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Review

Hand hygiene compliance and improvement interventions in the Eastern Mediterranean Region: a systematic review and meta-analysis

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Hand hygiene compliance among healthcare workers is crucial for preventing infections in healthcare settings. This systematic review and meta-analysis aimed to assess the compliance of healthcare workers in the Eastern Mediterranean region with hand hygiene guidelines and synthesize evidence on the success rate of strategies to improve hand hygiene. Five electronic databases (PubMed, CINAHL, Cochrane, Web of Science, and Scopus) were searched up to August 2020. Articles were included if they were conducted in the Eastern Mediterranean Region. A manual search was conducted for reference lists of included papers, and relevant additional references were reviewed. Two reviewers independently screened articles for inclusion, performed data extraction, and assessed quality. A meta-analysis was conducted to synthesize findings and determine the prevalence of hand hygiene compliance interventions. The search yielded 6678 articles. After removing duplicates and applying inclusion/exclusion criteria, 42 articles were included, of which 24 were meta-analyzed. The meta-analysis showed a compliance prevalence of 32% with significant heterogeneity (I^2= 99.7% p <0.001). Interventions using the World Health Organization (WHO) guidelines were over two times more likely to improve compliance rates (OR= 2.26, [95% CI:(2.09 - 2.44)], I^2= 95%, p<0.001) compared to no intervention. Other interventions were close to two times more likely to improve compliance rates (OR= 1.84, [95% CI:(1.66 - 2.04)], I^2= 98% p= 0.001). Approximately two-thirds of healthcare providers in the Eastern Mediterranean region were non-compliant with standard hand hygiene practices, highlighting the need for increased efforts, awareness, observation, and control policies.

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Introduction

Healthcare-associated infections (HCAIs) are associated with an increase in mortality, morbidity, length of hospital stays, antibiotic resistance, and healthcare costs [1,2]. Hand hygiene (HH), which includes handwashing or using an alcohol-based hand rub to clean one's hands, is one of the most effective approaches to reducing the spread of HCAIs [2].

The continuous provision of quality care is among the vital missions of healthcare facilities; however, several challenges within this setting pose a threat to this mission. One of such challenges is poor HH. The hands of HCWs are the primary mode of transmission of HCAIs with almost half of HCAIs being attributable to the poor hygiene of care providers in healthcare settings [3].

The World Health Organization developed global guidelines on HH, identifying five important periods when HH should be conducted in light of the poor compliance rate among healthcare workers (HCWs) worldwide [4]. To assess HH compliance, hospitals typically employ WHO's "My 5 Moments for Hand Hygiene" recommendations, which are based on scientific evidence [4].

The first systematic review on the topic of HH was published in 2001 by Naikoba *et al.* [5]. Many systematic reviews on improving HH compliance were subsequently published in the following years. However, the majority of these systematic reviews focused on improving interventions or specific hospital departments such as ICUs [6,7], emergencies [8], or certain healthcare specialties, such as nurses [9,10].

The aim of this systematic review and meta-analysis was to determine the prevalence of healthcare workers (HCWs) hand hygiene (HH) compliance and assess the effectiveness of intervention programs among HCWs in the Eastern Mediterranean Region (EMR). This study sought to provide insights into HH practices among HCWs and identify strategies and interventions that can enhance compliance across different contexts. We limited this systematic study to EMR, as the Middle Eastern population has diverse cultural traditions, which may manifest in medical conduct. This would enable the study to yield strategies and interventions that are relevant to the culture and resources in this region.

Methods

This systematic review was conducted in line with the PRISMA guidelines [11]. The protocol was registered and is available for review at https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=158809.

The registration code is CRD42021158809.

Search information and strategy

Five electronic databases (PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane, Web of Sciences, and Scopus) were searched for articles published before or on August 2020. The search strategy was performed by applying Boolean operators as follows: "Hand Hygiene" OR "Hand Disinfection" AND "Health Personnel." Synonyms were also used for each of these three core terms.

Eligibility criteria

Quasi-experimental studies, interpreted time series, randomized control trials (RCT), and cross-sectional studies that reported HH compliance rates or implemented interventions to improve the HH compliance rate in EMR were included. WHO groups world countries into six group regions. WHO's EMR comprises of 21 countries: Afghanistan, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian, Tunisia, United Arab Emirates, Yemen, and the occupied Palestinian territory [12]. Letters to the editor, conference posters, and studies not published in English were excluded. In addition, studies that targeted students, patients, or other nonclinical workers who did not provide direct patient care such as administrative workers or cleaning staff were also excluded.

Outcome

The WHO HH strategy is a comprehensive approach to the implementation of hand hygiene practices globally, and recommends five key moments for hand hygiene: 1. before patient contact, 2. before aseptic procedures, 3. after blood and bodily fluid exposure, 4. after contact with a patient, and 5. after contact with the patient's surroundings [4]. To support its implementation, the WHO has developed observational and self-assessment tools as well as multi-media tools for effectively implementing this strategy in healthcare settings for improved patient safety. Therefore, HH compliance was measured by observing the number of opportunities HCWs had to implement good HH and of these how many times they performed HH measures.

The rate of HH compliance is calculated by:

$$HH\,\% = \frac{\text{No. of observed HH compliance 5 moments [actions]}}{\text{Total No. of observed HH moments [opportunities]}} \times 100$$

Intervention

We considered any interventions to improve HH compliance. Studies that did not report baseline compliance rates were excluded. Studies focusing only on surgical rubs were excluded because of differences in techniques.

The external and internal observer HH rates or covert and overt observation methods were compared in included studies. Covert observation or external observation of HH compliance is considered the standard method for minimizing bias. In cases of multiple measurements for HH compliance after the intervention, the last measure was taken.

Studies selection

Three reviewers (AS, MB and RB) independently screened studies at the title and abstract, then at the full-text stage.

Disagreements were resolved through discussion with a third reviewer (NJF).

Data extraction

Two reviewers (AS and RB) independently extracted data from each article using a standardized data extraction sheet that they developed. The following information was extracted: first author's name, year of publication, center, country, hospital department, HH definition, HH measurement tool, number of observation actions, number of observation opportunities, and compliance percentage rate. In intervention studies, the following information was also collected: intervention type, duration of intervention, follow-up duration, compliance of HH rate before and after the intervention, and 95% CIs whenever available. In the case of insufficient information provided in articles, the corresponding author of these articles was contacted.

Assessment of quality in included studies

Two authors (AS and RB) independently assessed the risk of bias in the included studies. For cross-sectional studies, the Joanna Briggs Institute checklist [JBI, 2017] was used [13]. The checklist consists of eight items to verify acceptable methodology to assess inclusion criteria, study subjects and sitting, used valid and reliable measurements of exposure and outcome, defined and adjustment for possible confounders, and using appropriate statistical analysis. We considered self-reported measures for HH compliance as an invalid and unreliable measurement of outcome. Given that self-reported measures can be biased toward social desirability, memory errors, and inaccuracy [14], instances, where HH compliance was self-reported by study participants, were considered as an unreliable outcome measurement. The checklist items were scored as "yes" =1, while "no" and "unclear" =0. Studies were classified as high-quality when at least five of the eight criteria of the JBI checklist were met.

A Before-After (Pre-Post) Studies With No Control Group checklist was used [15]. The checklist measured 10 items to assess the internal validity of the studies, such as appropriateness of the stated study question, the description of the eligibility criteria, study population, sample size, intervention, the use of valid and reliable outcome measures, blinding, and appropriateness of the statistical analysis and multiple outcome measurements. "Yes" answers were scored as 1, while "no", "cannot determine," and "not reported" were scored as zero. Studies were classified as high-quality when at least seven of the 10 criteria in the pre-post studies checklist were met.

The Controlled Intervention Studies checklist [16] was used to assess the quality of RCT which was developed by the National Heart, Lung, and Blood Institute [NHLBI]. The checklist assesses the internal validity of the studies by assessing the appropriateness of randomization, treatment allocation, blinding, similarity of groups at baseline, loss to follow-up, adherence to the study protocol, avoidance of other interventions, outcome measures assessment, sample size, prespecified outcomes, and intention-to-treat analysis. The answers were scored as "yes" =1, "no", "cannot determine", "not reported = 0." Studies were classified as high quality when at least 10 of the 14 criteria of the checklist were met.

For all three quality assessment checklists, studies were considered of high quality if 70% of the criteria were met.

Statistical analysis

Meta-analysis was performed separately for each study outcome. A subgroup analysis of cross-sectional studies was performed based on the categories of HCWs professions (physicians, nurses, or both). In intervention studies, the subgroup analysis was performed in line with the type of intervention used; [A] Studies that centered their interventions around the comprehensive principles and foundational guidelines laid out by the WHO hand hygiene strategy. This includes those that might not have explicitly followed each of the "Five Moments" of the WHO approach, but which embraced its core ethos and recommendations. Additionally, this category encompasses studies where the interventions, although not directly labeled as the WHO strategy, exhibited a close resemblance in terms of objectives, methods, and desired outcomes, effectively mirroring the WHO's hand hygiene guidelines; or [B] studies employing other types of interventions. Publication bias in the intervention studies was assessed using a funnel plot.

Two outcomes were assessed: [i] HH compliance rate and [ii] improvement in HH compliance after intervention, which were expressed as percentages. We considered the HH compliance rate as a continuous outcome and the percentage as a score out of 100. Random effects (RE) models were used, given the wide range of interventions and methodologies used among the studies. Forest plots were generated to graphically show the effect size of the original studies on meta-analysis estimates. The chi-square heterogeneity test, Cochrane Q, and index of heterogeneity (I^2) statistics were used to assess the heterogeneity between studies. All statistical significance tests were two sided. Meta analyses of cross-sectional studies were conducted using Stata 16 *(StataCorp LP, College Station, Texas, USA)*, using the meta prop command [17,18]. Analyses for intervention studies were conducted using *Review Manager (RevMan). [Computer program]. Version 5.3. The Cochrane Collaboration, 2014.*

Results

Study selection

The search yielded 6678 titles after excluding duplicates. The full text of 263 potentially eligible articles was reviewed. Only one study from the reviewed full text seemed relevant from the title was excluded, as an abstract, full text, and author correspondence information could not be found [19]. This review contained 42 studies. There was 90% agreement between the two reviewers regarding the relevant articles to be included. The flow chart summarizes the search and study selection results (Figure 1).

Study characteristics

Observational studies

The characteristics of the included studies are summarized in Table I. All included observational studies were cross-sectional and published between 2006 and 2020. Nine studies

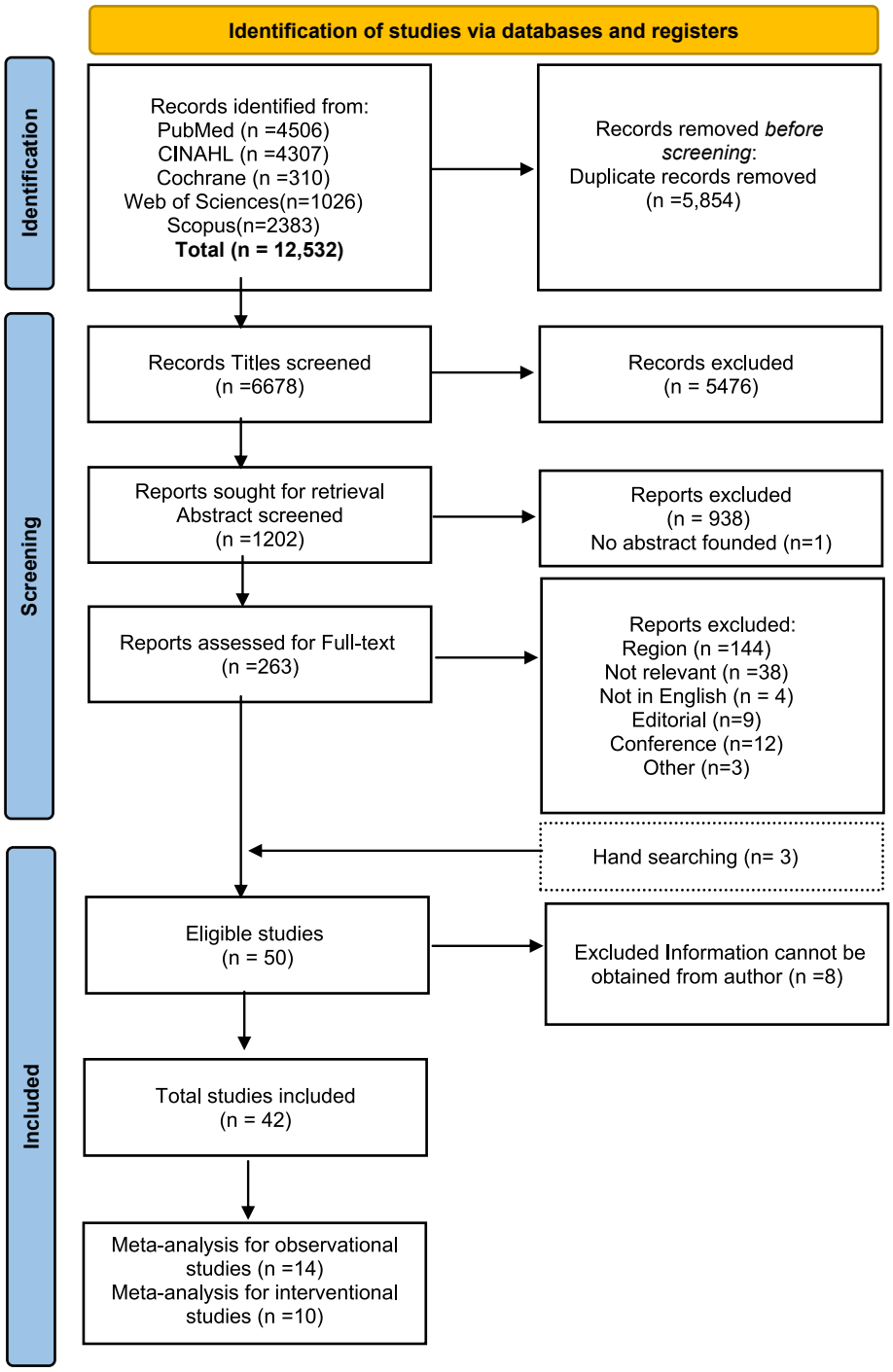

Figure 1. Flow chart of literature search and identification of relevant studies.

were conducted in Saudi Arabia [20—28], three in Pakistan [29—31], two in Jordan [32,33], one in Iraq [34], three in Iran [35—37], one in Kuwait [38], one in Egypt [39], one in Qatar [40], one in Palestine [41], and one multicenter study in Egypt, Tunisia, Algeria, and Morocco [42]. Compliance in the studies was measured in different hospital departments: in inpatient wards [40], medicine [23,25,26,29,33,38,43], surgery [23,25,26,29,33,38,40,42], pediatrics [23,24,38,41], gynecology and obstetrics [23,26], outpatients [20,23], emergency departments [20,23,26,38,40], dental clinics [29,34], primary care clinics [22], private clinics [31], and highly sensitive areas such as intensive care unties [ICUs] [21,23,26—28,33,38,40,42] and dialysis units [39,42]. Six studies did not mention which departments measured HH compliance [24,30,32,35—37]. Most studies assessed compliance among HCWs, while few studies assessed compliance among specific specialties: one in female physicians [30], three in nurses [33,38,39], and two in dentists [29,34].

HH compliance was measured using different observation methods. Eight studies reported HH compliance using a

Table I
Characteristics of the included studies (observational studies) N= 23

Author [year]	Country	Target population	Department	Sample size	HH measure tool	No. opportunities	No. actions	Overall HH compliance	QA
Ahmed *et al.* (2020) [29]	Pakistan	Physician & nurses	Medicine, Surgery and dental	212	Self-reported questionnaire	-	-	**Medicine ward** Physician 5.36%, nurses 8.09% **Surgical ward** Physician 10.53%, nurses 6.19% **dental ward** Physician 4.34%	L (43%)
Alfahan *et al.* (2016) [22]	Saudi Arabia	Primary health care	-	237	Self-reported questionnaire	-		81.90%	L (29%)
Al-Hussami *et al.* (2011) [32]	Jordan	Physician & nurses	-	349	Self-reported questionnaire	-	-	Physician 54% Nurses 66%	H (71%)
Alnakhli *et al.* (2014) [24]	Saudi Arabia	Physician & nurses	-	-	Observation	4623	3321	71.8%	H (71%)
Alazraqi T (2007) [21]	Saudi Arabia	Physician & nurses	ICU, PICU, NICU, IMCU, BU, and CCU		Observation	4023	2564	63%	L (29%)
Alshammari *et al.* (2018) [20]	Saudi Arabia	Physician & nurses	Outpatient and ER	87	Observation and self-reported questionnaire	-	-	28%	H (71%)
Alsubaie *et al.* (2013) [28]	Saudi Arabia	Physician & nurses	SICU, MICU, CICU, PICU, and NICU	242	Observation	3466[a]	1467[a]	42.3%[a]	L (29%)
Alwazzan *et al.* (2011) [38]	Kuwait	Nurses	Pediatrics, Surgery, Medicine, ICU, CCU and ER	-	Observation & self-reported questionnaire	935	312	Observation 33.40% self-reported questionnaire 73.8%	H (86%)
Amaziana *et al.* (2006) [42]	Egypt, Tunisia, Algeria, and Morocco	Physician & nurses	Medicine, surgery, ICU, and hemodialysis	-	Direct observation	3157	883	28% [a] Egypt 52.8% Tunisia 32.3% Algeria 18.6% Morocco 16.9%	L (14%)
Anwar *et al.* (2018) [30]	Pakistan	Female Physician	-	116	Self-reported questionnaire	-	-	Before examining the patients =45.7% After examining the patients=85.3% On contact with secretion of patients=88.8% After touching patient surroundings=52.5%	L (29%)

(*continued on next page*)

Table I (*continued*)

Author [year]	Country	Target population	Department	Sample size	HH measure tool	No. opportunities	No. actions	Overall HH compliance	QA
								Before doing invasive procedure =78.5%	
Ateia *et al.* (2013) [35]	Iran	Physician & nurses	-	-	Direct observation	1826[a]	136[a]	7.44%[a]	H (100%)
Bangash *et al.* (2019) [31]	Pakistan	Physician & nurses	Private clinic	105	Self-reported questionnaire	-	-	Before examining the patients = 41.9% After examining the patients =54.3% After termination of duty hours =31.4%	L (43%)
Basurraha and Madani (2006) [25]	Saudi Arabia	Physician & nurses	Medical and surgical wards	196	Observation	269[a]	45[a]	16.7%[a]	H (71%)
Bukahri *et al.* (2011) [23]	Saudi Arabia	Physician, nurses, and clinical technicians	surgical, medical, pediatric, ICU, NICU, PICU, labor ward, OPD, and ER	149	Self-reported questionnaire	1023	515	50.30%	L (0%)
Eljedi and Dalo (2014) [41]	Palestine	Physician & nurses	Pediatric hospital	299	Self-reported questionnaire	-	-	79.3%	L (14%)
El-Eneina and El-Mahdy (2011) [39]	Egypt	Nurses	Dialysis unit	17	Direct observation	992	0	0%	L (57%)
El-Saed *et al.* (2018) [26]	Saudi Arabia	Physicians, nurses, and other HCWs	ER, ICU, Medical, Surgical, Obstetrics, and Pediatrics	-	Observation (covert)	7040	3161	44.9%	L (43%)
Fesharaki *et al.* (2014) [36]	Iran	Physicians and medical staff	-	140	Observation	-	-	36%	H (100%)
Guanche Garcell *et al.* (2017) [40]	Qatar	Physicians, nurses, and other HCWs	Inpatient wards, CCU, ER, and operation theaters	-	Observation (external observer)	815	446	54.7%	L (57%)
Hassan *et al.* (2009) [33]	Jordan	Nurses	ICUs, medical/ surgical wards	40	Videotape, self-reported questionnaire	292	94	32%	L (43%)
Hussein *et al.* (2020) [34]	Iraq	Dentists	-	372	Self-reported questionnaire	-	-	85%	L (14%)
	Saudi Arabia			236	Direct observation	536			H (86%)

Mahfouz *et al.* (2013) [27]		Physicians, nurses, and other HCWs	ICU: IMUC, CCU, and PICU			316[a]	59%	
						241[a]	60[a]	
Naderi *et al.* (2012) [37]	Iran	Physicians & nurses	-	42	Observation	63	10.1%[a]	L (43%)

Health care workers [HCWs], intensive care unit [ICU], intermediate care unit [IMUC], critical care unit [CCU], pediatric intensive care unit [PICU], neonatal intensive care unit [NICU], bran unit [BU], surgical intensive care unit [SICU], medical intensive care unit [MICU], cardiac intensive care unit [CICU], out-patient department [OPD], emergency department [ER], quality assessment [QA], low [L], high [H].

[a] this estimate calculated by this equation HH%= No. of observed HH [actions]/Total No. of observed HH[opportunities] ×100.

self-reported questionnaire [22,23,29–32,34,41], 11 by direct observation [21,24–28,35–37,40,42], three by using both direct observation and self-report questionnaires [20,38,39], and one by using video and self-reported questionnaire [33]. Detailed descriptions of the results are provided in the Supplementary File A (Table A1).

Interventional studies

The characteristics of the 19 interventional studies are shown in Table II. Of these studies, three were RCTs [43–45], four were interrupted time series [46–49],12 were quasi-experimental studies, and one of them was a multicenter study [50–61][Pakistan, Saudi Arabia [KSMC] and Saudi Arabia [KAMC]]. The study duration ranged from 10 days [48] to five years [47]. The intervention was performed in different departments of the hospital. The highly sensitive areas were ICU units [45,46,51,52,54–57,59,60], [61][Pakistan, Saudi Arabia [KSMC] and Saudi Arabia [KAMC]] and surgical wards [45,51,59], [61][Pakistan, Saudi Arabia [KSMC] and Saudi Arabia [KAMC]], while the less sensitive areas were medicine [45,51,52,59], [61] [Pakistan], emergency [51,59], oncology [45,48,61][Pakistan and Saudi Arabia[KSMC]], gynecology and obstetrics [44,61][Pakistan and Saudi Arabia[KSMC]], pediatrics [51,61] [Saudi Arabia[KSMC]], and others [50,51,56,60]. Three studies included all hospital departments [47,49,53], while two did not mention study departments [44,58]. Several studies were conducted in different countries: 10 in Saudi Arabia [46–48,50,53,55,56,58], [61] [Saudi Arabia[KSMC] and Saudi Arabia [KAMC]], one in Pakistan [61] [Pakistan], one in Tunisia [51], two in Egypt [52,54], one in Kuwait [57], one in Qatar [49], three in Iran [43,44,59], one in the UAE [60], and one in Lebanon [45].

Nine studies used the WHO intervention strategy [46,50,51,54,55,59], [61][Pakistan, Saudi Arabia [KSMC] and Saudi Arabia [KAMC]]. Four studies applied an approach similar to that of WHO strategy [47,49,56,57]. Two studies implemented educational programs [43,44]. Six studies implemented different interventions, such as handprint culture [52], giving feedback as compared to giving incentives [45], diverse activities [48,53], global hand sanitizing relay challenge [58], and identification barrier interview-based program [44]. Detailed descriptions of the results are provided in the Supplementary file A (Table A2).

Meta-analysis

Of the 42 studies included in our systematic review, 14 observational studies [21,23–28,33,35,37–40,42] and 10 intervention studies [46,51,52,54–60] were included in two separate meta-analyses. The rest of the studies were excluded from the meta-analysis due to an inability to obtain additional data from the authors [20,36,45,47–51,61], or because the HH compliance rate was presented with different measures such as the mean or median [43,44].

Observational studies

Figure 2 illustrates the meta-analysis for the 14 observational studies, while Figure 3 illustrates the meta-analysis for the 10 interventional studies. As illustrated in Figure 2, the overall HH compliance rate for the observational studies was 32% (95% CI: 22%–44%), with evidence of significant heterogeneity (I^2= 99.7% P =0.00). Ten studies reported HH compliance among nurses to be 30% [95% CI: 12%–52%], (I^2 = 99.8%, P =0.00), seven studies reported HH compliance among physicians to be 26%(95% CI: 14%–39%), (I^2 = 99.1%, P=0.00),

Table II
Characteristics of the included studies for improvement of hand hygiene compliance after intervention N= 19

Author [year]	Country	Study design	Target population	Department	Intervention	Duration	Description of intervention	Improve of HH [a]	QA
Awaji and Al-Surimi (2016) [48]	Saudi Arabia	Time series study	All HCWs	Oncology	Several interventions	10 days	• Educating patients about HH importance, and encouraging them to ask their HCWs about HH practice. • Using reminders for HCWs about HH.	15%	L (40%)
Al Kuwaiti (2017) [50]	Saudi Arabia	Pre-post interventional	Inpatients HCWs	Inpatients ward	WHO strategy	12 months	• Increasing the availability and ease of access to alcohol-based hand rub and water supply • Holding educational events on HH and infection control • Offering training and support with monthly evaluation and feedback analysis • Presenting visual displays to promote HH practices • Ensuring a climate of institutional safety Additional: • Holding timely meetings with the hospital management and staff • Assessing the infrastructural and consumable requirements at the hospital • Installing screensavers on computers to display HH moments • Providing adequate personal protection equipment to HCWs, and teaching them how to use such equipment properly • Adhering strictly to visitors' policy, and educating visitors to keep hands clean and not contact vulnerable patients.	22%	L (50%)
Al-Dorzi *et al.* (2014) [46]	Saudi Arabia	Time series study	ICU HCWs	ICU	WHO strategy	Before: 2 months After: 15 months	• HH education for staff, coaching, and online modules • Increase number of staff • Addressing perceived HH barriers; active feedback of HH compliance to all staff by direct communication and emails • Reminders in workplace • Empowerment of staff to educate and stop violators, and warning letters from the chairman for repetitive violations	16%	L (50%)
Allegranzi *et al.* (2013) [61]	Pakistan[a]	Quasi-experimental	All HCWs	Internal medicine, surgery, emergency, ICU, and OB-Gyne	WHO strategy	19 months	• System change: particularly access of health-care workers to alcohol-based hand rub at the point of patient care to enable recourse to hand rubbing as the preferred method for hand hygiene • Training/education • Evaluation and feedback: monitoring of practices and provision of feedback about performance • Reminders in workplace: visual reminders in the workplace • Institutional safety climate Additional: • Local production of WHO-recommended, Gender-specific educational sessions.	20%	H (70%)
	Saudi Arabia[b] KSMC	Quasi-experimental	All HCWs	Surgery, emergency, ICU, OB-Gyne and obstetrics, pediatrics, and others	WHO strategy	16 months	• System change: particularly access of health-care workers to alcohol-based hand rub at the point of patient care to enable recourse to hand rubbing as the preferred method for hand hygiene • Training/education • Evaluation and feedback: monitoring of practices and provision of feedback about performance • Reminders in workplace: visual reminders in the workplace • Institutional safety climate Additional: • Local production of WHO-recommended, Gender-specific educational sessions, demonstrations of the hand-hygiene	8%	H (70%)

							technique, and fingertip method demonstrations for education of health-care workers		
	Saudi Arabia[c] KAMC	Quasi-experimental	All HCWs	ICU and surgical wards	WHO strategy	16 months	• System change: particularly access of health-care workers to alcohol-based hand rub at the point of patient care to enable recourse to hand rubbing as the preferred method for hand hygiene • Training/education • Evaluation and feedback: monitoring of practices and provision of feedback about performance • Reminders in workplace: visual reminders in the workplace • Institutional safety climate	20%	H (70%)
AlTawfiq *et al.* (2013) [47]	Saudi Arabia	Time series study	All HCWs	All hospital	Multifaceted approach (WHO strategy)	60 months	Additional: Gender-specific educational sessions, separate educational sessions for doctors, and stands for promotion of hand hygiene throughout the hospital • Hand hygiene compliance monitoring • Setting compliance goals • Feedback • Hand sanitizer placement • Promotion • Leadership commitment	45%	L (50%)
Ben Fredj *et al.* (2020) [51]	Tunisia	Pre-post interventional	Physician & nurses	Intensive care, surgery, medicine, emergency, Pediatrics, and dental.	WHO strategy	Pre: 2 months Intervention: 7 months	• Used a checklist to review once a month the availability of AHRB, liquid soap, washbasins, washbasins/bed ratio, and hand towels for single use. • Educational activities: open sensitization days, educational sessions, showing educational films followed by interactive discussion and presentation of the pre-intervention results. • Reminders in the workplace: HH leaflets were distributed to each department, and posters were bonded in strategic areas of the hospital departments. • Motivate the stakeholders to be involved in creating an environment that promotes and encourages patient safety, seeking the support of all HCWs.	56%	H (80%)
Fouad el at, (2018) [52]	Egypt	Pre-post intervention	All HCWS	Medical and cardiac PICU	Handprint culture	3 months	Handprints cultures were collected form HCWs before and after HH compliance	43%	L (40%)
Farhoudi *et al.* (2016) [59]	Iran	Quasi-experiment	Nurses	Medical, emergency, internal, PICU, and surgical	WHO strategy	12 months	• System change to ensure access of healthcare workers to HH facilities with emphasis on availability of ABHR formulations at the point of care • Ongoing training and education • Evaluation of practices and feedback • Reminders at the workplace • Providing a climate of safety through institution	Female ward 6% Male ward 8%	L (40%)
Harrabi *et al.* (2017) [53]	Saudi Arabia	Pre-post intervention	Physician & nurses	All hospital departments	Diverse activities	12 months	No description available	Estimate in different format [b]	L (10%)
Gomarverdi *et al.* (2019) [43]	Iran	RCT	Nurses	ICU	Multi-component educational	11 months	The intervention involved educational activities programmed with multiple instructional media and a behavioral activity with hands-on practice components.	23%	L (21%)
Khalifa *et al.* (2011) [54]	Egypt	Before—after study	Physician & nurses	BU	WHO strategy	Baseline: 4 months Improvement period: 4 months Post intervention:4 months	• System change: used a checklist to review once a month the availability of AHRB, liquid soap, washbasins, washbasins/bed ratio, and hand towels for single use. • Educational activities: open sensitization days, educational sessions, showing educational films followed by interactive discussion and presentation of the pre-intervention results. • Reminders in the workplace: HH leaflets were distributed to each department, and posters were bonded in strategic areas of the hospital departments.	26%	L (60%)

(*continued on next page*)

Table II (*continued*)

Author [year]	Country	Study design	Target population	Department	Intervention	Duration	Description of intervention	Improve of HH [a]	QA
							• Institutional safety climate: motivate the stakeholders to be involved in creating an environment that promotes and encourages patient safety, seeking the support of all HCWs.		
Mahfouz *et al.* (2014) [55]	Saudi Arabia	Pre-post intervention	All HCWS Other health-care workers (including X-ray and ECG technicians, physiotherapists and respiratory therapists)	ICUs units	WHO strategies	Baseline: 3 months After: 3 months	• System change: ensure availability of ABHR at the point of care in ICU, increase the number of dispensers and distributed at sites where it was not previously available • Training/education: all HCWs of these units attended intensive education sessions based on WHO methods, each training session lasted for 2—3 h. • Evaluation and feedback: monitoring HH compliance rates in ICU on a monthly basis, and communicating reports to the concerned staff and to the hospital leader. • Reminders in workplace: HH posters were displayed in all ICUs, materials used as reminders as posters, prescription notebooks, and computer screen savers, and continuous regular meetings were held for staff during educational and feedback sessions. • Consultation and advocacy meetings with the hospital management, and involvement of hospital leaders in HH improvement activities through active participation in HH days.	3%	L (60%)
Mazi *et al.* (2013) [56]	Saudi Arabia	Pre-post intervention	Physician & nurses	ICU, NICU, BU, and Kidney unit	Hand hygiene intervention campaign (WHO strategy)	Pre-intervention: 2 weeks Post-intervention: 2 weeks Follow up: 1 month	• Provide supplies: regular supply of alcohol gel/chlorhexidine was maintained in all units. • Education lectures & workshops • Provide feedback reports to the team leaders and the hospital director • Regular open discussions on compliance rates were held during the hospital infection control committee meetings	Control = 4% Incentive= 13% Feedback = 25%	L (50%)
Moghnieh *et al.* (2017) [45]	Lebanon	RCT	Nurses	Hematology-oncology, surgical, OB-Gyne, and general medicine	Feedback or Giving incentive	5 months	• Feedback: provide HCWs with their corresponding scores and HH moments they have missed, in addition to reminding about the importance of HH. • Incentive: Every 2 weeks, the participant who achieved the highest score in HH performance was awarded using money incentive.	18%	L (21%)
Salmaa *et al.* (2013) [57]	Kuwait	Pre-post intervention	Physician & nurses, physical therapists, radiologists, and respiratory therapists	ICUs	Hygiene Improvement Program (WHO strategy)	Pre: 3-months Intervention: 1-month Post: 3-months)	• Dispensers for alcohol-based hand sanitizers were installed in ICU units. • Education and lectures to HCWs concerning HH • Reminder posters and leaflets • Feedback about HH compliance campaign result was regularly presented to the ICU staff. • The senior staff fully supported the intervention.	3%	L (50%)
Salamti *et al.* (2013) [44]	Iran	RCT	Nurses		Motivational interviews & HH education 2h lecture		Motivational interviewing conducted by a health psychology specialist. Five sessions of interviewing were held, with a maximum of 15 participants and duration of 90 min	Physicians 52% Nurses 37%	L (14%)
Tartari *et al.* (2017) [58]	Saudi Arabia	Pre-post intervention	All HCWS	-	WHO Hand HSRelay challenge	-	HSRelay challenge consisted of as many HCWs as possible performing an uninterrupted sequential chain of HH actions according to the WHO technique	21%	L (10%)
Visan *et al.* (2017) [49]	Qatar	Time series study	Physician & Nurses	All hospital	Multimodal Strategy (WHO strategy)	Pre: 4 months Post: 4 years	• Availability of sinks and accessories was undertaken with recommendations based on international guidelines on hand hygiene, and ABHR were installed in operating theatres and procedure areas • Training/education, annual HH observation training given to all new and old hand hygiene observers. • Evaluation and feedback, Continuous monitoring and feedback: feedback was taken from any specific		L (30%)

							professional category or clinical unit with less than target results • Campaign posters and reminders in workplace Additional: • Encouragement by certificates and positive reinforcements were given to the Top 3 HH performing units • Poster making competitions and abstract poster competitions. • Random and surprise validation: UV light hand hygiene show for HCWs	
Yoo *et al.* (2019) [60]	UAE	Prospective interventional	Physicians & nurses	ICU and non-ICU	Barrier identification interview-based program	15 months	Based on the questionnaires and interviews, noncompliance HCWs to identify personal and systemic barriers to HH.	H (80%)

[a] Difference of HH Compliance [post intervention − pre intervention], hand hygiene [HH], World health organization [3], Healthcare workers [HCWs], Intensive care unit [ICU], surgical intensive care unit [SICU], Neonatal intensive care unit [NICU],Pediatric intensive care unit [PICU], Burns unit [BU]Target solutions tools [TST], obstetrics-gynecology [OB gyne], alcohol-based hand rub [ABHR], Hygiene Sanitizing Relay challenge[HSRelay], United Arab of Emirates [UAE], quality assessment [QA], low [L], high [H].
[b] Details estimate provide in additional file A (Table A2).

and four studies reported HH compliance among different HCWs to be 52% (95% CI:46%−58%), ($I^2 = 95.5\%$, $P < 0.001$). Subgroup analysis by study location and observation method did not reveal different results [data not shown].

Interventional studies

Figure 3 a shows the meta-analysis according to the intervention to improve HH compliance. Only ten studies were included in the analysis [overall OR = 2.09, (95% CI: 1.97, 2.23)], with evidence of significant heterogeneity ($I^2 = 96\%$, $P < 0.001$). The subgroup analysis was divided by the type of intervention, WHO strategy, and other types of interventions. The WHO intervention showed improvement in HH compliance (OR = 2.26, (95% CI:2.09−2.44)), (I^2=95%, P<0.001). The subgroup analysis of other types of interventions had OR = 1.84, (95%CI:(1.66−2.04)), (I^2=98% P<0.001). No evidence of such publication bias is present here [Figure 3 b]. However, the interpretation is complicated by the fact that different studies are comparing different interventions, thus the effect sizes are expected to differ.

Quality of the included studies

Observational studies

The quality score of the included observational studies ranged from zero to seven out of seven, of which eight studies had a score of at least five out of seven (70%) or above [20,24,25,27,32,35,36,38]. Almost half of the studies included in this review did not offer clear information on the inclusion criteria [20,22,26−28,31,34,37−39,42]. In three studies, the statistical methods used were not clear [20,23,41], and it was unclear whether the outcome was measured objectively in 11 studies [21−23,29,30,32−34,40−42].

Interventional studies

The quality scores ranged from one to eight out of 10, of which three studies had a score of at least seven out of 10 (70%) or above [51,60,61]. The majority of the studies did not mention adequate information about eligibility and enrolment criteria [46−50,52−56,58,59], whereas three studies used unclear outcome measurements [49,53,58]. Only two studies did not describe the interventions used [53,58]. Moreover, the included RCT studies [43−45] scored low on quality with scores ranging from two to three out of 14. Details of the quality assessment results are provided in the supplementary file A (Table A3).

Discussion

Hand hygiene compliance is the most critical factor in preventing and controlling the spread of healthcare-associated infection [1]. This is the first systematic review to assess HH compliance among HWCs in the EMR. Many studies included in this systematic review were unique, as they were not featured in previous systematic reviews. The integration of such wide-ranging studies inherently introduces a level of heterogeneity that represents the broad range of research and healthcare settings in the region, which is a strength as well as a challenge for this review.

Out of 42 studies included in the systematic review, 14 observational studies and 10 interventional studies included in the meta-analysis reported HH compliance. The summary result from the meta-analysis of HH compliance varies between

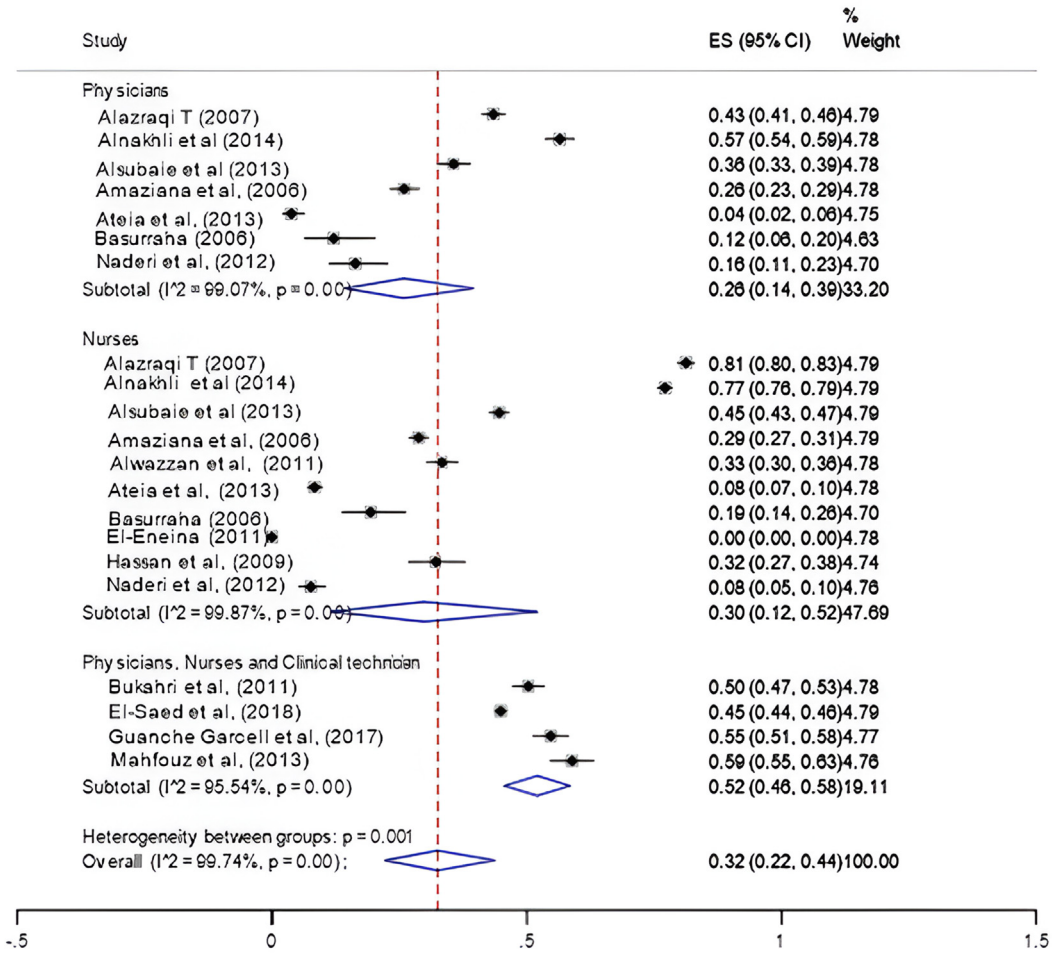

Figure 2. Forest plot for hand hygiene compliance prevalence (observational studies) Physician: forest plot hand hygiene compliance prevalence among physician only. Nurses: forest plot hand hygiene compliance prevalence among nurses only. Physician, nurses and clinical technician: forest plot hand hygiene compliance prevalence among different HCWs categories.

countries in EMR and among different HCWs categories. This finding is in line with previous literature [62,63]. The pooled hand hygiene compliance rate from observational studies included in the meta-analysis among all HCWs was 32% (95% CI: 22%—44%). According to the study's subgroup analysis, groups were categorized into physicians with 26% compliance (95% CI: 14%—39%) and into nurses with 30% compliance (95% CI: 12%—52%).

Out of the HCWs staff, nurses had the better HH compliance and attention to infection control possibly due to the feeling that they are monitored by physicians higher authorities. Physicians' low compliance is consistent with previous systematic reviews [6]. This is an important finding, which should be considered in designing future interventions. Based on the HH rates from the meta-analysis, the EMR regions HH compliance rates rank as one of the lowest in the world. Recent research noted an overall HH compliance rate of 45% for doctors on average worldwide [66], with studies noting rates as high as a mean of 80.8% for intensive care units in European countries [67] and in Sub-Saharan Africa, 57% among doctors [68]. Interventions to improve compliance among physicians may be of particular value, given their relatively poor performance and the lack of attention.

Majority of the intervention's studies were conducted in high income countries, while only eight studies were carried out in middle — low-income countries [64]. Greater compliance levels were reported in studies from both high- and low-income countries 81% [22] to 85% [34]. This result is different from what is found in literature [6,65,66]. Low-income countries are known to have low health outcomes and lack of healthcare resources. Observed low compliance levels were reported in low-income countries only; 0% [39], 7% [35], and 10% [37]. However, further research is needed to focus on how best to improve HH compliance in these areas and within the resource limitations in healthcare systems in these countries. Moreover, HCWs self-reported HH compliance were found to be higher [22,30,34,41] compared to direct observation [20,25,35,37,39]. This factor of data suggested that HCWs believed to be more compliant with HH than they actually were.

Interventional programs play a critical role in improving compliance rates. The findings showed that different intervention programs improved HH compliance by OR = 2.09, (95% CI: 1.97,2.23). This shows the importance of infection control and quality departments in implementing interventions to increase HH compliance. WHO strategy and education sessions were the main HH strategies used among HCWs in this

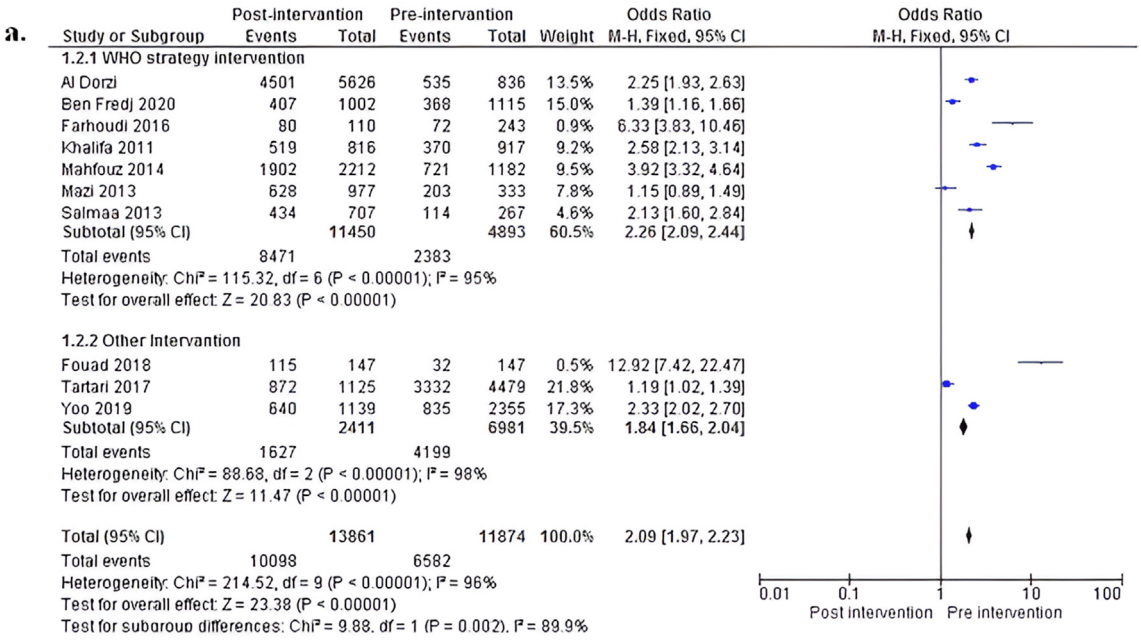

Figure 3. a. Forest plot for improvement of hand hygiene compliance after applying an intervention. 1.2.1Forest plot for WHO strategy intervention 1.2.2. forest plot for other interventions. b. Funnel plot for publication bias (10 studies).

systematic review. Where different interventions were employed, the handprint intervention was found to have the highest improvement rate of 48% [52]. The visual message of hand-printed bacterial growth before and after HH seems to be an effective method for improving HH compliance [52].

The most common intervention methods used in this review to increase HH compliance is WHO multimodal hand hygiene strategy. It consists of a range of tools to be implemented in healthcare sitting to improve HH. It is a five essential elements which is: system change, including availability of alcohol-based handrub at the point of patient care and/or access to a safe, continuous water supply and soap and towels; training and education of health-care professionals; monitoring of hand hygiene practices and performance feedback; reminders in the workplace; and the creation of a HH safety culture with the participation of both individual HCWs and senior hospital managers. These five components implemented in parallel; the implementation strategy itself is designed to be adaptable and it can be used even within facilities with existing action on HH [3].

Several barriers can result in poor HH compliance, as identified in the literature. The most frequent reasons

reported by HCWs were high workload, insufficient time, understaffing, skin irritation, unavailable supplies, obstruction to worker-patient relations, priority patient needs, wearing gloves, forgetfulness, lack of knowledge of how improved compliance decreases HAIs, and unawareness of guidelines [69].

Our analysis revealed considerable heterogeneity in the summary estimates of HH compliance, with rates exceeding 90%. This may suggest a very wide breadth of healthcare contexts, protocols and approaches in the region. It also poses questions about the universal applicability of the study finding. To address this heterogeneity, subgroup analysis was employed by specialty of healthcare provided and type of intervention, duration of studies, sample size, number of opportunities, and the quality of the study did not markedly decrease heterogeneity. Factors that could explain the significant heterogeneity are the inclusion of studies that had a very high or very low sample size and number of opportunities, variability in defining and reporting the HH compliance, variation in the length of intervention and study duration, variation in the professional level of health care provider and different hospital departments, and variation in measurement and observation tools used. Some of these variables are difficult to control and define and were not accounted for in the original studies. Concerning the quality of the studies themselves, only 10 of the included studies had an acceptable score of 70% or higher per the quality assessment criteria. Thus, our systematic review was limited by the poor quality of some included studies. While efforts were made to address the heterogeneity of the findings, the discrepancies also underscore the need for interventions tailored to the subtle differences of healthcare settings in the region, and also potentially point for the need for HH procedures that are adapted to the wide-ranging contexts of the region. Contextualizing our findings within the broader healthcare landscape, there is an evident need for collaborative efforts to promote HH awareness and adoption. Leveraging successful strategies from regions with high compliance can offer a blueprint, but it is imperative these are tailored to resonate with the unique socio-cultural and infrastructural features of the EMR.

Limitations and strengths

This study had several limitations. First, the definition of HH varied between the studies. Additionally, only articles written in English were reviewed. In some cases, several attempts to contact the authors failed and thus some articles could not be included due to insufficient information. Many of the included studies had several limitations, including a short follow-up duration, small study size, lack of control groups, inability to make subjects unaware of being observed, and outcome measures that concentrate on frequency but disregard the technique. Very few studies used HAI rates as an outcome measure. In addition, some studies applied the HH intervention specifically to the ICUs department, making it difficult to generalize to other settings.

To the best of our knowledge, this is the first systematic review and meta-analysis to analyze HH compliance in EMR as well as to summarize the different interventions applied in EMR to improve HH compliance among HCWs.

Conclusions

Approximately two-thirds of HCWs are not compliant with HH according to the standards. The use of a multidimensional technique is an effective way to improve HH compliance among HCWs. This indicates the need to increase efforts and awareness, observation, and control policies to improve HH compliance.

Author contributions

Rbab Bajunaid: Conceptualization, Methodology, Investigation, Validation, Formal analysis, Writing- Original draft preparation, Visualization, and Writing - Review & Editing. **Abduallah Saeed:** Conceptualization, Methodology, Investigation, Validation, Formal analysis, Writing- Original draft preparation, Visualization, and Writing - Review & Editing. **Muataz Bostaji:** Conceptualization, Methodology, Investigation, Validation, and Writing - Review & Editing. **Nada J Farsi:** Supervision, Conceptualization, Methodology, and Writing - Review & Editing.

Conflicts of interest statement

The authors have no conflict of interest to declare relevant to this manuscript.

Ethics

No ethical approval was required for this review.

Funding statement

There was no financial support for the study.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available in the supplementary file.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.infpip.2024.100363.

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