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INTERVENTIONS TO IMPROVE HAND HYGIENE COMPLIANCE IN THE INTENSIVE CARE UNIT: A SYSTEMATIC REVIEW

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Abstract

Objective: To synthesize the literature describing interventions to improve hand hygiene (HH) in Intensive Care Units (ICUs), to evaluate the quality of the extant research, and to outline the type, and efficacy, of interventions described.

Data sources: Systematic searches were conducted in November 2016 using five electronic databases: Medline, CINAHL, PsycInfo, Embase, and Web of Science. Additionally, the reference lists of included studies and existing review papers were screened.

Study selection: English language, peer-reviewed studies that evaluated an intervention to improve HH in an adult ICU setting, and reported HH compliance rates collected via observation, were included.

Data extraction: Data were extracted on the setting, participant characteristics, experimental design, HH measurement, intervention characteristics and outcomes. Interventional components were categorized using the Behavior Change Wheel. Methodological quality was examined using the Downs and Black Checklist.

Data synthesis: Thirty-eight studies were included. The methodological quality of studies was poor, with studies scoring a mean of 8.6 out of 24 (SD=2.7). Over 90% of studies implemented a bundled intervention. The most frequently employed interventional strategies were Education (78.9%), Enablement (71.1%), Training (68.4%), Environmental Restructuring (65.8%), and Persuasion (65.8%). Intervention outcomes were variable with a

mean relative percentage change of 94.7% (SD=195.7; range: 4.3-1155.4%) from pre- to post-intervention.

Conclusions: This review demonstrates that best practice for improving HH in ICUs remains unestablished. Future research employing rigorous experimental designs, careful statistical analysis, and clearly described interventions is important.

INTRODUCTION

A total of 4% of hospital patients have one or more healthcare-associated infections (HAIs)(1), and almost 100,000 deaths per annum in the US are attributable to HAIs(2). Research suggests that more than half of HAIs may be preventable(3), with appropriate hand hygiene (HH) considered to be the most effective safeguard(4). The World Health Organization's (WHO)(5) HH guidelines have been widely adopted and highly influential(6). However, there remains a need for the implementation of consistent and comprehensive interventions to improve HH(7).

The need for effective infection control practices is particularly important within intensive care. The treatment of immunocompromised patients, along with the frequency of invasive procedures, physical contact between Health Care Workers (HCWs) and patients, and emergency situations in which aseptic technique and hygiene precautions are compromised, both distinguish Intensive Care Units (ICUs) from other hospital areas and amplify the problem of HAIs(8). However, in spite of this, HH compliance rates in ICU settings have been demonstrated to be lower (30-40%) than HH compliance rates in other hospital settings (50-60%)(9).

Although the ICU differs from other hospital areas(8), previous systematic reviews of interventions(10-15) to improve HH have failed to consider the effectiveness of interventions by setting, or reported on intervention characteristics or outcomes within the ICU. The aim of this systematic review was to synthesize the literature describing interventions to improve HH conducted in ICU settings, to evaluate the quality of this research, and to outline the type, and efficacy, of interventions that have been implemented. This review will guide hospital managers and clinicians on how limited resources can be optimally employed to improve HH in the ICU.

MATERIALS AND METHODS

This review is reported in accordance with the PRISMA guidelines for systematic reviews(16).

Study identification

Systematic searches were conducted in November 2016 using five electronic databases: Medline, CINAHL, PsycInfo, Embase, and Web of Science. A sample search strategy for the Medline OVID database is shown in Supplemental Digital Content 1. Our search strategy was comprised of Medical Subject Headings (MeSH) search terms and keywords and was altered as necessary for databases other than Medline. Our searches were limited to articles published since 2009, the year in which the WHO's HH guidelines(5) were published as these have markedly impacted on HH practice(6). We also screened the reference lists of papers identified for inclusion during the electronic searches and the reference lists of several other reviews(10,12-15,17) pertaining to hospital-based HH interventions.

Study selection

In order to meet our inclusion criteria, studies had to: a) be published in an English language peer-reviewed journal; b) report original research; c) evaluate an intervention to improve HCWs' HH compliance conducted in at least one adult ICU setting, and; d) present ICU-specific data on HH compliance outcomes that were collected via behavioral observation (direct or remote) by a human- considered to be the 'gold standard' within HH measurement(18).

The titles and abstracts of records returned during the search process were screened by one author using the inclusion criteria. Two authors then independently reviewed the full-text of all articles which appeared to meet the inclusion criteria or articles in which there was

insufficient information in the title and abstract to make a decision regarding inclusion or exclusion. There were no discrepancies regarding decisions on inclusion or exclusion of studies.

Data extraction

Two authors independently completed data extraction and any disagreements were resolved through discussion. A structured tool was used to extract information on where the study had been conducted, participant characteristics, study design, HH compliance measurement methodology, intervention characteristics, and changes in HH compliance resulting from intervention. Interventional strategies were categorized using the Behavior Change Wheel(19), a framework for categorizing behavioral intervention strategies, by three of the authors. An overview of this framework, and descriptions of each of the interventional strategies it encompasses, is provided in Table 1.

Table 1

An overview of the interventional strategies described within the Behavior Change Wheel(24), the frequency of their use, and examples of corresponding practices within the included studies.

Interventional Strategy	Strategy description	No. of studies (%)*	Example from included studies
<i>Coercion</i>	The leveraging of a potential punishment to discourage individuals from engaging in a behavior	2 (5.3%)	Implementation of process for corrective action(70)
<i>Education</i>	The use of interventional techniques intended to increase knowledge or understanding	30 (78.9%)	HH education delivered using videos, coaching and/or online modules(30)
<i>Enablement</i>	Increasing the ease of engagement in behavior or reducing barriers to engagement in a behavior	27 (71.1%)	Improvements in the availability of HH resources such as sinks or alcohol-based hand rub(39)
<i>Environmental Restructuring</i>	Making changes to the physical or social environment in order to facilitate engagement in the desired behavior	25 (65.8%)	Use of visual reminders such as posters(26)
<i>Incentivization</i>	The leveraging of rewards to motivate individuals to engage in a behavior	2 (5.3%)	Competition for best HH compliance(23)
<i>Modelling</i>	The highlighting of examples of desired behavior in order to encourage others to emulate this behavior	-	-
<i>Persuasion</i>	The use of communication to produce positive or negative feelings that may promote engagement in behavior	25 (65.8%)	Performance feedback on HH compliance displayed on electronic boards(35)
<i>Restriction</i>	The use of rules to attempt to influence engagement or non-engagement in the behavior	2 (5.3%)	Implementation of universal contact precautions(30)
<i>Training</i>	The teaching of a skill or behavior	26 (68.4%)	The use of simulation sessions to teach appropriate HH practices(40)

Note. HH=Hand Hygiene. * Figures do not total to 38 as some studies used more than one type of interventional strategy.

Where appropriate data were provided, changes in HH compliance resulting from the intervention were expressed as relative percentage change.

Quality assessment

The methodological rigor of studies was assessed using a modified version of the Downs and Black checklist(20; Supplemental Digital Content 2). This 27-item checklist assesses the study's standard of reporting, external validity, internal validity, and power. Four items were removed as they were not considered relevant to the type of studies in this systematic review. One additional change was made: power was scored as either sufficient power (1), or insufficient power (0), with the requisite number of observations of HH compliance calculated on the basis of an effect size 0.2, alpha .05, and the use of a two-tailed test. Total scores for the checklist could range from 0-24. This checklist(20) has been shown to be reliable and valid(20-22). Two authors completed the quality assessment and disagreements were resolved through discussion.

RESULTS

Over 5,800 articles were screened, of which 38 studies met the inclusion criteria (see Figure 1 for PRISMA diagram). Table 2 provides a summary of the included studies (for more detail, see Supplemental Digital Content 3).

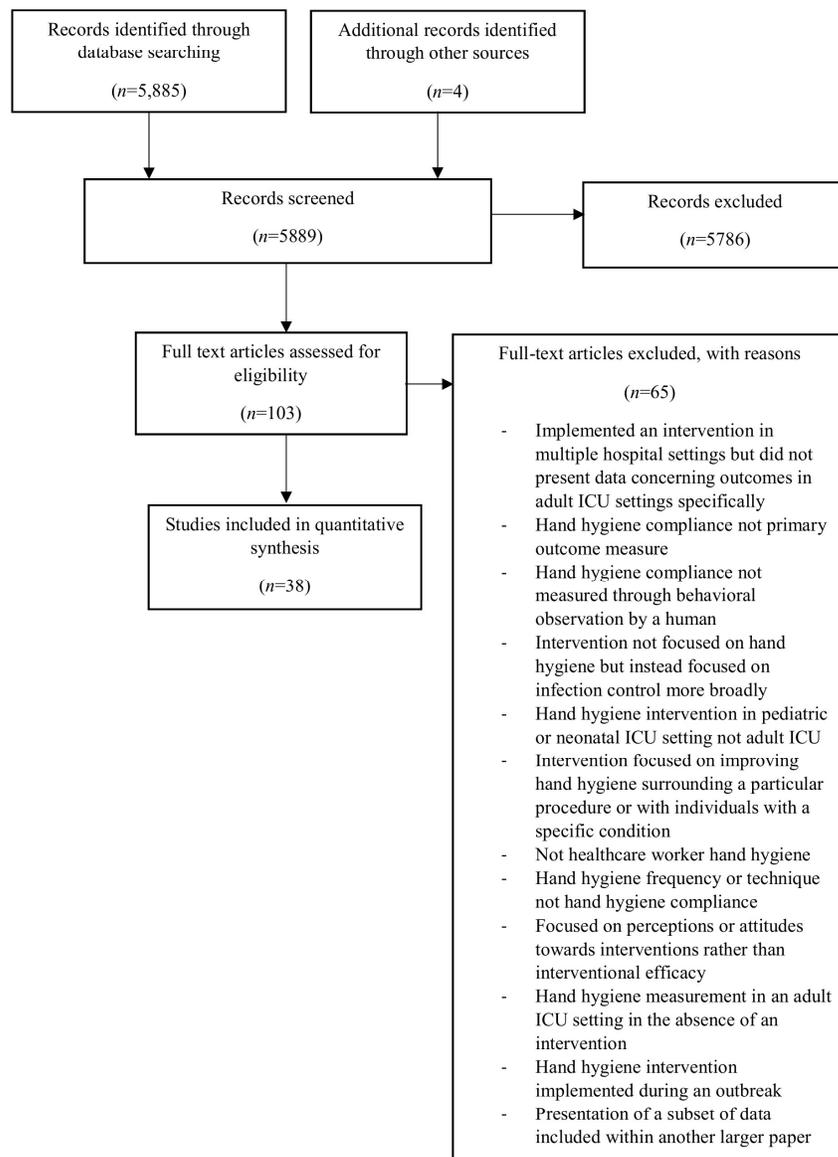


Figure 1 PRISMA Diagram

Table 2. Characteristics of the 38 included studies which assess the effectiveness of interventions for improving hand hygiene in an intensive care setting.

Characteristics	No. of studies (%)
Study Location*:	
Asia	16 (42%)
Europe	9 (23.7%)
South America	7 (18.4%)
North America	6 (15.8%)
Africa	2 (5.3%)
Participants:	
All HCWs (including doctors, nurses, and allied health professionals)	31 (81.6%)
Nurses only	4 (10.5%)
Doctors and nurses only	2 (5.3%)
Doctors only	1 (2.6%)
ICU Setting*:	
Unspecified ICU setting	19 (50%)
Medical-surgical ICU	11 (28.9%)
Medical ICU	7 (18.4%)
Surgical ICU	7 (18.4%)
Cardiac-related ICU (e.g., cardiothoracic and vascular surgery ICU, cardiac care ICU)	6 (15.8%)
Neurosurgery ICU	5 (13.2%)
Respiratory ICU	2 (5.3%)
Other ICU	5 (13.2%)
Study Design:	
Pretest-posttest design	27(71.1%)
Time series design	6 (15.8%)
Posttest-only design	2 (5.3%)
Stepped wedge cluster randomized trial	2 (5.3%)
Randomized controlled trial	1 (2.6%)
Hand Hygiene Measurement:	
WHO HH observation method	12 (31.6%)
Before patient contact and before aseptic task (as per INICC guidelines)	7 (18.4%)
Before and after contact with the patient and/or their surroundings	5(13.2%)
At entry to, and exit from, the patient space	4 (10.5%)
Other	10 (26.3%)
Awareness of Hand Hygiene Measurement:	
Not covert	30 (78.9%)
Covert	8 (21.1%)

Note. * Figures do not total to 38 as some studies fit within more than one of the categories. HCW=Healthcare worker, WHO= World Health Organization, HH= hand hygiene, INICC= International Nosocomial Infection Control Consortium.

Quality of the included studies

The mean quality score was 8.6 out of a possible total of 24 (SD=2.7; range:4-17). Studies generally performed well on items relating to the description of the aim/objective/hypothesis, description of outcome measures, being sufficiently powered, and non-engagement in data dredging. However, studies typically performed poorly on items relating to the appropriate use of statistical tests, demonstration that the sample was representative of the population, the blinding of those measuring the main outcomes, and consideration or reporting of attrition.

Location, Participants, and Intensive Care Setting

The studies were most frequently conducted in Asia, followed by Europe, and South America. The majority of studies included all HCWs who had contact with patients in the ICU setting. HH interventions were most commonly carried out in medical-surgical ICUs.

Study Design

Pretest-posttest designs were most commonly used to evaluate HH interventions. Time series designs were the next most frequently used.

Hand Hygiene Measurement

The review's inclusion criteria required that HH be measured using observation, however the observation protocols within the studies varied. The WHO's Five Moments of HH observation methodology(5) was most commonly used. HCWs were unaware that they were being observed in only 21.1% of studies.

Interventions

A summary of the interventions implemented within each study is provided in Supplemental Digital Content 3. Almost all (92.1%) studies implemented a bundled

intervention to improve HH, with only three studies(23-25) relying upon a single interventional strategy.

Education strategies were most commonly used (see Table 1). Enablement strategies were also used with a high frequency. Training, Environmental Restructuring, and Persuasion were also used in more than half of the studies. Incentivization, Coercion, and Restrictions were used less frequently. Modelling was not used within the included studies.

It was not possible to extract any data relating to HH compliance from four studies(26-29). Across the remaining studies, the mean level of HH compliance pre-intervention was 41.1% (SD=19.1; range:6.5-70%). Mean HH compliance post-intervention was 63.9% (SD=20; range:15.8-95%). The mean relative percentage change in HH compliance was 94.7% (SD=195.7; range:4.3-1155.4%).

Data were not provided on, or it was not possible to determine, the duration of the intervention in four studies(28,30-32). Among the remaining studies, intervention duration ranged from 30 minutes(33) to nine years(34).

Only eight(25,35-41) studies provided data relating to the maintenance of intervention effects. The period of follow-up ranged from six weeks(38) to three years(39). Three studies(35,39,41) reported on maintenance outcomes while the intervention remained in place, with two studies(39,41) reporting that improvements in HH compliance persisted and one study(35) reporting a small but statistically significant decreasing trend in compliance. Four studies(25,37,38,40) reported on the maintenance of intervention effects following removal, or completion, of the intervention. In one study(25), treatment effects were maintained. In the remaining studies(37,38,40), decreases in HH compliance post-intervention were observed in at least some settings. One study(36) did not indicate whether

the intervention remained in place at the 48 week follow-up, at which HH compliance was maintained.

DISCUSSION

In spite of the recognition of HH as the most important strategy(4) for preventing HAIs(42), HH has received less research attention than other areas of healthcare(43). Aiming to guide hospital managers and clinicians regarding how best to invest resources for improving HH in the ICU, the current review offers a synthesis of the literature describing interventions to improve HH conducted in ICU settings, to evaluate the quality of the extant research, and to outline the type, and efficacy, of interventions that have been implemented. A total of 38 studies were reviewed, with over 90% of these describing the use of bundled interventions. The interventional strategies most frequently used were Education, Enablement, Training, Environmental Restructuring, and Persuasions. Incentivization, Coercion, and Restrictions were rarely evaluated as strategies to improve HH. The data highlight the weak methodological quality of much of the extant research, the variability in effectiveness of HH interventions, and the lack of knowledge concerning the efficacy of individual components within bundled interventions.

One of the key findings of this review was the low methodological rigor of the included papers, with many studies employing weak experimental designs. Further, the statistical analysis in many of the studies was inappropriate, treating observations of the same HCWs pre-intervention and post-intervention as independent data for analysis rather than acknowledging the dependence of the pre- and post- data points or controlling for baseline within analyses. This is a substantive problem which may render the analyses erroneous(44). Studies also failed to assess and provide data on the reliability of HH observations. While behavioral observation typically yields valid data, it is important to ensure the accuracy and

reliability of observations(45). Future research should ensure both the calibration of raters and the assessment of interrater agreement(45). Finally, within many of the studies, the level of description of interventions was insufficient to facilitate replication, or the repetition of experimental procedures(45). It is essential that future research describe procedures in sufficient detail that they may be repeated and the reproducibility of outcomes may be examined. Factors that may explain the poor quality of research include a lack of research funding available to support HH research or the rapid implementation of interventions in response to the identification of poor HH compliance. To advance our knowledge of empirically supported interventions for improving HH compliance in ICUs, it is essential that well-planned, methodologically rigorous research studies are conducted.

There was a high degree of variability in intervention effects. In some instances, implementation of the same intervention at different sites resulted in highly variable intervention effects (e.g., the International Nosocomial Infection Control Consortium's multidimensional HH approach(32,34,46-50). These data highlight the need for a better understanding of the association between organization characteristics, HCW characteristics, method of implementation, and intervention outcomes. It is well recognized that context can impact upon the implementation of an intervention and influence intervention effects(51). Studies which fail to collect such data on the fidelity and implementation of an intervention limit the conclusions that can be drawn about the generalizability of findings(51).

There is a need to examine the efficacy of the individual interventional strategies implemented within bundled interventions. Bundled interventions are employed with the logic that several effective intervention strategies implemented together should have a substantive impact. However, there is no evidence that interventions with multiple components are more effective than single-component interventions; in fact, direct comparison of interventions with a single component and bundled interventions has

sometimes revealed a similar or greater efficacy of single component interventions(52). Further, the lack of evidence for the individual interventional strategies within many HH bundled interventions is limiting(53). In the absence of an experimental design that allows an evaluation of the effect of each individual strategy within a bundled intervention(54,55), it cannot be determined whether individual intervention strategies are worth the financial cost and resources they require. Pragmatically, such research may be challenging to conduct in ‘real world’ settings but the importance of such research, measuring the effect of individual intervention strategies within bundled interventions, cannot be underestimated. Such research could start by assessing interventional components that have been found to have at least a low grade of research evidence supporting their use in other hospital settings(43) such as the provision of appropriate products and resources for HH (Enablement), Education, reminders (Environmental Restructuring), and feedback on HH compliance (Communication)(43). A substantial amount of resources are invested in HH improvement efforts within ICUs and such research would allow for the determination of whether these resources are necessary or whether an effective, empirically supported intervention can be delivered at a lower cost and with lesser time requirements.

Limitations

There are a number of limitations to this review’s methodology that should be acknowledged. First, only studies published in peer-reviewed journals were eligible for inclusion. The exclusion of the grey literature can lead to the over-estimation of intervention effectiveness(56). However, there are also considerations surrounding the inclusion of the grey literature including the lack of best practice guidance around how and where to conduct searches, the impact of grey literature searches on methodological reproducibility, and the difficulty in interpreting data due the low methodological quality, and poor reporting(57-59). Second, only papers published since 2009 were reviewed. This decision was made as the

WHO's HH guidelines(5) were published in that year and have markedly impacted(6) research and practice. Third, only studies that measured HH compliance via behavioral observation were reviewed, with papers that used self-report data, automated recording or relied on product volume usage data excluded. This decision was made as observation is considered to be the 'gold standard' of HH measurement(18) and other methods may yield unreliable and potentially invalid data. Finally, when describing intervention effects we focused on a simple quantification of outcomes; relative percentage change in HH compliance. This was the only means of quantifying intervention effects as few studies presented the data necessary to calculate effect sizes. Many of the methodological differences across the studies (e.g., awareness of HH measurement, HH measurement methodology, study design) may have contributed to variability in intervention outcomes that was observed. Future research should supply the data necessary to support effect size calculations which would facilitate the conduct of a meta-analysis and allow for the identification of variables associated with differing intervention effects.

Future Research

Our findings suggest a number of additional recommendations for improving the rigor, and guiding the focus, of future research focused on improving HH compliance in ICUs.

First, the literature offers little insight into the maintenance of intervention effects beyond intervention cessation. Of the four (10.5%) studies that examined this, intervention effects were only maintained in one. It is therefore unclear whether HH improvements can be sustained if an intervention is removed or if it is necessary for interventions to remain in place. The difficulty of maintaining improvements in HH has been noted previously(9). Sustaining a healthcare intervention over time is challenging and requires the incorporation of

the intervention strategies within employee work duties, training of new personnel, continued financial investment, and adaptation as circumstances or guidelines change(60). Future research that collects data on the maintenance of intervention effects will advance our knowledge on the type of interventions that result in sustained improvements post-intervention cessation, the true cost of producing sustained improvements in HH compliance, and variables that may affect the maintenance of intervention effects.

Second, there was a lack of focus on the economics of the interventions evaluated. This may stem from the difficulty of linking changes in HH compliance to HAI rates, given the indirect relationship between the two variables and the multifactorial nature of HAIs. In this review, only one study(61) conducted a cost effectiveness evaluation, and found HH to be a cost effective means of reducing HAIs. These data are in concordance with other research which suggests that the costs of promoting and improving HH may constitute less than 1% of the HAI costs(62). Cost effectiveness analyses inform decision making within many health care systems(63), and there is a need for data to support the investment in HH or other healthcare issues will be prioritized.

Third, there were high rates ($\geq 50\%$ of sites or participants) of attrition within some studies(32,46,50,33,48,49) but these received little consideration. Failure to adequately describe or account for these participant losses impacted upon the quality evaluation of studies(20). Further research is needed to explore interventional characteristics that may be predictive of attrition, or to further explore organizations' or HCWs' experiences within HH interventions which may elucidate reasons for failing to reach the study endpoint.

CONCLUSIONS

Although the WHO's HH guidelines have been enormously influential and impactful, it is erroneous for hospital managers and clinicians to think that the problem of poor HH

compliance, and its implications for patient outcomes, has been solved. The findings of this review clearly demonstrate that evidence-based practice for improving HH compliance in ICU settings remains unestablished. Greater consideration is required by hospital managers and clinicians as to how limited resources can be best invested in interventions that are both empirically supported and effective. In the absence of sufficient research data within ICU settings, frontline staff should ensure that interventional strategies implemented within their workplaces are those that have been found to have at least a low grade of research evidence supporting their use in other hospital settings, such as Enablement, Education, Environmental Restructuring, and Communication(43). Staff must also continue to push for greater consideration, and evaluation, of HH interventions implemented within their units. This, in combination with well-designed future research studies, will help to ensure that knowledge concerning best practice in HH improvement within ICUs is advanced and that hospitals are best poised to protect their patients from HAIs.

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Summary of Medline OVID Search Strategy

1: exp Hand Hygiene/
2: Handwashing.ti,ab.
3: (Hand adj2 Cleansing).ti,ab.
4: (Hand adj2 Cleaning).ti,ab.
5: (Hand adj2 Decontamination).ti,ab.
6: (Hand adj2 Gel).ti,ab.
7: (Hand adj2 Saniti*).ti,ab.
8: (Hand adj2 Rub).ti,ab.
9: 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10: exp Personnel, hospital/
11: exp Hospitals/
12: exp Critical care/
13: Health*.ti,ab.
14: Medic*.ti,ab.
15: 10 or 11 or 12 or 13 or 14
16: 9 and 15
17: limit 16 to (english language and humans and not (addresses or autobiography or bibliography or biography or case reports or clinical conference or comment or congresses or consensus development conference or consensus development conference, NIH or dataset or dictionary or directory or duplicate publication or editorial or english abstract or festschrift or government publication or interactive tutorial or interview or lectures or legal cases or legislation or letter or news or newspaper article or overall or patient education handout or periodical index or personal narratives or portraits or published erratum or research support or retracted publication or retraction of publication or technical report or twin study or video-audio media or webcasts)).

Note: Exp= explode, ti=title, ab=abstract,

Quality Assessment outcomes resulting from the application of the Downs and Black (20) checklist

Area	Item	Downs and Black Criterion	N of studies meeting criterion (% of total studies)
REPORTING	1	Is the hypothesis/aim/objective of the study clearly described?	32 (84.2%)
	2	Are the main outcomes to be measured clearly described in the Introduction or Methods section?	32 (84.2%)
	3	Are the characteristics of the participants included in the study clearly described?	12 (31.6%)
	4	Are the interventions of interest clearly described?	25 (65.8%)
	5	Are the distributions of principal confounders in each group of subjects to be compared clearly described?	8 (21.1%)
	6	Are the main findings of the study clearly described?	24 (63.2%)
	7	Does the study provide estimates of the random variability in the data for the main outcomes?	10 (26.3%)
	8	Have the characteristics of participants lost to follow-up been described?	0 0
	9	Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?	29 (76.3%)
EXTERNAL VALIDITY	10	Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	0 (0%)
	11	Were the staff, places, and facilities where the participants were treated, representative of the treatment the majority of participants receive?	37 (97.4%)
INTERNAL VALIDITY- BIAS	12	Was an attempt made to blind those measuring the main outcomes of the intervention?	2 (5.3%)
	13	If any of the results of the study were based on “data dredging”, was this made clear?	38 (100%)
	14	In trials and cohort studies, do the analyses adjust for different lengths of follow-up of participants, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?	1 (2.6%)
	15	Were the statistical tests used to assess the main outcomes appropriate?	17 (44.7%)
	16	Were the main outcome measures used accurate (valid and reliable)?	6 (15.8%)
IN T E	17	Were the participants in different intervention groups (trials and cohort studies) or were the cases and controls	3 (7.9%)

		(case-control studies) recruited from the same population?	
	18	Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?	3 (7.9%)
	19	Were study subjects randomised to intervention groups?	4 (10.5%)
	20	Was the randomised intervention assignment concealed from both participants and health care staff until recruitment was complete and irrevocable?	3 (7.9%)
	21	Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	4 (10.5%)
	22	Were losses of participants to follow-up taken into account?	1 (2.6%)
POWER	23	Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? (In the current study, a change was made to this item and power was scored as either sufficient power (1), or insufficient power (0), with the requisite number of observations of hand hygiene compliance calculated on the basis of an effect size 0.2, alpha of .05, and the use of a two-tailed test).	33 (86.8%)

Note. Four items were removed as they were not considered relevant to the type of studies in this systematic review. These items were: 1) Have all important adverse events that may be a consequence of the intervention been reported? (Reporting); 2) Were the subjects asked to participate in the study representative of the entire population from which they were recruited? (External Validity); 3) Was an attempt made to blind study subjects to the intervention they have received? (Internal Validity-Bias), and; 4) Was compliance with the intervention/s reliable? (Internal Validity-Bias).

Detailed overview of the 38 included studies.

Study	Country	Participants	Setting	Design	Hand Hygiene Measurement	Intervention	Mean HH compliance Pre-Intervention	Mean HH compliance Post-intervention	Net Intervention Effect	Quality Score
Al-Dorzi et al.(30)	Saudi Arabia	HCWs and ICU visitors.	21 bed medical-surgical closed ICU	Time Series Design	WHO observation method	HH education using videos, coaching and online modules; Workplace reminders including HH breaks; Addressing perceived HH barriers; Active feedback of HH compliance to staff; Empowerment of staff to educate and stop violators; Warning letters from the chairman for repetitive violations; Implementation of universal contact precautions for all patients	64%	Ranged from 78-89%* among the various categories of HCWs	-	5
Alhenn et al.(23)	Saudi Arabia	HCWs	Adult ICU with 100 beds divided into four physically separate sections.	One group Pretest Posttest design	WHO observation method	Competition for the best compliance with HH practice	52%	70%	34.6%	6
Allegranzi et al.(26)	Italy; Mali; Pakistan; Saudi Arabia	HCWs	Italy- 41 ICUs across 18 cities Mali- one intensive care department Pakistan- one intensive care department Saudi Arabia- two intensive care departments	Series of one group pretest posttest designs	WHO observation method	Italy- WHO standard techniques (Ensuring system change; Training and education; Monitoring of practices and provision of feedback on performance; Visual reminders in the workplace; Creation of a safety climate in the workplace); Web platform with enquiries system; Increased availability of ABHR; Fingertip method demonstrations for workers; Bedside feedback; Guide to implementation summary; Posters; Gadgets Mali- WHO standard techniques; Local production of ABHR; Intervention launch event; Separate educational sessions for doctors; Leaflet for launch of HH campaign; Promotional T-shirts Pakistan- WHO standard techniques; Local production of ABHR; Gender specific educational sessions; Posters translated into Urdu	UTD	UTD	UTD	6

						<p>Saudi Arabia-</p> <p>1. WHO standard techniques; Local production of ABHR; Gender-specific educational sessions; Demonstrations of the HH technique; Fingertip method demonstrations for workers; Patient participation in HH promotion; Campaign logo; Posters and banners; Gadgets; Screensavers; Promotional video; Educational brochures and pocket leaflets for HCWs, visitors and patients in four languages; Drawing book for children; National HH guidelines; Summary of HH guidelines for HCWs during the pilgrimage season</p> <p>2. WHO standard techniques; Gender specific educational sessions; Separate educational sessions for doctors; Stands for promotion of HH throughout hospital; Patient Participation in HH promotion; Banners and posters; Brochures for HCWs; Brochures for patients; Pocket leaflets for HCWs; Gadgets</p>				
Apisamthanarak et al.(31)	Thailand	125 HCWs	Six ICUs at a University Hospital	Series of pretest posttest designs	WHO observation method	<p>1: HH education by the infection control division every three months (n=2);</p> <p>2: Intensified HH intervention (comprising monthly education emphasizing HH adherence and impact on patient safety; Weekly workgroup discussions exploring reasons for not performing HH among HCWs) (n=2);</p> <p>3: Intensified HH intervention (as above) with increased availability of ABHR (n=2)</p>	1: 68%	1: 71%	1: 4.4%	9
Armellino et al.(35)	USA	HCWs	One medical ICU at a tertiary hospital	Time series design	Remote video auditing by human observers of HH opportunities at entry to, and exit from, patient spaces	Remote video auditing without feedback; Remote video auditing with performance feedback displayed on electronic boards and email summary reports for supervisors	6.5%	81.6%	1155.4%	10
Armellino et al.(36)	USA	HCWs	18 bed surgical ICU at an academic	Time series design	Remote video auditing by human observers	Remote video auditing without feedback; Remote video auditing with performance feedback displayed on	30.4%	82.3%	170.7%	9

			tertiary care hospital		of HH opportunities at entry to, and exit from, patient spaces	electronic boards and email summary reports for supervisors				
Barahona-Guzmán et al.(46)	Colombia	HCWs	7 adult ICUs	Pretest Posttest design	Direct observation of HH opportunities before patient contact and before an aseptic task in accordance with INICC surveillance forms	INICC multidimensional hand hygiene approach: administrative support; increased supplies availability; education and training; poster reminders in the workplace; process surveillance; performance feedback	50.5% ⁺	77.5% ⁺	53.5% ⁺	9
Biswal et al.(37)	India	HCWs	7 adult ICUs including cardiac care ICU, cardiovascular and thoracic ICU, Gastroenterology ICU, Liver ICU, Main ICU, Neurosurgery ICU, and Respiratory ICU	Series of one group pretest posttest designs	Audit using the WHO Five moments of HH observational tool	Two hand hygiene awareness campaigns across 18 months. These campaigns included educational sessions on the WHO's five moments of HH, Demonstrations of HH technique using videos and ultraviolet gel technology, poster reminders, promotion of ABHR and increase in HH resources	16.4% ⁺	35.1% ⁺	114% ⁺	10
Biswal et al.(64)	India	HCWs	5 adult ICUs including a main ICU, transplant ICU, neurosurgery ICU, cardiology ICU, and cardiothoracic and vascular surgery ICU	Series of one group pretest posttest designs	All HH opportunities for one patient over 30 mins daily had compliance assessed. HH moments assessed included: before and after patient care, before an invasive procedure, when hands were visibly soiled with patient body fluid, and	Three HH awareness weeks over 18 months- education sessions, posters, and direct training and supervision included	17.7% ⁺	37.6% ⁺	112.4% ⁺	8

					before and after removing gloves; Participants not aware they were being observed					
Borges et al.(65)	Brazil	HCWs	3 adult ICUs including a clinical ICU, a surgical ICU, and a medical-surgical ICU	Series of one group pretest posttest designs	Assessed HH opportunities before and after any contact with a patient or with the inanimate material in a patient's room	Display of, and feedback on, HH compliance rates; Poster reminders for HH and colorful stamps; Performance feedback; Distribution of ABHR bottles	11%* ⁺	16.3%* ⁺	48.2%* ⁺	5
Camargo et al.(66)	Brazil	HCWs	Three four-bed wards within a medical-surgical ICU at a tertiary care private hospital.	Between groups posttest only design	HH compliance assessed before and after patient care along with opportunities around respiratory care, catheter care, uro-genital care, general care, nasogastric tube care, and others; HCWs unaware that they were being observed	Educational and motivational program with practical demonstration of HH techniques, theoretical issues concerning the benefits of HH and disclosure of HH compliance rates in the ICU in past years; Comparison of different types of ABHR	-	46.7%	UTD	6
Chakravarthy et al.(47)	India	HCWs	Three ICUs across one academic teaching hospital and two private hospitals with one medical, one medical-surgical and one surgical ICU included	Series of Pretest Posttest design	HH compliance monitored before patient contact and before an aseptic task. INICC process surveillance HH forms	The INICC Multidimensional Hand Hygiene Approach: Administrative support; Increased supplies availability; Education and training on HH practices; Poster reminders; Process surveillance; Unit-level performance feedback	36.9%	74.8%	102.7%	12
Chun et al.(38)	South Korea	24 nurses	One medical ICU at a tertiary care teaching hospital	Pretest Posttest design	Nurses' HH compliance assessed around activities including intravenous or intramuscular	Handwashing education programs including group education on HH and its importance; individual HH evaluation and feedback	46.8%	71.4%	52.6%	9

					injection, respiratory ventilator care, care regarding excretion, and nasogastric tube feeding					
dos Santos et al.(39)	Brazil	HCWs	One ICU in a university, tertiary-level, public hospital. The ICU had two wards for clinical and surgical patients and one for coronary and cardiac surgery patients.	Time series design	Nine opportunities for HH were observed: before touching a patient, after touching a patient, after body fluid exposure, before aseptic procedure, before gloving, after gloving, before preparing medication, and among different procedures at the same patient	Improvement in availability of HH resources (e.g., sinks, ABHR); Educational meetings for all staff on HH routines and indications; Distribution of educational information to all staff; All ICU protocols for patient care and safety emphasized HH; Monthly unit-level feedback	30%	UTD	UTD	8
Erasmus et al.(33)	The Netherlands	Eight nurses	One ICU of a university teaching hospital	Pretest Posttest design	HH assessed in accordance with WHO's five moments guidelines	Structured interview about the importance of HH, rated self-compliance, preferred method of HH, possible barriers to HH encountered in daily practice, and the development of action plans (implementation intentions) for HH. During baseline observations, nurses were unaware that HH was focus of the study	10.7%	15.8%	47.7%	5
Fuller et al.(27)	England and Wales	HCWs	16 Intensive Therapy Unit in 16 acute hospitals	A stepped wedge cluster randomized controlled design	HH compliance measured using the Hand Hygiene Observation Tool; HH observations were covert	A feedback intervention comprising both immediate individual feedback after a period of observation and assistance for HCWs in formulating an action plan to improve behavior in cases of noncompliance, and observation of group compliance and feedback on group compliance at a ward meeting and development of action plans	UTD	UTD	UTD	15
García-Vásquez et al.(67)	Spain	HCWs	One ICU in a second level hospital center	Pretest Posttest Design	HH compliance measured before and after contact with the patient;	Acquisition of a water-alcohol antiseptic, and dispensers for this, to add to existing HH resources; Information sessions on the new	43.4% [#]	54.2% [#]	24.9% [#]	9

					HCWs unaware that they were being observed	antiseptic with indications and instructions for use; Distribution of informative notices on the recommendations for use of barrier measures and correct HH practices				
Hitoto et al.(24)	France	HCWs	4 ICUs including three medical ICUs and one surgical ICU	Pretest Posttest Design	HH compliance measured in accordance with the WHO's five moments of HH	Screening for MRSA carriers on admission of all patients and provision of feedback to staff members on patients' MRSA status	44.8%	48.5%	8.3%	8
Jansson et al.(40)	Finland	30 critical care nurses randomized to intervention or control group	22-bed adult mixed medical-surgical ICU	Randomized controlled trial	HH compliance measured before and after patient contact; Only measured during endotracheal suctioning events	Intervention: Simulation session including: orientation to simulation center, orientation to mannequin, actual simulated scenario, and 60 minute post-scenario debriefing session. The debriefing session included discussion of indications for HH, duration of handrubbing, HH technique, and other aspects of HH	40.8%	59.2%	45.1%	11
Johnson et al.(28)	USA	HCWs	24-bed medical ICU within a Level 1 Trauma Center	One group pretest posttest design	HH compliance measured around entry to, and exit from, patients' rooms	First, a one day seminar that covered evidence-based practices including those relating to HH. Feedback from attendees sought on barriers to HH, what individual staff could do to improve performance, and what the unit leadership team could do to improve performance. Action plan developed; Implementation of a collaborative governance (i.e., decision making model that places responsibility for appropriate and safe patient care with the practicing clinician) structure within the hospital; Educational campaign "Caught you clean handed" implemented. Campaign included visual reminders, increasing knowledge regarding need to increase infection prevention strategies and HH among families/patients, and 1:1 education for staff on campaign purpose, unit-level compliance rates, and words to use to facilitate the education of patient/families/visitors/peers about HH; An environment of accountability was created in which staff members were responsible for discussing	UTD	UTD	UTD	4

						deviations in practice that they observed with their peers				
Kirkland et al.(41)	USA	HCWs	Medical-surgical ICU and Cardiac ICU	Interrupted time series design	HH compliance rates before and after contact with patients or their environments; Observation was covert	Leadership and accountability (leadership emphasized importance of HH for patient safety, unacceptability of current performance, and public commitment to improve); Measurement and feedback (introduction of routine HH audits on all units, continued surveillance, and publication of monthly unit-level feedback data); Improvements in hand sanitizer availability; Education and training (electronic learning module, training video, and a certification program); Marketing and communication (awareness-raising posters and screen savers, stories in hospital publications and local news outlets, and direct communication with staff about expectations and progress)	51% [#]	80.5% [#]	57.8% [#]	8
Leblebicioglu et al.(32)	Turkey	HCWs	10 ICUs within academic hospitals	Series of pretest posttest designs	HH compliance measured before patient contact and before an aseptic task	INICC Multidimensional HH approach: Administrative support; Improved availability of supplies; Education and training; Reminders in the workplace; Process surveillance; Unit-level performance feedback	20.6% ^{+#}	43.3% ^{+#}	110.2% ^{+#}	9
Lee et al.(68)	South Korea	Medical personnel (doctors and nurses)	ICU of a Tertiary care teaching hospital	Series of pretest posttest designs	HH compliance as per WHO's five moments of HH	HH promotion campaign encompassing a poster campaign, HH monitoring and performance feedback, and education with special attention to importance of perception of being a role model for other colleagues	43.8% [#]	73.3% [#]	67.4% [#]	9
Mahfouz et al.(29)	Saudi Arabia	HCWs- 179 nurses, 34 physicians, 23 other HCWs	An ICU and a cardiac care unit at a tertiary hospital	Series of pretest posttest designs	HH compliance as per WHO's five moments of HH	Consultation and advocacy meetings (sought cooperation with, and support for, project); Increased provision of AHR; Training, education and visual reminders (2-3 hour training sessions focused on background to WHO patient safety and the First Global Patient Safety Challenge; definition, effect and burden of healthcare associated infections; transmission of pathogens and the critical role of HH; WHO guidelines on HH in healthcare including why, when, and how to perform HH); Increased use of	UTD	UTD	UTD	9

						reminders in the workplace; Involvement of hospital leaders in HH improvement activities through active participation in HH days; Evaluation and individual-level and hospital-level feedback				
Mathai et al.(69)	India	HCWs	Adult ICU of a tertiary care hospital	Pretest Posttest Design	The National Center for Patient Safety of the Department of Veteran Affairs Hand Hygiene Observation Tool	Educational initiatives (based on the WHO's Five Moments of HH); Visual reminders; Ad hoc verbal reminders whenever HH noncompliance observed; Increased availability and ease of access of HH materials	26%	57.4%	120.8%	7
Medeiros et al.(48)	Brazil	HCWs	Four adult medical-surgical ICUs across two academic teaching hospitals and two private hospitals	Series of Pretest Posttest designs	HH compliance measured before patient contact and before an aseptic task	INICC Multidimensional HH approach: Administrative support; Improved availability of supplies; Education and training; Reminders in the workplace; Process surveillance; Unit-level performance feedback	27%	58%	114.8%	9
Mestre et al.(70)	Spain	HCWs	ICU within a private hospital	Pretest Posttest design	HH compliance measured as per four of WHO's five moments of HH; The moment "after touching surroundings" was not evaluated	Phase one WHO HH multimodal intervention approach including: Increased availability of ABHR; Staff education; Visual reminders; HH audit; Unit-level feedback; Creation of an institutional safety climate; Regional campaign promoted by the "Alliance for Patient Safety" supported by WHO resources ongoing during intervention Phase two Intervention as described previously with the addition of increase of ABHR dispensers, increased frequency of audits, increased frequency and standardization of feedback, and implementation of a standardized process for proactive corrective actions (i.e., use of specific form to record corrective actions. Modification of incorrect HH behavior and clarification of doubts or uncertainty)	70%	Phase one: 73% Phase two: 85%	Phase one: 4.3% Phase two: 21.4%	7

Miranda- Novales et al.(49)	Mexico	HCWs	Five medical- surgical ICUs and one neurosurgical ICU	Series of Pretest Posttest designs	HH compliance measured before patient contact and before an aseptic task	INICC Multidimensional HH approach: Administrative support; Improved availability of supplies; Education and training; Reminders in the workplace; Process surveillance; Unit-level performance feedback	43.8% ^{+#}	71.3% ^{+#}	62.8% ^{+#}	10
Patel et al.(71)	South Africa	HCWs	975 bed specialist and subspecialist hospital including an ICU ward	Pretest Posttest design	HH compliance before and after patient contact	The WHO HH multimodal intervention approach: Provision of all infrastructural and consumable requirements for HH; Hospital-specific standardized training presentation delivered weekly; Poster reminders; Ad hoc in-service training on the WHO's five moments of HH; HH audits; Monthly unit-level feedback	65%*	90%*	38.5%*	9
Reich et al.(25)	USA	Physicians	Surgical ICU in a Level 1 Trauma Tertiary-care medical center	Time series design	HH compliance at entry to, and exit from, patient rooms	HH compliance rates were distributed via a monthly email report card (which ranked services from most to least compliant) to chiefs of services and presented monthly at critical care committee and infection prevention meetings	65.1%	91.2%	40.1%	6
Rodriguez et al.(72)	Argentina	HCWs	10 adult ICUs from general hospitals	Stepped wedge cluster randomized trial	HH compliance as per WHO's five moments of HH; Observation was covert	Support from hospital directors and engagement of hospital directors in monthly executive walk around; Increased availability of ABHR; Visual reminders for, and pocket guides to, HH; Display of a storyboard that presented information on support from hospital directors for HH, results of monthly HH observations, and photos of the healthcare team; Feedback on HH compliance to coordinators of intervention sites and comparison of site's data with that of other intervention sites or international performance data. This data was added to storyboard	63.5% ^{+#}	74.7% ^{+#}	17.6% ^{+#}	17
Rosenthal et al.(34)	Argentina	HCWs	10 ICUs- eight medical- surgical ICUs and 2 coronary ICUs	Series of Pretest Posttest designs	HH compliance measured before patient contact and before an aseptic task; Observations were covert	INICC Multidimensional HH approach: Administrative support; Improved availability of supplies; Education and training; Reminders in the workplace; Process surveillance; Unit-level performance feedback	24.8% ^{+#}	65.7% ^{+#}	164.9% ^{+#}	10
Sakihama et al.(73)	Japan	Nurses and doctors	ICUs in three hospitals- one	Pretest Posttest	HH compliance prior to patient	Multimodal intervention based on WHO recommendations and previous	16%	26%	62.5%	9

			university-affiliated, tertiary care medical center and two community-based, tertiary care medical centers.	Design	contact (WHO moment 4)	research: Improvement of infrastructure (hand washing faucets for each room, placement of ABHR dispensers, portable ABHR for HCWs); Training and education (education resources along with periodic seminars and lectures regarding HH); Evaluation and feedback (evaluation via direct observation and ABHR consumption. Feedback to infection control committee and to the HCWs within participating wards); Visual reminders (posters); Improvement of institutional safety climate (commitment of hospital executives and representative HCWs at participating wards. Meetings about HH within participating wards and identification of champions within participating wards); Contest whereby the facility with the highest HH adherence post-intervention won \$5,000 and a trophy				
Souweine et al.(74)	France	HCWs	Seven adult ICUs of four hospitals including 5 medical-surgical ICUs, one medical ICU, and one neurosurgical ICU	Pretest Posttest Design	HH compliance measured after glove removal and on room exit following contact either with the patient or with his/her immediate surroundings	Two meetings in each ICU- one to inform HCWs on how and when to use ABHR and the other to show them how and when to use ABHR and encourage them to use it; Introduction of ABHR	51.6%	60%	16.3%	7
Su et al.(50)	China	HCWs	Five ICUs of three hospitals including one medical-surgical ICU, one neurosurgical ICU, one respiratory ICU and two surgical ICUs	Pretest Posttest Design	HH compliance measured before patient contact and before an aseptic task; Observation was covert	INICC Multidimensional HH approach: Administrative support; Improved availability of supplies; Education and training; Reminders in the workplace; Process surveillance; Unit-level performance feedback	51%	67%	31.4%	13
Taneja et al.(75)	India	106 nurses	ICUs of one tertiary care hospital	Pretest Posttest Design	HH compliance measured before and after patient contact	Visual Reminders, focus group sessions, and education and demonstrations	52%	63%	21.2%	6

Thu et al.(61)	Vietnam	HCWs	Two ICUs and 15 critical care units	Pretest Posttest Design	HH compliance as per the WHO's five moments of HH	Ceremony with a quiz on HH for all HCWs; Continuous HH education program for HCWs using posters, flyers, and seminars; Improvement of infrastructure and HH resources (including more dispensers and portable bottles)	25.7%	57.5%	123.7%	9
Wetzker et al.(76)	Germany	HCWs	25 surgical ICUs and 14 medical ICUs	Posttest only design	HH compliance as per the WHO's five moments of HH	German national HH campaign which supports implementation of multimodal infection prevention interventions and provides training materials and video tutorials	-	76.6%	-	7

Note. *These figures are estimated from graphs. +These figures have been calculated by reviewers to exclude pediatric and newborn ICU data.

#These figures have been computed by researchers from provided data. ABHR=Alcohol-based Hand Rub; HCW= Healthcare worker; HH=Hand Hygiene; ICU= Intensive Care Unit; WHO= World Health Organization; UTD= Unable to determine.

