and focuses them on work-related behavior.[63] Combining performance evaluation/feedback with education/training sessions showed a significant improvement in disinfection throughout the review.

Even with the ongoing COVID-19 pandemic highlighting disease transmission in health care facilities, environmental services is still an occupation that receives little attention in society,[64] and carries low occupational prestige in the United States.[65] In the United States, many ESWs are immigrants, people of color, and receive low wages.[66] The reviewed studies identified many ESWs who feel limited respect, appreciation, or positive feedback at work, yet ESWs consistently identified the need to do the job well. They are concerned about patient safety, which forces them to do a good job even if it takes too much time[67] and they are possibly underappreciated. Even though most aspects that lead to job satisfaction (eg, respect, appreciation, and positive feedback) were observed to be low, surprisingly, high job satisfaction was reported in 3 studies.[27-29] These results support the argument of the Taylors motivation theory—lower paid jobs like environmental services may only be well motivated by money or monetary benefits.[68] According to Ramlall et al, motivated employees will remain in the organization for a longer period of time, resulting in a lower employee turnover rate, which is cost-saving for the organization.[69]

LIMITATIONS

Additional studies might be published that were not included in the databases that we searched. Also, only including articles published in English and those published before the year 2000 might have excluded some articles. Lastly, some studies that were included in our initial search might have been excluded as ESWs were not clearly mentioned as the participants of the study.

CONCLUSIONS

The ESW plays a central role in effective disinfection, illustrating why it was important to identify factors associated with ESWs environmental disinfection practices. Knowledge is a prerequisite for behavior change but knowledge alone does not always translate into practice. Interventions must also focus on improving the attitudes and perceptions of ESWs in regards to environmental disinfection. ESW recognized their importance and were proud and satisfied with their work (Table 3). However, respect and appreciation of their work varied among studies. Perceived barriers to implementing environmental disinfection practices included shortage of supplies, interruptions, insufficient time, and patient clutter and patient disturbances. Disinfection methods and instructions varied making it sometimes difficult to properly implement. Education/training sessions, combined with performance evaluation/feedback, were reported to significantly improve ESW disinfection practices. However, these improvements were not sustained so training needs to be continuous and not a one-time effort.

To build the evidence base about environmental disinfection, improvements are needed to how studies are designed and executed. Studies limited to a short period of time did not demonstrate a sustained and long-term impact of the interventions. Therefore, longitudinal studies are needed with adequate time to investigate changes and whether these changes are sustainable over time. Further, researchers used different definitions for surface cleanliness making it difficult to compare results across studies.[70] Moreover, implementing a new intervention could disrupt routine disinfection practices. Likewise, uncontrollable factors, such as changes in the ESW or managerial level staff, could disrupt implementation of the intervention. Specific plans to mitigate these kinds of challenges and minimize

their effect on study outcomes needs to be addressed. Another concern is that direct observations could lead to a Hawthorne effect so needs to be addressed in the study implementation.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2021.01.001.

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