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Review

Interventions to improve hand hygiene compliance in emergency departments: a systematic review

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SUMMARY

The emergency department (ED) is where hand hygiene problems are significant as the procedures in the ED are often high risk and invasive. To date, there have been no comprehensive reviews on hand hygiene in EDs. The aim of this study was to investigate hand hygiene compliance (HHC) rate, factors affecting the HHC rate, and intervention strategies to improve HHC in EDs. Electronic databases were used to search for research published from 1948 to January 2018. The databases included ovidMEDLINE, ovidEMBASE, the Cochrane Library, CINAHL, Koreamed, and Kmbase. All study designs were included. Two reviewers independently extracted the data and assessed the bias risk using reliable and validated tools. A narrative synthesis was performed. Twenty-four studies, including 12 cross-sectional surveys and 12 interventional studies, were included. Of the 12 interventional studies reviewed, only 33% ($N = 4$) reported HHC rates of more than 50%. Factors that influenced HHC included types of healthcare worker, hand hygiene indication, ED crowding, positive attitudes towards HHC, patient location, auditing hand hygiene, and type of shift. Almost all of the studies (83.3%) applied multimodal or dual interventions to improve HHC. A range of strategies, including education, monitoring and providing feedback, campaigns, and cues, effectively improved HHC. The review findings indicate that there is a room for improvement in HHC in EDs. Future randomized controlled trials are necessary to determine which intervention modalities are most effective and sustainable for HHC improvement.

Introduction

Healthcare-associated infections (HCAIs) are key issues related to patient safety. Indeed, 5–15% of hospitalized patients experience HCAIs in developed countries, and recent European studies also reported that 4.6–9.3% of hospitalized patients experience HCAIs in hospitals [1]. For this reason, it is strongly recommended that healthcare organizations prioritize

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the surveillance and prevention of HCAIs to ensure patient safety. One such guideline was proposed by the World Health Organization (WHO), which states that there are five moments when healthcare providers should practice hand hygiene during patient care to prevent HCAIs: (1) before touching a patient, (2) before a cleaning procedure, (3) after exposure to body fluids, (4) after touching a patient, and (5) patient surroundings [2]. As such, hand hygiene of healthcare providers is an important component to prevent HCAIs [3]; however, compliance with these WHO guidelines is low (22–60%) [4].

Emergency departments (EDs) are where the hand hygiene problem is significant as the procedures in EDs are often high risk and invasive, and there is limited time to evaluate whether patients are susceptible to infections or likely to transfer an infection to others [5]. Furthermore, a systematic review of hand hygiene compliance (HHC) in the EDs was inconclusive, as HHC rates ranged widely from 7.7% to 89.7% [6]. Suboptimal management of HCAIs in EDs due to a failure to adhere to hand hygiene recommendations results in a threat to patient health [7]. Also, the potential harm is growing as more patients are admitted to hospitals through EDs [8]. For this reason, there is a need to conduct a comprehensive review on HHC in EDs. This study therefore conducted a systematic review to examine the HHC rate, factors affecting the HHC rate, and intervention strategies to improve HHC in EDs.

Methods

We registered the review protocol in PROSPERO (i.e. the International Prospective Register of Systematic Reviews; http://www.crd.york.ac.uk/prospero/) under the following registration number: PROSPERO 2016 CRD42016041965.

Criteria for Considering Studies for this Review

Types of studies. Randomized controlled trials, controlled clinical trials (non-randomized controlled trials), before and after studies, and cross-sectional studies that investigated HHC rate or effectiveness of interventions to improve HHC in EDs were included. Studies focusing on the compliance of various healthcare workers were included if they included an HHC rate specific to EDs. Studies with medical or nursing students were excluded. Only reports in English or Korean were included in this review.

Types of participants. The target population were healthcare service providers working in EDs in hospitals. Therefore, the participants were nurses, physicians, residents, healthcare assistants, and therapists.

Types of interventions. Studies that reported or estimated HHC rates or provided the data to calculate HHC were included. Intervention studies intended to improve HHC to reduce HCAIs in EDs were also included.

Types of outcome measures. Studies that reported or estimated the HHC rate through objective measurement including direct observation and camera surveillance were included, as were studies that included the data through which it was possible to calculate the HHC rate.

Exclusion criteria. Studies were excluded if: the study participants were emergency medical technicians providing emergency services outside the hospital, and nursing and/or medical students focused on observing rather than practicing in a clinical setting; (2) the HHC rate was measured by proxy indicators such as product usage; (3) the studies were conducted during an outbreak of HCAIs; and (4) HHC was measured with self-reported data.

Data Sources and Search

The search was conducted using Ovid MEDLINE, Ovid EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). Korean databases included Koreamed and Korean Medical database (KMbase). The Medical Subject Headings (MeSH) term 'exp Handwashing/' and 'exp Emergency Service, Hospital/' were used, and keywords for the search were 'hand antisepsis', 'hand cleaning' 'emergency room', and 'emergency department'. No limitation was set regarding language, and the search was performed through January 2018 (see Appendix 1).

Study Selection and Data Extraction

Two independent reviewers on the research team selected the studies according to the pre-specified eligibility criteria. They independently screened the titles and abstracts. Potentially relevant full texts were then retrieved for selection. A study was excluded if both reviewers agreed that it did not meet the eligibility criteria. Inconsistencies in study selection were resolved through a discussion with a third reviewer. The two reviewers on the research team then extracted the data independently using a standardized form. The data extraction form included: the study design, country of publication, number and characteristics of the participants, response rate, sampling method, factors influencing HHC, details of the intervention, follow-up periods, and primary/secondary outcomes. Any disagreements regarding extracted data were resolved via consensus with a third reviewer.

Assessment of Bias Risk in the Included Studies

Two reviewers independently evaluated the methodological quality of the included studies. For non-randomized studies, the Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS) tool was applied [9]. RoBANS consists of six domains: selection of participants, confounding variables, measurement of the intervention/exposure, blinding of outcome assessments, incomplete outcome data, and selective outcome reporting. We judged the risk of bias of each study as 'high', 'unclear' or 'low' based on the RoBANS tool. For correlational, non-experimental, or cross-sectional study designs, quality-assessment tools were used to assess four areas of each study: research design, sampling, measurement, and statistical analysis for a total of 14 possible points assigned from 13 criteria [10]. Any disagreement was resolved through discussion or consultation with a third reviewer.

Data analysis

Because there was substantial heterogeneity of the studies included in this review with respect to severity of the patient's condition when they visited the ED, ED crowding, definition of HHC measurement, and healthcare system, a descriptive analysis (narrative synthesis) was conducted.

Results

From the database search, the titles and abstracts of 973 studies were screened for the eligibility criteria. The full texts of 57 studies with potential relevance were retrieved and reviewed, among which 33 were excluded according to the exclusion criteria. As a result, 24 studies on HHC in EDs were included in this review (see Figure 1).

Details of the Included Studies

Of the studies included, 12 were cross-sectional surveys and 12 were interventional studies, including eight before and after studies, two interrupted time series, one post-intervention study, and one quasi-experimental study (see Table I). In the majority of the before and after intervention studies, HHC was measured through direct observation by medical students, hospital staff (e.g., nurses), and researchers; one study used surveillance cameras to collect the HHC data [4]. The follow-up duration of intervention studies ranged from 2 weeks to 3 years. Studies were conducted in various countries including the USA, Saudi Arabia, Italy, Germany, Canada, Japan, and South Korea.

Quality Assessment Results

With the original quality assessment tool for cross-sectional studies, scores of 10 or more out of 14 are considered high quality, scores ranging from five to nine are considered moderate, and scores less than 4 are considered low quality. However, the following three criteria were not applied to the cross-sectional studies included in this review: a reliable measure of the independent variable, internal consistency for the dependent variables, and handling of outliers. These three criteria were not available for the following reasons: (1) data were collected using direct observation by personnel or a camera, and (2) psychometric instrument tools were not used to capture the outcomes of interest. Consequently, reliability of the independent variables was not required. Therefore, eight of 12 studies were rated as high quality (with scores $\geq$8). The remaining four studies were evaluated as moderate quality ($4 \leq$ scores ≤ 7) (see Table II).

Eight of the 12 included studies had an appropriate sample size based on the rule of thumb of 10 cases per independent variable. In the majority of the studies (nine out of 12), the sampling methods were not carried out because direct observation was performed by all hand hygiene opportunities of staff members available in the EDs during investigation. Six of the 12

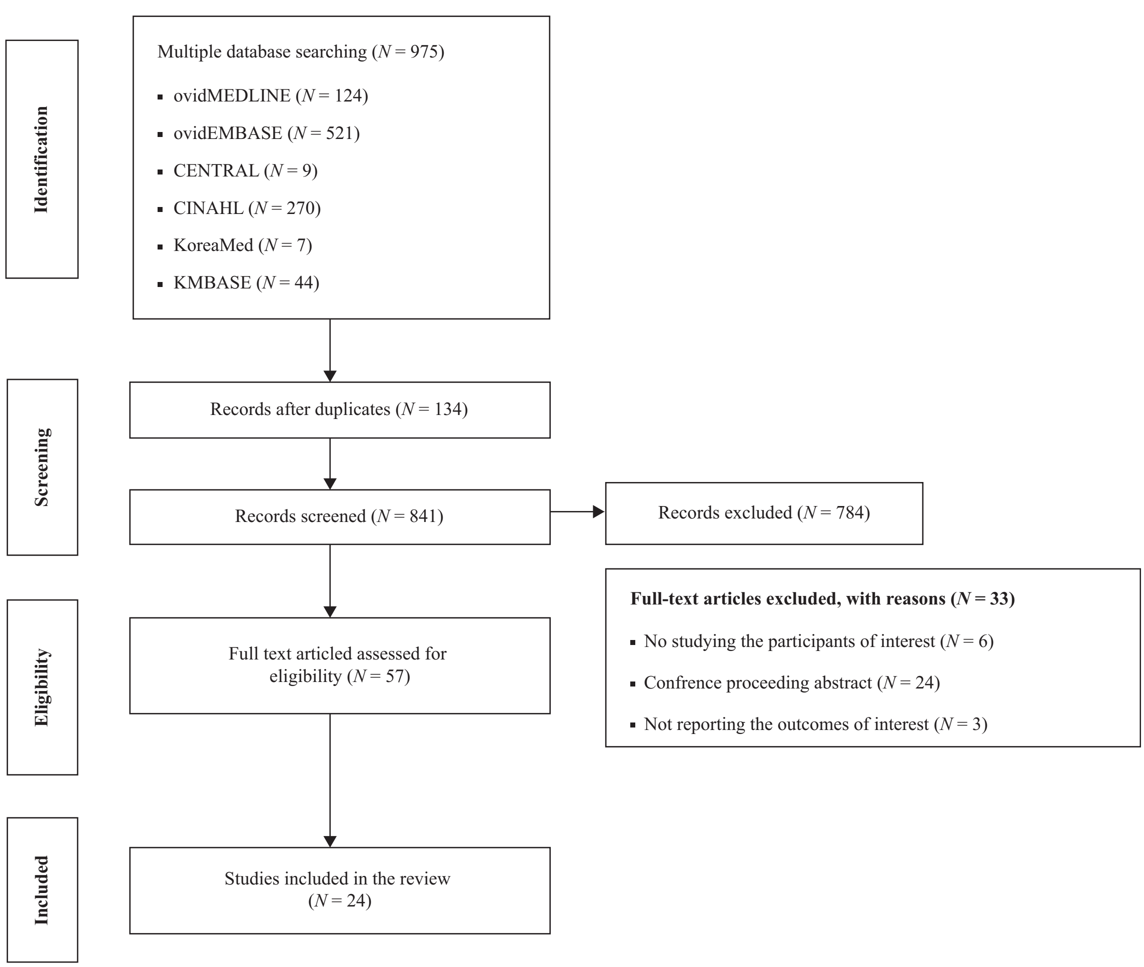

Figure 1. PRISMA flow diagram for the selection of studies.

Table I
Study characteristics of hand hygiene compliance (N=24)

First author, year	Study design/ country	No. of participants/ setting	Response rate (%)	Sampling method	Objective HHC measurement method	Standards for HH	Availability of ABHRs	Timing of HHC measurement	Study findings regarding HHC rate
Observational/survey studies (N = 12)									
Meengs et al., 1994	Observational study/USA	Total 35 Faculty 11 Resident 11 Nurse 13 /ED Total contacts 409 (clean 272, dirty 46, gloved 91)	100%	Convenience sampling	Investigators	- Clean dirty scales by Fulkerson (gloved and ungloved) -Frequency and duration	Yes	30 days	- 32.3% of total contacts (SD 2.31%) -28.4% of 272 clean contacts (SD 2.34%) -50.0% of 46 dirty contacts (SD 7.4%) -64.8% of 91 gloved contacts (SD 5.0%)
Picheansathian et al., 1995	Observational study/Thailand	40 nurses (23 RNs, 17 practical nurses) (no. of procedures: RNs 190; Practical nurses 113) /ED	100%	Convenience sampling	Investigator and a trained observer	- Before patient contact -After patient contact -After removing gloves or immediately after soiling with potentially infectious material	No	4 months	- RNs: 58% -practical nurses: 18%
Pittet et al., 2004	Cross-sectional survey/ Switzerland	163 physicians /Total 1266 physicians in the University of Geneva Hospital	94%	Convenience sampling	Two trained observers	- Three categories (high, medium, and low risk) guideline for HH -Failure to remove gloves after patient contract or between a dirty and a clean body site on the same patient	Yes	6 months	- Overall adherence of hospital: 57% -ED adherence: 50%
Al-Damouk et al., 2004	Observational study/UK	Doctors' patient episodes 65 UK 22 New Zealand 43 /ED	100%	Convenience sampling	Two medical students	- Before and after seeing patients and invasive procedures	No	Not reported	- HHC during patient consultations: 14% in the UK and 12% in New Zealand
Saint et al., 2009	Observational study/Italy	No. of before patient contacts 420 Nurse 239 Doctor 181 /ED	100%	Convenience sampling	A total of six students and one of the study authors serve as external observers	WHO protocol, focused on hand hygiene before contact with the patient	Yes	3 months	- Nurses: 19.2% -Doctors: 7.7%
Venkatesh et al., 2011	Survey/USA	No. of opportunities 5865 Physician's assistant 334 Physician 1841 Nurse 2333 Nurse's assistant 846 /ED	100%	convenience sampling	Five trained the ED research staff and one infection specialist	WHO protocol — focused on before and after contact with each patient or patient environment	Yes	16 months	- Total HHC: 89.7% -Physician's assistants: 96.7% -Physician: 91.9% -Nurse: 89.4% -Nurse's assistant: 89.6%
Martel et al., 2013	Cross-sectional study/Canada	Physician, nurse, resident, medical student /EDs (N = 114) Physician 10.7% Nurse 57.3%	99.1%	nonprobability convenience sample	Five medical students	Before and after patient contact	No	8 days	- Median objective compliance with respiratory hygiene measures of triage nurses was 22% (interquartile range 11—33%) -43% before patient contact and 53% after patient contact
Yanagizawa-Drott et al., 2015	Survey/Sweden	59 Swedish ED (institutional level) /ED	82%	Complete enumeration via e-mail	ED directors	Modified questionnaire regarding direct observation and regular feedback of HHC	No	3 months	- HHC rate of 80% or more: 43%
Muller et al., 2015	Cross-sectional study/Canada	Opportunities 1116 Nurse 68% Physicians 18% Other HCWs 14% /ED	100%	Convenience sampling	A trained observer	WHO protocol ED crowding markers	Yes	22 months	- mean HHC: 29% -nurses: 30% -physicians: 34% -others: 19%

(continued on next page)

Table I (*continued*)

First author, year	Study design/ country	No. of participants/ setting	Response rate (%)	Sampling method	Objective HHC measurement method	Standards for HH	Availability of ABHRs	Timing of HHC measurement	Study findings regarding HHC rate
Sakihama et al., 2016	Observational study/Japan	3545 HCW worker—patient observations /Four units (internal medicine, surgery, intensive care, and/or ED) /Four geographically diverse hospitals (one university hospital, three community teaching hospitals)	100%	Convenience sampling	Certified infection control nurse served as the sole external observer	WHO protocol	Yes	5 months	- Overall HHC: 19% (95% CI 18–20) -Physicians: 15% -Nurses: 23% -HHC in ED: 12.0–16.4%
Carter et al., 2016	Cross-sectional and observational study/USA	A total of 1673 HH opportunities were observed over the course of 199 observation periods /a large, urban, academic ED		All of the number of available ED HH opportunities	Four observers & research associates	WHO's 'My 5 Moments for Hand Hygiene'	No	4 months	- Nurses: 52.5% -Physicians: 59.3% -Nurse assistants: 53.5% -Others: 49.0%
Haac et al., 2017	Cross-sectional and observational study/USA	HCWs—patient interactions: 342 (RN, MD, technician, student, resident) No. of opportunities: 1034 /trauma resuscitation unit		Convenience sampling	Video surveillance system to mitigate potential Hawthorne effect	WHO guidelines Glove use	No	1 month	- Overall HHC: 7% (71/1034) -3% (10/375) before patient contact -0% (0/178) before a clean procedure -11% (2/19) after body fluid contact -15% (57/376) after patient contact -2% (2/86) after contact with the environment
Interventional studies (N = 12)									
Dorsey et al., 1996	Before and after study/USA	Baseline 132 Post-intervention 120 EPs (emergency physicians), RNs, NPs (nurse practitioners) /ED			A single observer	CDC handwashing guidelines	No	After 2 weeks	- HHC at before vs. after intervention EPs 38% → 41% RNs 50% → 63% NPs 65% → 72%
Larson et al., 2005	Quasi Experimental study/USA	• No. of opportunities 5568 (ED and pediatric intensive care unit) 153 h of observation • Manual alcohol dispensers vs. touch-free alcohol dispensers			Three research assistants	CDC guidelines	Yes	4 months	- No. of episodes of HH per patient per hour, mean (SD) Manual: 3.33 (2.7) vs. touch-free: 4.42 (2.8) ($P = 0.04$) -No. of episodes of HH before contact with a patient per hour, mean (SD) Manual: 1.26 (1.74) vs. touch-free: 1.58 (1.59) ($P = 0.003$)
Haas et al., 2008	Before and after study/USA	No. of opportunities 757 Physician 329 Nurse 288 Other 139 /ED			A single trained observer	WHO's hand hygiene protocol	Yes	Baseline, post intervention, 1 month, 3 months	- Baseline: 43% -Post-intervention: 62% -1-month intervention: 53% -3-month intervention: 51%
Homa et al., 2011	Before and after study/USA	Physicians, other HCWs (no. of participants was not mentioned) /ED			Trained infection prevention staff members	Count before and after direct contact with the patient or patient's immediate environment	Yes	Started in 2006, follow-up was performed between March 2008 and December 2009	- HHC in 2006: 41% → 91% in 2009 -Physicians: 64% -ED: 81%

di Martino et al., 2011	Pre-post intervention study/Italy	ED of pediatric hospital Doctors 19 Nurses 28 Auxiliary staff 6	—		Two observers	Before patient contact	Yes	Intervention for 2 weeks, Pre- (3 months) —post (3 months) and follow-up (4 months) observation for 11 months	- Overall HHC of pre-intervention: 14.3% → post-intervention: 44.9% → 1-year post intervention: 45.2% -Nurses: 40.7% → 49.8% ($P = 0.03$) -doctors: 50.5% → 36.5% ($P = 0.008$)
Bukhari et al., 2011	Post-intervention study/Saudi Arabia	Doctors Nurses Healthcare technicians (no. of participants was not mentioned) /ED			Infection control practitioners and nursing health educators	WHO's 'My 5 Moments for Hand Hygiene'	Yes	1 year	- Doctors: 20% -Nurses: 60% -Healthcare technicians: 50%
Scheithauer et al., 2013	Prospective, tri-phase before and after study/Germany	No of opportunities 5674 physicians, nurses, medical students, trainees /ED	—	—	One highly trained observer of infection control team	Modified version of the WHO observation record	No	30 weeks (three 6-week observation phases interrupted by two 6-week interventions)	- Phase 1: 21% → phase 2: 29% → phase 3: 45% ($P < 0.001$) -Trainee nurses: 30% in phase 1: 33% in phase 3 -Nurses: 18% in phase 1→ 45% in phase 3 -Physicians: 26% in phase 1 → 43% in phase 3
Schmitz et al., 2014	Before and after study/Ethiopia	baseline (N = 217) Post-intervention (N = 250) /ED			A single observer trained the WHO's HH observation method	Only two WHO protocols 1. Before patient contact 2. After contact with a patient or patient surroundings	Yes	Post- 4 weeks	- Overall HHC: 5.1% at baseline → 12.7% at post-intervention
Wiles, 2015	Before and after study/USA	Emergency nurses and technicians (N = 95)	—		Hospital staff internal and external to ED	CDC guidelines	Yes	3 months after the project	- Mean HHC 70% at baseline → 84% at post-intervention → 81% at 3 months follow-up
Oh, 2015	Post-intervention study/South Korea	RNs, physicians and transferers (N = 533) /tertiary and educational children's hospital	—	—	Five trained nurses	WHO protocol	Yes	2 months	- HHC in post-intervention in ED: 97.2%
Arntz et al., 2016	Before-and-after study/The Netherlands	57 ED nurses and ED physicians /ED and level 1 trauma centre	—	—	Two medical students were educated on the five HH indications during internship at the ED	'My 5 Moments of Hand Hygiene' defined by WHO protocol	Yes	Baseline, after first, second, third intervention week, 4 weeks apart	- HHC: 18% baseline → 41% after the first intervention→ 50% at the second intervention week → 46% at the third intervention week -Nurses: 12.4% at baseline (95% CI 8—14) → 47.0% at the third week (95% CI 30—48; $P<0.001$) -Physicians: 27.4% at baseline (95% CI 20—34) → 43.6% at the third week (95% CI 26—45; $P=0.013$)
Jeanes et al., 2017	Before-and-after study/UK	No. of opportunities: 621 & 729 & 711 in 2012—2014 (nurse, doctor, healthcare assistant, therapist, others) /ED			Infection control practitioners and auditors who had received training in HH	A new developed monitoring tool	Yes	2012—2014	HHC: 89% in 2012 → 92% in 2013 → 92% in 2014

ABHR, alcohol-based hand rub; CDC, Centers for Disease Control and Prevention; CI, confidence interval; ED, emergency department; HCW, healthcare worker; HH, hand hygiene; HHC, hand hygiene compliance; RN, registered nurse; SD, standard deviation; WHO, World Health Organization.

Table II

Results of the quality assessment of the 12 included observational and correlational studies

First author, year	Design		Sample				Measurement					Statistical analysis		Total	Grading
							Independent variable		Dependent variable						
	Prospective study	Probability sampling	Appropriate/ justified sample size	Sample drawn from more than one site	Anonymity protected	Response rate >60%	Reliable measure of independent variable	Used a valid instrument for measurement of independent variable	Dependent variables were observed rather than self-reported**	Internal consistency for dependent variable ≥0.7	Theoretical framework or model used for guidance	Correlations analysed when multiple effects studied	Outliers managed and addressed in study		
Meengs et al., 1994	1	1	0	0	1	1	NA	0	2	NA	0	1	NA	7/11	Moderate
Picheansathian, 1995	1	0	0	1	1	1	NA	0	2	NA	0	0	NA	6/ 11	Moderate
Al-Damouk et al., 2004	1	1	0	1	1	1	NA	0	2	NA	0	0	NA	8/ 11	High
Pittet et al., 2004	1	1	1	0	1	1	NA	1	2	NA	0	1	NA	10/ 11	High
Saint et al., 2009	1	0	1	1	1	1	NA	1	2	NA	0	1	NA	9/ 11	High
Venkatesh et al., 2011	1	1	1	0	1	1	NA	1	2	NA	0	0	NA	10/ 11	High
Martel et al., 2013	1	0	1	1	1	1	NA	0	2	NA	0	0	NA	7/ 11	Moderate
Muller et al., 2015	1	1	1	0	1	1	NA	0	2	NA	0	1	NA	8/11	High
Yanagizawa-Drott, et al. 2015	1	1	1	1	1	1	NA	0	2	NA	0	1	NA	9/ 11	High
Carter et al., 2016	1	1	1	0	1	1	NA	1	2	NA	0	1	NA	9/ 11	High
Sakihama et al., 2016	1	1	1	1	1	1	NA	1	2	NA	0	0	NA	10/ 11	High
Haac et al., 2017	0	1	0	0	1	1	NA	1	2	NA	0	0	NA	6/ 11	Moderate

1or 2: Yes, 0: No. NA, not applicable. *The final score is out of 11 instead of 14 because 'reliable measurement of independent variable,' 'internal consistency for dependent variable ≥0.7,' and 'handling outliers' were not applicable to the cross-sectional study of hand hygiene compliance.

**This item scored 2 points, and all others scored 1 point according to quality assessment tool for correlational, non-experimental, or cross-sectional study designs.

included studies attempted to examine relationships between various factors and HHC. None of the studies used a theoretical framework to guide the research.

The results of the quality assessment in the non-randomized studies are presented in Table III. With respect to the selection of participants, measurement of exposure/intervention, and selective outcome reporting, all of the included studies were low risk of bias. One-third of the included studies were inadequate regarding the adjustment of confounding variables. In only six of the 12 included studies, the observers who collected the data were blinded to the participants to prevent the Hawthorne effect. Also, 42% of the included studies did not include sufficient information about their methods for handling attrition bias.

Outcomes

HHC. Of the 12 studies that were reviewed, 41.7% ($N = 5$) reported HHC rates of more than 50% in EDs [11–15]. In a study of physicians in university hospitals, the overall HHC rate was 57%, but adherence in EDs was 50%. The overall HHC rate in an urban, academic ED, which is defined as the use of an alcohol hand rub or standard handwashing before and after contact with each patient or patient environment, was 89.7% (95% confidence interval (CI), 88.9–90.5%) [12]. In a cross-sectional survey of Swedish EDs, 43% of the responding institutions reported that the most recently audited HHC rate was greater than 80% [13]. In a single-site, observational study, overall HHC of EDs was 53.6% among observed hand hygiene opportunities, and the HHC rate of physicians was the highest at 59.3% [14]. In a study of registered nurses and practical nurses, overall HHC rate was 58% in registered nurses; however, the HHC rate preceding patient contact was 2% [15]. The remaining eight studies reported a low HHC rate that ranged from 7% to 32.3% (see Table I).

Factors associated with HHC. The majority of the included cross-sectional studies (nine out of 12) examined predictors of HHC in EDs. The types of healthcare workers, hand hygiene indications, ED crowding (ED workload), positive attitude toward HHC, patient location, auditing hand hygiene, and type of shift were reported as determinants that influence HHC (see Table IV). Eight out of 10 studies reported that nurses, as compared to physicians or other healthcare worker types, had high HHC [14–22]. In three studies, HHC was significantly lower when the ED was crowded than when the ED was not crowded [14,16,23]. Positive attitudes towards HHC predicted better HHC in two studies [11,24]. In one study, audits that took place at least monthly were an independent predictor of HHC [13], and one study reported the presence of infection control practitioner deployment as an influencing factor [22].

Intervention strategies to improve HHC. The interventions implemented within each study are summarized in Table V. Almost all of the studies (83.3%) applied a multimodal or dual intervention to improve HHC, and only two studies [25,26] implemented a single intervention strategy of access to and supply of hand sanitizer. According to the classification of intervention strategies used by Gould et al. [27], an educational strategy was the most common intervention. Monitoring and providing feedback on HHC was used in seven studies [5,18,20,21,28–30]. Campaigns to increase awareness of HHC that included marketing efforts were used in five studies [18,19,29–31]. Four studies used the provision of alcohol-based hand rub (ABHR) and/or soap and waterless hand sanitizer and the installation of touch-free dispensers of alcohol sanitizer. Three studies used cues to increase HHC by examining hands disinfected with a fluorescent rub-on under ultraviolet light [21,30,32]. Eleven interventional studies that applied campaign and educational strategies reported significant improvement in HHC after the intervention; only one [31] showed no significant improvement after the intervention.

Discussion

The findings of this systematic review on HHC from 12 cross-sectional studies indicated that the HHC rate in EDs varied from 7% to 89.7%. This could be explained by the differences in definitions of HHC, a variety of factors, such as lack of time, urgent clinical situation, overcrowding, heavy workloads, and staff shortages, and a complex and dynamic healthcare environment in ED. Although the burden of HCAI directly attributable to ED care is unknown, there is room for improvement of HHC in the rapid-paced, high-volume setting of ED care [33].

Table III
Quality assessment of the 12 included non-randomized studies using Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS)

First author, year	The selection of participants	Confounding variables	Measurement of exposure	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting
Dorsey et al., 1996	Low	Low	Low	Low	High	Low
Larson et al., 2005	Low	High	Low	Low	Low	Low
Haas et al., 2008	Low	Low	Low	High	Low	Low
Homa et al., 2011	Low	High	Low	High	Unclear	Low
Bukhari et al., 2011	Low	High	Low	Low	Low	Low
di Martino et al., 2011	Low	Low	Low	Low	Unclear	Low
Scheithauer et al., 2013	Low	Low	Low	High	Unclear	Low
Schmitz et al., 2014	Low	Low	Low	Low	Unclear	Low
Oh, 2015	Low	Low	Low	High	Unclear	Low
Wiles, 2015	Low	Low	Low	High	Low	Low
Arntz et al., 2016	Low	Low	Low	Low	Low	Low
Jeanes et al., 2017	Low	High	Low	Unclear	Low	Low

Table IV
Determinants increasing hand hygiene compliance in cross-sectional studies

First author, year	Determinants studied in included studies	Correlation r (P-value)/OR (95% CI)
Meengs et al., 1994	• The staff's level of training	- Nurses and faculty ($P<0.001$)
	• Gender	- Nurses and resident ($P<0.001$)
	• Whether the previous activity was clean, dirty, gloved	- Females were less than males ($P=0.007$)
	• The number of patient contacts	- Gloves increased hand hygiene frequency ($P<0.001$)
		- As number of contacts increased, faculty physician's frequency decreased (correlation r: -0.80; $P=0.003$)
Pittet et al., 2004	• A positive attitude towards hand hygiene after patient contact	OR (95% CI): 5.19 (2.17–12.4)
	• The belief that they were a model for other colleagues	OR (95% CI): 1.89 (1.03–3.47)
	• The awareness of being observed	OR (95% CI): 3.55 (2.00–6.28)
Saint et al., 2009	• Clinician type	Nurses and doctors: $P<0.001$
Venkatesh, 2011	• HCW type	
	- Physician	Adjusted RR (95% CI): 0.97 (0.95–0.99)
	- Nurse	Adjusted RR (95% CI): 0.94 (0.93–0.96)
	- Nurse's assistant	Adjusted RR (95% CI): 0.96 (0.93–0.98)
	• ED unit	
	- Observation unit	Adjusted RR (95% CI): 0.93 (0.89–0.96)
	• Patient location	
	- Hallway	Adjusted RR (95% CI): 0.89 (0.86–0.92)
	• Room visibility	
	- High	Adjusted RR (95% CI): 0.98 (0.97–0.99)
	• Glove use	
	- Yes	Adjusted RR (95% CI): 0.92 (0.89–0.94)
Martel et al., 2013	• Those for whom lack of comfort was considered an obstacle to wearing a mask.	$P=0.03$
	• Persons for whom 'tendency to forget' was a reason cited as obstacle toward mask wearing reported lower perceived compliance to recommendations than the other respondents	$P<0.001$
Yanagizawa-Drott et al., 2015	• Predictors of high HHC ($>80\%$): auditing hand hygiene at least monthly	$P=0.03$ Adjusted OR (95% CI): 5.72 (1.19–27.43)
Muller et al.,2015	• Healthcare workers	
	- Physicians	OR (95% CI): 1.0 (0.71–1.4)
	- Others	OR (95% CI): 0.51 (0.33–0.79)
	• Indication	
	- Before aseptic procedure	OR (95% CI): 0.36 (0.18–0.74)
	- After patient contact	OR (95% CI): 2.0 (1.5–2.7)
	• Time to physician assessment (reflecting ED workload)	
	- >1.5 h	OR (95% CI): 0.67 (0.51–0.89)
Sakihama et al., 2016	• The presence of infection control practitioner deployment by facility	$P<0.001$
Carter et al., 2016	• Night shift (20:30–08:30)	OR (95% CI): 1.37 (1.04–1.80)
	• Patient location	
	- Hallway	OR (95% CI): 0.73 (0.55–0.97)
	• Physician	OR (95% CI): 1.60 (1.25–2.04)
	• ED crowding	
	- Overcrowded ($101 =< \text{NEDOCS} <= 140$)	OR (95% CI): 0.56 (0.42–0.75)
	- Severely crowded ($141 =< \text{NEDOCS} <= 180$)	OR (95% CI): 0.63 (0.46–0.86)
	- Dangerously crowded ($\text{NEDOCS} >181$)	OR (95% CI): 0.39 (0.28–0.55)

CI, confidence interval; ED, emergency department; HCW, healthcare worker; NEDOCS = National Emergency Department Crowding Scale; OR, odds ratio; RR, risk ratio.

Table V
Intervention to improve hand hygiene compliance rate (N=11)

First author, year	Detail of intervention	Type of intervention
Larson et al., 2005	Installation of touch-free dispensers of alcohol sanitizer	Placement of ABHR only
Haas et al., 2008	Provision of a personal wearable alcohol gel dispenser	Placement of ABHR only
Buhbari et al., 2011	Daily audit Monthly staff education Quarterly workshops about hand hygiene Education material distribution of the WHO's posters of five moments	Multimodal intervention - Feedback (reinforcement) - Education
Homa et al., 2011	Explicit acknowledgment and support from organizational leaders regarding the importance of HHC Measurement and feedback of HHC and infection incidence Availability and improved accessibility to HHC products Standardized approach to education and training of staff about HHC Increased awareness of HHC through marketing efforts within the organization	Multimodal intervention - Feedback - Education - Campaign - Placement of ABHR
di Martino et al., 2011	Both physicians and nurses were educated about infection and hand hygiene via seminars and other educational sessions. The use of ABHR as a suitable substitute for soap and water was emphasized during the educational sessions. Physician and nurse champions were identified on each unit to promote HHC by modelling proper behaviour and wearing buttons that read ''Chiedimi se mi sono lavato le mani'' (''Ask me if I have washed my hands'') Pocket-sized, ABHR bottles (100 mL) were provided to all physicians and nurses	Multimodal intervention - Education - Campaign - Placement of ABHR
Scheithauer et al., 2013	1. General education about hand hygiene (twice) - Direct on-work observations with immediate feedback on an individual basis (1 week; 1 h/day) - Compiling and implementation of standard operation procedure for • Blood culture withdrawal • Placing and handling intravasal devices • Performance of IV medication • Wound dressing (change) • Placement of urinary catheter 2. General education about hand hygiene (once) - Direct on-work observation with immediate feedback on an individual basis (4 weeks; 1 h/day) - Re-evaluation and improvement of the standard operation procedure - Efficient distribution of the standard operation procedure - Compiling and implementation of a flowchart for standardized patient admission and workflow practices - Presentation of interim results as a training and motivational tool	Multimodal intervention - Education - Feedback
Schmitz et al., 2014	Making soap and commercially prepared waterless hand sanitizer available (a small bottle of 112 mL) for their personal use Training took the form of a 30-min didactic education session that focused on the importance of hand hygiene Posting visual reminders (over 250 posters) for hand hygiene throughout the entire hospital. 'Hand hygiene champions' who were leaders at the hospital and served as role models and facilitators of change Monitoring and providing feedback on hand hygiene practices	Multimodal intervention - Placement of ABHR - Education - Campaign - Feedback
Oh, 2015	Measurement and feedback of HHC Training and education that focused on the importance of hand hygiene, methods, and effects Experience of hand contamination with fluorescent material Increasing awareness of HHC through marketing efforts using the notice board and intra-network A change of the HHC rate was posted on pop-up windows.	Multimodal intervention - Feedback - Education - Cues - Campaign

(*continued on next page*)

Table V (*continued*)

First author, year	Detail of intervention	Type of intervention
Wiles, 2015	A UV light provided volunteers with a visual representation of HHC effectiveness Reinforced the HHC guidelines for staff Placed a small amount of microsphere powder in common locations (e.g., telephone, computer mouse area) and photographed using UV light after 2–4 h.	Multimodal intervention - Cues - Education
Arntz et al. 2016	Education on the five indications of HHC according to the WHO guidelines and the relevance of preventing hospital-acquired infections were provided daily Several reminders such as 75 pocket-sized flyers Screensavers illustrating the five WHO indications of HHC Assessments of HHC techniques were available to HCWs, which included examining hands disinfected with a fluorescent rub-on under UV light during the education sessions Daily feedback by newly appointed nurses as role models during the second period and continued through the third intervention period In the third intervention period, an undercover nurse was used who attempted to provoke colleagues to comment on his or her unprofessional behaviour	Multimodal intervention - Education - Reminders - Cues - Feedback
Jeanes et al., 2017	Improve the staff's hand skin conditions Improve hand hygiene product availability and reduce the number of overflowing waste bins Reduce the ambiguity and feasibility of HHC using hand hygiene imperatives or 'must do' rules Develop a tool to monitor HHC and a quality improvement plan	Multimodal intervention - Placement of ABHR - Feedback - Education

ABHR, alcohol-based hand rub; HCW, healthcare worker; HHC, hand hygiene compliance; UV, ultraviolet; WHO, World Health Organization.

This review also suggests that the use of a multi-dimensional strategy is an effective way to improve HHC among HCWs in EDs. A combination of education, campaign, feedback, supply of hand hygiene products, and cues could potentially raise the HHC rate in EDs. Overall, in the studies that implemented HHC improvement strategies, the magnitude of the effect on HHC varied widely from 9.1% to 50.0% [18,19]. This variation may be derived from factors such as HCWs' background knowledge and attitudes about the importance of HHC, ED crowding, staff levels of training, the number of patient contacts, monitoring and surveillance systems at the institutions, and type of intervention strategy. With respect to the study's methodological quality, the observational and cross-sectional studies that reported HHC rates were acceptable, which were rated as moderate to high quality. In the interventional studies, the overall risk of bias of the included studies could be regarded as moderate quality, although some of the studies did not adequately address how they handled confounding variables, blinding of HHC direct observation, and incomplete outcome data.

The results regarding factors affecting HHC in EDs from this review were similar to those of Erasmus et al. [34], despite the difference in HHC rate measures. HHC rates were lower in EDs than in other settings [17,18,35], lower among physicians than among nurses in most of the studies, and lower before as compared with after patient contact. A lower HHC rate was associated with ED workload when the ED had its highest level of crowding compared to when the ED was not crowded. Higher HHC rates were associated with accessibility of ABHR or gel.

Additionally, the existing literature included in this review mentioned that barriers to hand hygiene in the ED included ambiguity about when to perform hand hygiene [5], use of gloves [12], stress, activities with high risk of cross-transmission of pathogens, lack of positive examples by their superiors, bad habits, simple forgetfulness, and skin irritation and drying caused by the continuous use of products [36].

A previous systematic review on interventions to improve HHC during patient care found that a combination of strategies might slightly improve HHC and slightly reduce infection rates [27]. Additionally, performance feedback, education, cues such as signs and scent, supplies, and access of ABHRs slightly improved HHC [27]. In this systematic review, multi-modal, dual, or single-component strategies to improve HHC in EDs were found to be effective. In detail, a range of strategies such as education, monitoring and providing feedback, campaigns, and cues can improve HHC in EDs. This review finding supported a consensus based on existing evidence that a bundled intervention strategy including education, reminders, feedback, and access to ABHR were more effective in improving HHC [37]. This review emphasized that a combination of strategy accelerating and promoting handwashing behaviours at the institutional level, as well as providing education and feedback at the individual level, were needed for preventing the transmission of infectious disease in EDs.

Timing of HHC measurement of interventional studies included in the review varied from post-intervention 2 weeks [31] to 3 years [5,18]. The follow-up duration might reflect the sustainability of interventions. Only three of 12 interventional studies reported the HHC of pre-intervention and 1 year to 3 years after the intervention [5,18,19]. In all three studies, improved HHC was maintained up to the end-point of measurements. The effective and sustainable interventions to improve HHC for infection prevention in ED care settings were bundled intervention strategies. In detail, the active components of multimodal interventions were education, feedback, campaign and access to ABHR. This review finding was line with the comments that improvements might be sustainable if they were owned, understood, or supported by healthcare personnel and the organization [38]. Therefore, healthcare providers and managers need to collaborate to ensure sustainability of HHC improvement strategy [5]. Additionally, further research is required to develop a sustainable HHC improvement intervention focused on ED care settings.

There are several limitations to this review's methodology that should be recognized. First, only studies published in peer-reviewed journals in English or Korean were eligible for inclusion. Second, only studies that measured HHC via direct observation were selected; therefore, studies that used self-reported data or those that relied on product volume usage data were excluded. Because direct observation is the main method for measuring HHC [39], the Hawthorne effect can lead to an overestimation of compliance. Finally, all of the included studies were of non-randomized control trial study designs, which is not the gold standard for examining an intervention effect. However, the findings of this review demonstrate the current status of HHC in EDs and provide evidence-based intervention strategies for improving HHC in EDs.

Our results indicate that there is room for improvement in HHC rates in EDs, and it is necessary to implement HHC improvement interventions targeting HCWs such as physicians with lower HHC rates. Various strategies including education, feedback, cues and placement of ABHRs are effective in improving HHC in EDs. Further well-designed controlled studies are necessary to examine the true effects and identify which intervention modalities are more effective than others for HHC improvement in EDs.

Conflict of interest statement
The authors declare that they have no competing interests.

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None.

Appendix 1. Search strategy for ovidMEDLINE

1	Handwashing/
2	(hand antisepsis or handwash$ or hand wash$ or hand disinfection or hand hygiene or surgical scrub$).tw.
3	(hand adj1 (decontamination or cleansing or cleaning)).tw.
4	exp Hand/
5	(emergency adj1 (ward$1 or room$1 or department$1)).tw.
6	exp Emergency Nursing/
7	Sterilization.mp.
8	4 and 7
9	steril*.tw.
10	4 and 9
11	1 or 2 or 3 or 10
12	exp emergency health service/
13	exp emergency/
14	exp emergency care/
15	exp emergency medicine/
16	exp emergency nursing/
17	exp emergency ward/
18	(emergency adj1 (ward$1 or room$1 or department$1)).tw.
19	12 or 13 or 14 or 15 or 16 or 17 or 18
20	11 and 19

The terms were adapted for the other databases:
ovidEMBASE
CINAHL
CENTRAL
KoreaMed
KMbase

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