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Review

Hand hygiene compliance by direct observation in physicians and nurses: a systematic review and meta-analysis

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Background: Direct observation of hand hygiene compliance is the gold standard despite limitations and potential for bias. Previous literature highlights poorer hand hygiene compliance among physicians than nurses and suggests that covert monitoring may give better compliance estimates than overt monitoring.

Aim: To explore differences in compliance between physicians and nurses further, and to determine whether compliance estimates differed when observations were covert rather than overt.

Methods: A systematic search of databases PubMed, Embase, CENTRAL and CINAHL was performed. Experimental or observational studies in hospital settings in high-income countries published in English from 2010 onwards were included if estimates for both physicians and nurses using direct observation were reported. The search yielded 4814 studies, of which 105 were included.

Findings: The weighted pooled compliance rate for nurses was 52% (95% CI: 47–57) and for doctors was 45% (95% CI: 40–49%). Heterogeneity was considerable ($I^2 = 99\%$). The majority of studies were at moderate or high risk of bias. Random-effects meta-analysis of low risk of bias studies suggests higher compliance for nurses than physicians for both overt (difference of 7%; 95% CI for the difference: 0.8–13.5; $P = 0.027$) and covert (difference of 7%; 95% CI: 3–11; $P = 0.0002$) observation. Considerable heterogeneity was found in all analyses.

Conclusion: Wide variability in compliance estimates and differences in the methodological quality of hand hygiene studies were identified. Further research with meta-regression should explore sources of heterogeneity and improve the conduct and reporting of hand hygiene studies.

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Introduction

Hand hygiene in the healthcare setting has been shown to reduce the incidence of healthcare-associated infections (HAIs) [1]. Despite guidelines for their prevention, HAIs remain a widespread challenge, and are associated with prolonged hospital admission, increased financial cost and excess mortality [2]. The SARS-CoV-2 pandemic has highlighted the need for renewed focus on the fundamentals of infection control including hand hygiene.

In May 2009, the World Health Organization (WHO) published guidelines on hand hygiene in healthcare, outlining 'five moments for hand hygiene' [3]. These five moments are: (1) before touching a patient, (2) before clean/aseptic procedure, (3) after body fluid exposure, (4) after touching a patient, and (5) after touching patient surroundings. Methods for observing hand hygiene include direct methods (e.g. direct observation or self-reported compliance) and indirect methods (e.g. automated monitoring or product consumption). As the only method that can assess hand hygiene at all moments, direct observation of hand hygiene compliance is currently recommended as the 'gold standard'. However, direct observation is not without limitations. Potential areas of bias include observation bias, observer bias, and selection bias, with previous reviews highlighting bias in hand hygiene compliance monitoring [3–5].

Observation bias, induced by the presence of an observer influencing participant behaviour, is a widely cited source of bias in hand hygiene research and termed the Hawthorne effect [6,7]. Recent work by Purssell *et al.* attempted to quantify the Hawthorne effect by analysing nine studies comparing covert with overt measurement and concluded that occasional covert monitoring may give a better estimate of hand hygiene compliance [8].

Observer bias may result from systematic error introduced by inter-observer variation in recording observations. Appropriate validation of observers is recommended to minimize this bias [3]. It has also been suggested that unit-based observers may introduce bias into compliance estimates, and that peers could be biased in their compliance estimates towards non-peers [4,9]. Selection bias may arise because groups of participants differ in ways other than the intervention or exposure of interest or may differ systematically from the population of interest and are not representative. In studies of observation of hand hygiene, this bias may arise when the selection of participants is not random [3].

A previous systematic review in 2010 on studies using direct observation or self-reported compliance found that compliance is lower among physicians than among nurses, and lower before rather than after patient contact [10]. However, the impact of overt and covert observation on hand hygiene compliance estimates among physicians and nurses is unclear. In addition, the WHO 'five moments for hand hygiene' are now recommended for compliance estimates rather than before and after contact [3]. An up-to-date review of the literature is needed to explore compliance among physicians and nurses using direct observation, and whether differences in compliance are also seen when observations are covert rather than overt. Finally, the review seeks to determine whether observation by peers impacts on compliance estimates, and if poorer compliance by physicians is seen at all opportunities for hand hygiene as per the WHO 'five moments' or at specific opportunities.

Objectives

The primary and secondary questions that the review seeks to address are: (1) How do levels of compliance by direct observation of hand hygiene compare between physicians and nurses? (2) Are there differences between physicians and nurses in compliance rates measured by overt and covert observation? (3) Are there differences between physicians and nurses in compliance rates measured by different types of observers (e.g. nurses, physicians, infection control personnel, etc.)?; (4) Are there differences between physicians and nurses in compliance as per the WHO 'five moments for hand hygiene'?

Methods

This review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11].

Registration and protocol

The review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) database under the following registration number: CRD42021253106.

Protocol amended on June 2nd, 2021 at title and abstract screening: Addition of reviewer (D.O.D.). Inclusion criteria updated to include high-income countries only (as defined by World Bank 2021). Protocol amended on June 16th, 2021 at full text screening: Addition to planned data extraction of observer category, and to strategy for data synthesis to analyse whether differences in compliance estimates by different observers. Protocol amended on July 24th, 2021: Change to risk-of-bias tools to RoB2 for cluster-randomized trials and JBI checklist for quasi-experimental studies for non-randomized studies of interventions.

Eligibility criteria

Studies were included if meeting the following eligibility criteria: healthcare worker population; an experimental or observational study design; compliance quantitatively measured by direct observation either overt or covert; specifies individual compliance estimates for both nurses and physicians; hospital setting; conducted in a high-income country as defined by the World Bank 2021 [12]; published in English; published from 2010 onwards.

Studies were excluded if: non-healthcare worker population; self-reported compliance; compliance measured by indirect methods (e.g. electronic monitoring or soap/alcohol-based hand rub (ABHR) usage); individual compliance estimates for both physicians and nurses not specified; surgical handwashing as relates to a different technique; non-hospital setting; conducted in a low- or middle-income country (LMIC) as defined by the World Bank 2021 [12]; not published in English; published prior to 2010; articles without original data; conference abstracts or posters.

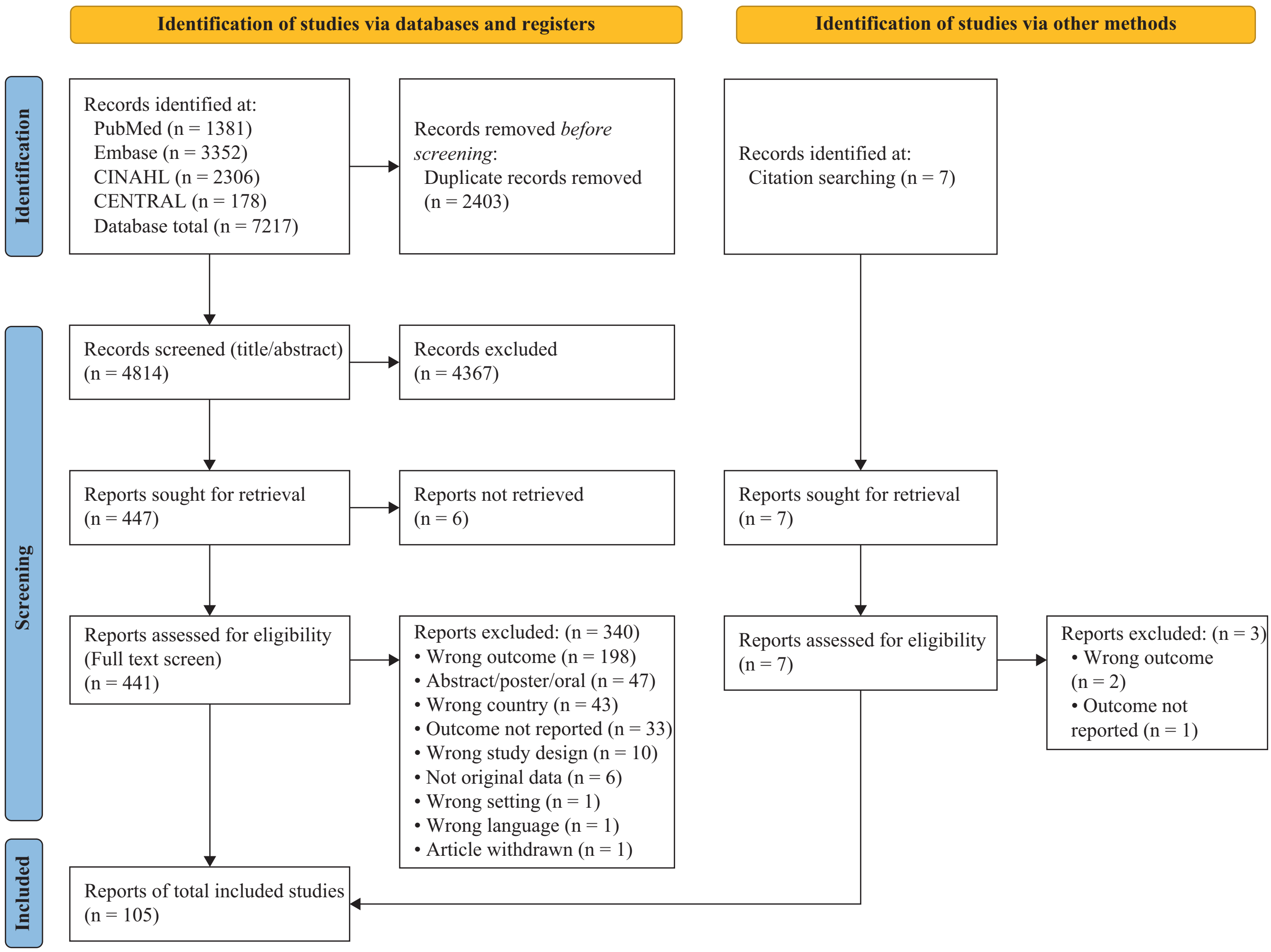

Figure 1. PRISMA flow diagram for the selection of studies [11].

Studies from LMICs were excluded due to significant challenges and barriers to hand hygiene compliance (e.g. water or ABHR availability) that may create large variation in compliance estimates [13]. Studies from 2010 onwards were included to reflect theoretical methodological changes in assessing hand hygiene compliance following the WHO guidelines on hand hygiene in healthcare [3]. Study designs included were experimental or quasi-experimental (randomized controlled trials (RCTs), before–after studies and interrupted time series) and observational studies (cohort and cross-sectional) as potentially providing valid evidence for the review question.

Information sources and search strategy

A comprehensive search was conducted on PubMed, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), and CINAHL (EBSCOhost) databases for relevant literature on April 26th, 2021. A library information specialist and the Peer Review of Electronic Search Strategies (PRESS) checklist were consulted to refine the search strategy [14]. The search strategy was validated by checking whether it could retrieve a set of eligible key studies [15–17]. The search strategy is presented in full in Supplementary Appendix A. The reference lists of relevant systematic reviews and study reports included in the systematic review were manually hand-searched for any additional relevant studies [5,8,18–20].

Selection process

Title and abstract screening were independently performed in duplicate by two reviewers (D.B. and D.O.D.) based on the previously described inclusion/exclusion criteria. Discrepancies were resolved by discussion and consensus. Full text screening of studies that appeared to meet the eligibility criteria were assessed for inclusion independently by two reviewers (D.B. and D.O.D.). Discrepancies were resolved by discussion and consensus.

Data collection process

Extraction of study outcomes data was performed in duplicate by two reviewers independently (D.B. and D.O.D.) with data on study characteristics extracted by one reviewer (D.B.). A piloted data extraction form was used, with any discrepancies resolved by discussion and consensus. In cases of linked studies with multiple reports corresponding to a study at different time-points, the final report was used as containing the most complete outcomes data.

Table I
Characteristics of included studies

Characteristic	No. of studies	References
Region		
Europe	45	[16,25,32,34,40,41,45,50–52,55,56,59,61,65–67,69,70,75,77,85–87,89,90,92,94–97,104–107,110,112–118,121,123]
North America	27	[17,28,36–39,44,46–49,57,58,60,68,71–74,78,82,84,88,91,111,119,122]
Middle East	15	[15,26,27,29–31,42,53,64,80,81,83,103,120,126]
Asia	12	[35,43,76,79,99–102,108,109,124,125]
Oceania	6	[33,54,62,63,93,98]
Study design		
Cluster-RCT	5	[25,60,115,117,121]
Non-randomized study of intervention	52	[26–28,32,34,37,41,43,45–47,50–54,57,59,65,66,68,69,71,73,76,78,80,82,83,85–87,89,91,93,96,98–100,102–104,107–109,111,114,116,118,120,122,126]
Observational	48	[15–17,29–31,33,35,36,38–40,42,44,48,49,55,56,58,61–64,67,70,72,74,75,77,79,81,84,88,90,92,94,95,97,101,105,106,110,112,113,119,123–125]
Setting		
ICU	15	[16,26,28,31,34,37,52,58,65,89,90,103,105,113,117]
Hospital-wide	13	[27,36,42,43,46,47,57,68,74,76,79,120,126]
Emergency Department (ED)	10	[30,32,50,53,67,69,88,91,104,119]
Medical/surgical wards	9	[33,55,56,66,75,86,95,96,116]
Paediatric wards	4	[61,78,97,106]
ICU and various units	34	[15,29,35,40,41,45,49,51,54,59,60,63,64,70,72,73,80–85,87,93,99–102,112,118,121–123,125]
ED and various units	3	[17,111,124]
Various/other wards	11	[25,44,48,62,77,92,98,107,110,114,115]
Outpatients	3	[38,39,71]
Not recorded	3	[94,108,109]
Observation method		
Overt	68	[16,25–27,30,33,39–41,43–45,48,50–54,59,61–67,69–76,80–91,93–98,103–107,109,112–115,117–119,121–123]
Covert	28	[28,29,31,32,34,37,42,46,47,49,55–58,60,68,77,78,92,99–102,110,111,116,120,124]
Both	7	[15,17,35,36,38,125,126]
Not recorded	2	[79,108]
Compliance measurement		
WHO five moments	58	[15,16,25,29,31–34,40,42,43,45,52–54,57,59,61–67,69,70,75,76,79–81,83–87,93,95–98,103–107,109,113–115,117,118,120–125]
WHO five moments and technique	3	[26,35,90]
Various moments	21	[17,27,37,48,50,51,55,56,58,73,74,77,88,89,92,94,99–102,116]
Before and after contact	11	[39,41,46,60,71,78,82,91,111,112,119]
Entry and exit	10	[28,30,36,38,44,47,49,72,110,126]
Not recorded	2	[68,108]
Observer validation		
Yes	41	[15–17,27,28,31,33,40,41,44,53,54,59,62,63,67,69,71,73,75,77,82,84–86,93,98–102,108,114–116,118,120,122,124–126]

(*continued on next page*)

Table I (*continued*)

Characteristic	No. of studies	References
No	2	[39,70]
Not recorded	62	[25,26,29,30,32,34–37,42,43,45–52,55–58,60,61,64–66,68,72,74,76,78–81,83,87–92,94–97,103–107,109–113,117,119,121,123]
Observer category		
Nurse/nursing students	26	[29,41,51,57,60,61,64–66,73,76,81,86,93,99–102,106,109,113–115,117,120]
Doctor/medical students	5	[16,31,32,49,110]
Infection control personnel unspecified	10	[40,42,45,46,52,59,69,80,83,98]
Mixed (nurse, doctor, infection control, other)	16	[15,17,27,34–36,38,68,103,116,118,119,122,124–126]
Other (patients, allied health professionals, researchers, other employees)	11	[25,26,30,39,47,53,75,78,82,92,111]
Not recorded	37	[28,33,37,43,44,48,50,54–56,58,62,63,67,70–72,74,77,79,84,85,87–91,94–97,104,105,107,108,112,121,123]
WHO-recommended observation sessions (20 min ±10)		
Yes	24	[15,29,41,43,48,51,53,57,64,68,73,74,84–88,95–97,103,110,115,126]
No	20	[16,31,33,55,56,58,61,67,72,81,89,90,105–107,112,113,118,119,125]
Not recorded	61	[17,25–28,30,32,34–40,42,44–47,49,50,52,54,59,60,62,63,65,66,69–71,75–80,82,83,91–94,98–102,104,108,109,111,114,116,117,120–124]
>200 opportunities per professional category[a]		
Yes	49	[15–17,25,28,29,31,33,34,38,39,43,49,53,55–58,61–63,70,74,77,78,82,84,85,87,89,90,92,99–102,107,111,113–115,117–119,121,123–126]
No	24	[32,37,41,48,50,51,60,67,69,71–73,76,81,83,86,88,94–97,103,110,116]
Not recorded	32	[26,27,30,35,36,40,42,44–47,52,54,59,64–66,68,75,79,80,91,93,98,104–106,108,109,112,120,122]

[a] Established from available baseline study data.

Data items

Data were collected on the study identifying features (author, title, publication year, journal, country of origin), study design, study setting, sample size (where the unit of analysis is the number of hand hygiene opportunities), type of participants, method of observation, compliance measurement tool, observer category and validation, funding, intervention type if used, baseline compliance rates of physicians and nurses, and compliance rates as per the WHO 'five moments for hand hygiene' of physicians and nurses [3]. The primary outcome of interest was hand hygiene compliance measured by direct observation. Baseline data were taken as the reported overall baseline compliance estimate or the first compliance estimate if multiple estimates were reported. If discrepancies were found in study data between tables and text, numeric data were taken from tables.

Study risk-of-bias assessment

Two reviewers independently assessed the risk of bias and methodological quality of the included studies (D.B. and D.O.D.). Any discrepancies were resolved by discussion and consensus agreement. Risk of bias for cluster-randomized controlled trials was assessed using the revised Cochrane risk-of-bias tool (RoB2) for cluster-randomized trials [21]. Bias was assessed relating to the randomization process, timing of identification or recruitment of participants, deviations from the intended interventions, missing outcome data, outcome measurement, selection of the reported results.

The Joanna Briggs Institute (JBI) checklist for quasi-experimental studies was used for non-randomized studies of interventions [22]. Bias was assessed relating to the temporal relationship of cause and effect, differences between participants, differences in interventions between compared groups, use of a control group, multiple outcome measurements pre and post intervention, completeness of follow-up, outcomes measurement in comparison groups, outcomes measurement reliability, and statistical analysis.

For cross-sectional studies, the JBI Critical Appraisal Checklist for analytical cross-sectional studies was used, assessing bias related to sample inclusion criteria, participant and setting description, exposure measurement, confounding identification, confounding strategies, outcome measurement, and statistical analysis [23]. For cohort studies, the JBI Critical Appraisal Checklist for cohort studies was used and assessed bias relating to recruitment, exposure measurement, confounding identification, confounding strategies, outcome measurement, follow-up and statistical analysis [23].

Synthesis methods

Meta-analysis was planned as per protocol. Compliance was defined as the percentage of total hand hygiene opportunities for which participants performed hand hygiene actions. The risk difference and 95% confidence interval (CI) between nurses and physicians in dichotomous outcomes of hand hygiene compliance was calculated for each study with available outcomes data using the baseline compliance estimates. In cases where hand hygiene opportunities and compliance percentage were reported but not hand hygiene actions, these were calculated using the information provided in text or tables. A random-effects proportion meta-analysis was used to estimate a weighted pooled compliance rate with 95% confidence interval, separately for nurses and doctors across all studies. Meta-analysis was conducted using MedCalc software version 20.1. A random-effects meta-analysis using the DerSimonian–Laird method was used to estimate a pooled risk difference between compliance for nurses and physicians with a 95% confidence interval, with overt and covert studies analysed separately. Heterogeneity was assessed by visual inspection of the forest plots, the χ^2-test and I^2. The I^2 threshold of >75%–100% was taken to approximate to considerable heterogeneity [24]. The meta-analysis was conducted using StatsDirect version3.

Results

Study selection

The search yielded 7217 studies, with 4814 remaining after removal of duplicates. After title and abstract screening, the

Study	Compliant actions/HHO		Weight	Risk difference (95% confidence interval)
	Nurse	Physician		
Aghdassi [25]	1830/3068	916/1408	14.4%	–0.054 (–0.084, –0.024)
Azim [33]	10,620/13,989	1301/2516	14.7%	0.242 (0.221, 0.263)
El-Saed [15]	8870/9877	3212/3994	14.8%	0.094 (0.080, 0.108)
Stahmeyer [113]	647/1538	128/300	13.1%	–0.006 (–0.068, 0.054)
Stewardson [115]	1703/2510	587/1005	14.3%	0.094 (0.059, 0.130)
Van der Kooi [117]	21,994/43,987	3849/8573	14.9%	0.051 (0.040, 0.063)
Von Lengerke [121]	1808/3258	228/469	13.8%	0.069 (0.020, 0.117)
Combined (random)			100.0%	0.071 (0.008, 0.135)

Heterogeneity: $\chi^2 = 4.86$, df = 1 ($P = 0.027$), $I^2 = 98.3\%$

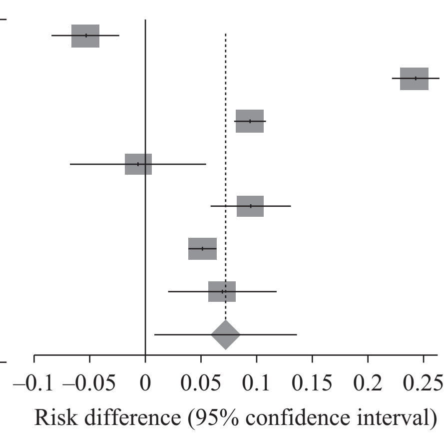

Figure 2. Random-effects meta-analysis results: overt, low risk of bias studies.

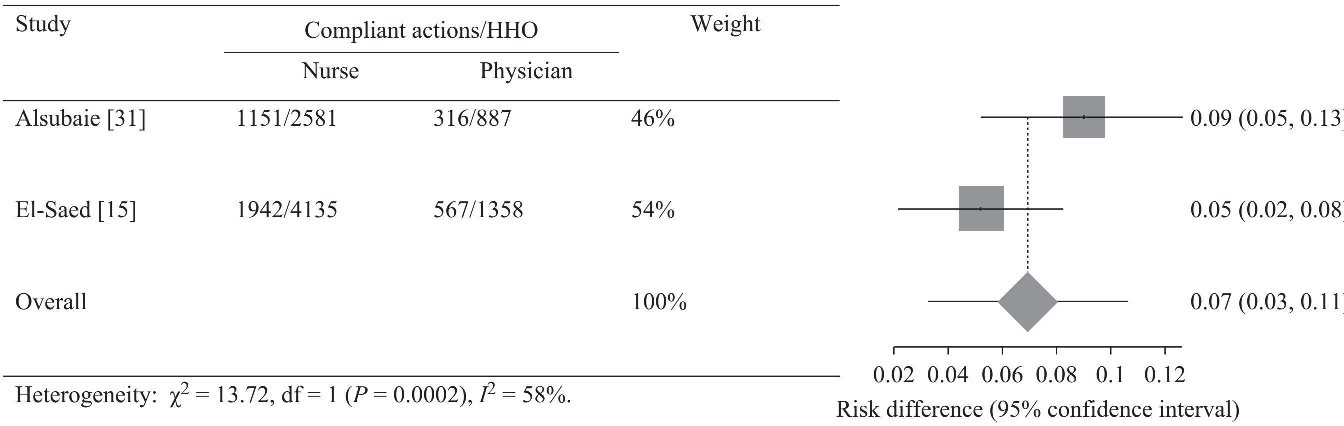

Figure 3. Random-effects meta-analysis results: covert, low risk of bias studies.

full texts of 441 studies were retrieved and screened. Following full text screening, 340 studies were excluded with reasons for exclusion listed in the PRISMA flow diagram Figure 1 and Supplementary Appendix B. The full text of an additional seven studies identified through citation searching were also retrieved and screened with three further studies excluded. A total of 105 studies were finally selected as matching the inclusion criteria in this review (Figure 1).

Study characteristics

Among the included studies were five cluster-RCTs, 52 non-randomized studies of interventions, and 48 observational studies [15—17,25—126]. Key characteristics of included studies are summarized in Table I. A full table of findings including outcomes data for each included study, presented according to risk of bias and sample size, is contained in Supplementary Appendix C.

Studies were conducted most frequently in Europe (N = 45, 43%), followed by North America (N = 27, 26%) and the Middle East (N = 15, 14%). The majority of studies were single centre (N = 78, 74%). Of the 27 multicentre studies, eight consisted of national data [45,52,54,62,63,70,87,123]. The hospital setting where studies were conducted varied from hospital-wide to single units. One-third of studies were conducted in a combination of various hospital units with the intensive care unit (ICU) (N = 34, 32%). ICU was the most common single unit setting (N = 15, 14%), followed by the emergency department (N = 13, 12%) and medical or surgical wards (N = 9, 9%).

Overt observation methods (N = 68, 65%) were employed more frequently than covert observation methods (N = 28, 27%), with a few studies using both methods (N = 7, 7%), and two studies not reporting the method. Overt observation methods varied from 'unobtrusive' observation, to announcing that a hand hygiene audit was being conducted. Equally, covert observation methods varied between studies with different strategies employed to conceal observations. Some studies used overt observation with the true reasons for observation being concealed, whereas others employed covert observers posing as employees or students.

The most frequently used compliance measurement was the WHO 'five moments for hand hygiene' (N = 58, 55%), with a few studies adding technique assessment (N = 3). Other studies assessed compliance at one specific moment or a combination of the five moments (N = 21, 20%), before and after contact (N = 11, 10%) or at entry and exit (N = 10, 9%).

Risk of bias in studies

The risk of bias was assessed for the included studies using the RoB2 for cluster-randomized trials, the JBI checklist for quasi-experimental studies for non-randomized studies of interventions, and the JBI checklist for cohort and analytical cross-sectional studies. A summary of these assessments is provided in Supplementary Appendix D. In terms of overall risk of bias, there were concerns regarding the risk of bias in the majority of studies (96/105). Most cluster-RCTs were judged to be at low risk of bias (N = 4) apart from one in which concerns over the randomization process were raised [60]. All non-randomized studies of interventions were judged to be at moderate or high risk of bias. The most frequent reason for downgrading was the absence of either a control group or multiple measurements both pre and post intervention. In addition, concerns were raised in many studies regarding the reliability of outcomes measurement with the training and validation of observers inconsistently reported. Most observational studies were judged at moderate or high risk of bias, with a few judged to be at low risk (N = 5). The majority did not adequately minimize potential confounding and risk of bias from selection bias, observer bias or observational bias. These potential risks of bias were not discussed or identified in many studies, with training and validation of observers again poorly reported in many studies. In total, nine out of 105 studies were judged to be at low risk of bias.

Table II
Range of reported compliance estimates with WHO five moments for hand hygiene for physicians and nurses by overt observation (N = 4 studies)

Moment	Physician (%)	Nurse (%)
1	38.4—83.8	39.1—92.7
2	48.0—90.7	13.0—95.8
3	67.3—100	50.0—97.1
4	55.1—84.2	81.6—92.2
5	28.0—74.8	40.1—87.5

Studies judged to be at low risk of bias ($N = 9$) included four cluster-randomized trials and five observational studies [15,25,31,33,75,113,115,117,121]. Of these, two were multicentre studies conducted in multiple countries in Europe and Israel [75,117]. Seven were single-centre studies conducted in Germany ($N = 3$), Saudi Arabia ($N = 2$), Switzerland ($N = 1$) and Australia ($N = 1$) [15,25,31,33,113,115,121]. Sample sizes of hand hygiene opportunities ranged from 1896 to 59,122, with a total sample size of 167,462 hand hygiene opportunities across all low risk-of-bias studies. Three studies were conducted exclusively in the ICU [31,113,117]. One was conducted in ICU and haematopoietic stem cell transplant units [121], and one was conducted in a mixture of settings including the ICU, emergency department, and wards [15]. The remaining four studies were conducted in a variety of non-ICU inpatient wards [25,33,75,115]. All studies assessed compliance according to the WHO 'five moments for hand hygiene'. Seven studies employed overt observation methods [25,33,75,113,115,117,121], one utilized covert observation [31], and one employed both overt and covert methods [15]. There was a wide range of baseline compliance estimates for low risk-of-bias studies from 35.6% to 80.4% for physicians and from 42.1% to 89.8% for nurses. Nurse compliance was reported as higher in most overt observation estimates (six out of eight) with physicians higher in one study [25] and no difference in another [113]. Both studies with covert observation estimates reported higher compliance in nurses than physicians [15,31]. The observers used were varied and included nurses, infection control personnel, research personnel, students, and interns. Two studies reported individual compliance estimates of physicians and nurses as per the WHO 'five moments for hand hygiene' [15,33].

Hand hygiene compliance among physicians and nurses

Analysis of all studies included in the review ($N = 105$), irrespective of the risk of bias, revealed wide variability of compliance estimates. Baseline compliance estimates for physicians and nurses ranged between 1.5% and 92% and between 4.7% and 97.2%, respectively.

The weighted pooled compliance rate for nurses was 52% (95% CI: 47–57) and for doctors 45% (40–49). The level of heterogeneity was considerable, with $I^2 = 99\%$ (Supplementary Appendix E).

Compliance rates measured by overt and covert observation

As per protocol, meta-analysis of the difference between baseline compliance estimates for nurses and physicians was performed with overt and covert studies pooled separately. Two studies did not report observation method clearly and were excluded from the analysis [79,108].

In a random-effects meta-analysis of seven overt studies judged at low risk of bias with available data, nurses displayed higher compliance than physicians, as shown in Figure 2 (pooled difference in compliance rates of 7%; 95% CI for the difference: 0.8–13.5; $P = 0.027$), but considerable heterogeneity was found ($I^2 = 98.3\%$). Meta-analysis of two covert studies judged at low risk of bias also showed greater compliance among nurses than physicians, as shown in Figure 3 (pooled difference in compliance rates of 7%; 95% CI for the difference: 3–11; $P = 0.0002$), again with substantial heterogeneity ($I^2 = 58\%$).

Meta-analysis of all overt studies irrespective of the risk of bias showed greater compliance among nurses than physicians (pooled difference in compliance rates of 9%; 95% CI for the difference: 7–10.8; $P < 0.0001$), with considerable heterogeneity ($I^2 = 97.1\%$). Meta-analysis of all covert studies irrespective of the risk of bias showed no significant difference between physicians and nurses (pooled difference in compliance rates of 3%; 95% CI for the difference: −1 to 6.9; $P = 0.1391$); however, considerable heterogeneity was found ($I^2 = 96.1\%$). High levels of heterogeneity limit the conclusions to be drawn from the analysis, with meta-analysis results of all studies irrespective of the risk of bias provided in Supplementary Appendix E.

Compliance rates measured by different types of observers

Significant variation was seen regarding the category of observers employed, and 35% of studies ($N = 37$) did not report the observer used. The most reported healthcare worker category of observer was nurses/nursing students ($N = 26$), followed by mixed observers ($N = 16$) and infection control personnel unspecified ($N = 10$). The least reported category of observer was doctors/medical students ($N = 5$).

Whether observers were unit- or non-unit based was infrequently reported. Only two studies included in the review specifically analysed compliance differences between unit-based and non-unit-based observers [35,64]. However, these observers differed in observation methods from overt to covert in one study [35] and were unclear in the other [64]. Other studies measured compliance with different categories of observers, whereas comparing overt to covert compliance suggested that differences were due to observation methods [15,17,36,125,126].

Perhaps more importantly regarding the potential for observer bias, 59% of studies did not directly report observer validation ($N = 62$), with only two studies ($N = 2$) explicitly stating that observer validation had not been performed in the discussion of limitations. Due to differences between studies in observation methods and potential for confounding, reliable inferences could not be made regarding differences in compliance estimates by different types of observers.

Compliance rates as per the WHO five moments for hand hygiene

Only four studies included in the review gave a breakdown of physician and nurse compliance separately as per the WHO five moments for hand hygiene [15,33,81,90]. Three studies estimated compliance using overt observation methods [33,81,90] with one study estimating compliance with both overt and covert methods [15]. The overt compliance estimates for physicians and nurses showed large variability at each moment limiting comparisons as outlined in Table II. Nurses recorded higher compliance than physicians in three of the four studies for Moments 1 and 2 [15,33,90], and all studies for Moments 4 and 5. Whereas physicians recorded higher compliance in three studies at Moment 3 [15,81,90], nurses recorded higher compliance in all moments in the solitary covert study estimate [15].

Discussion

Several observations are made in this review of hand hygiene compliance by direct observation in physicians and nurses. First, this review found that the weighted pooled compliance rate across all included studies for nurses was 52% (95% CI: 47—57) and for doctors 45% (95% CI: 40—49). However, the level of heterogeneity was considerable with $I^2 = 99\%$. The potential exists that studies may not report findings when no significant difference between nurses and physicians is found, leading to an overestimation of differences.

However, findings from this review agree with previous literature and were broadly similar to those of Allegranzi *et al.* which found baseline compliance of 54.9% for nurses and 43.7% for physicians in a global implementation of the WHO multimodal strategy in mixed-income countries [10,127,128]. Erasmus *et al.* similarly reported higher compliance among nurses (48%) than among physicians (32%) [10]. The inclusion by Erasmus *et al.* of studies with self-reported compliance and those that analysed either physicians or nurses alone may account for slight differences in compliance estimates [10]. Additionally, the variability shown in study results may have affected precision in the estimates.

Second, meta-analysis of studies judged to be at low risk of bias appears to show greater compliance for nurses than physicians by both overt and covert compliance estimates. Only two studies contributed to this covert meta-analysis. Whereas meta-analysis of all studies irrespective of the risk of bias appears to show greater compliance for nurses than physicians by overt compliance estimates, no significant difference between physicians and nurses was seen by covert compliance estimates. Again, considerable heterogeneity was found in all analyses, limiting the conclusions.

The cause of this heterogeneity may be due to clinical or methodological heterogeneity between studies. For meta-analysis of all studies, this may include differences in the definition of a hand hygiene opportunity. However, despite the same definition of the WHO 'five moments for hand hygiene' being used in all studies judged at low risk of bias, considerable heterogeneity remained.

Meta-analysis was conducted separately by risk of bias and type of observation (overt, covert). Heterogeneity was lowest for the studies with covert observation that were assessed as low risk of bias. Additional variables that may influence heterogeneity include the setting, the selection of participants, the number of hand hygiene opportunities, the length of observation time, participants' awareness of observation, and the measurement of inter-rater reliability. Increasing the number of subgroup analyses, however, increases the chances of false-positive and false-negative results and may lead to misleading results [129]. A meta-regression allows for multiple characteristics of studies to be included as predictors of the effect estimate at the same time and further research should explore the potential of meta-regression to understand sources of heterogeneity in hand hygiene studies.

The review did indeed find differences in observation methods between studies. Many studies did not clearly report the methods of observation nor the training or validation of observers. The length of the observation sessions was not clear or differed in some studies from the WHO-recommended period of 20 min (±10). Of the nine low risk-of-bias studies, five used the WHO-recommended period or longer and four did not record the length of the observation period. Additionally, some studies did not adhere to the WHO-recommended 200 opportunities per observation period and per observation unit [3]. The majority (eight out of nine) of the low risk-of-bias studies had a minimum of 200 opportunities per professional category (nurse, doctor). In overt studies, observation methods ranged from 'unobtrusive' observation to announcing the commencement of a hand hygiene audit. Similarly, covert studies varied from using truly covert observers to overt observation with the true reasons concealed. These differences in the level of the Hawthorne effect or observation bias may confound differences in compliance estimates. In addition, the level of observation bias may vary between participants in a study. As one illustration of this, a study quantifying the Hawthorne effect by Hagel *et al.* informed attending nurses at the start of the observation period of the purpose of the hand hygiene observation [16]. However, other healthcare workers who entered the observation room were not informed unless specifically asked.

Alternative or supplementary approaches to classical observation of healthcare worker hand hygiene compliance, such as automated hand hygiene monitoring systems, may be useful in overcoming the bias associated with the presence of an observer. However, drawbacks include the associated costs of implementation, usability and system accuracy limitations, and privacy concerns [130].

While many studies reported an overall breakdown of compliance as per the WHO 'five moments for hand hygiene,' individual compliance estimates for physicians and nurses were rarely reported (four out of 105). Further estimates may provide information as to whether educational efforts for nurses and physicians should be tailored for each group.

Limitations of the evidence in this review include that only studies published in English were selected. Only high-income countries were assessed to reduce potential variability in compliance estimates resulting from infrastructure barriers to hand hygiene in low- and middle-income countries. Despite this, large variability in compliance estimates was found. Conference abstracts and posters were excluded as not containing adequate information to appraise the design, methods, results, and risk of bias. The potential for publication bias may also exist from the exclusion of unpublished data as studies with significant results may be published ahead of studies with either null or negative results. Potential limitations may also exist from exclusion of studies where outcomes of compliance were not reported. This may potentially be due to selective under-reporting of results, where outcomes may not be reported if no statistically significant difference between healthcare worker categories is found. This exclusion may bias the synthesis towards finding a difference between physicians and nurses. Limitations of the review synthesis arose from significant heterogeneity and missing outcomes data for some studies which may affect the overall precision of results. In addition to randomized controlled trials, the review included non-randomized studies of interventions and observational studies. While it may be argued that these are lower-quality study designs, direct observation of hand hygiene remains the 'gold standard' [3]. These study designs were therefore included as potentially providing valid evidence for the review question, with each study evaluated on the risk of bias specific to that design.

Additional limitations arose from the existing studies included in the review. Reporting within studies was variable, including poorly reported statistical significances of differences in compliance. In addition, reporting of selection methods, observation methods and the training and validation of observers was poor in many studies. Although studies that did not explicitly report inter-rater reliability were included in the synthesis, it is possible that some of these studies may not have measured this factor, and therefore the synthesis may include non-observer validated studies. Most studies were judged to be at moderate or high risk of bias (96 out of 105). Notably, non-randomized studies of interventions rarely employed a control group or trend analysis over time. Most non-randomized studies of interventions were uncontrolled before–after studies, and were therefore weaker study designs from which to draw causal inference about the effect of interventions.

In conclusion, it has been seen that in studies of direct observation of hand hygiene, nurse compliance is higher than that of physicians. However, wide variability in compliance estimates was found even among studies judged at low risk of bias. Random-effects meta-analysis of low risk-of-bias studies suggests higher compliance for nurses than physicians by both overt and covert observation. Meta-analysis of overt and covert studies revealed considerable heterogeneity. Further analysis with meta-regression should explore the sources of this heterogeneity.

Despite WHO guidelines on the observation of hand hygiene, differences in the methodological quality of studies remain [3,131]. There is a need for non-randomized studies of interventions to consider the use of either control groups or trend analysis over time. Although a degree of bias is inherent in observational studies, there is a need for future research to consider and minimize this bias [132]. In addition, the definition of 'unobtrusive' observations needs to be considered. It is important that if observational bias cannot be eliminated entirely, it should at least remain equal among participants for reliable and unbiased comparisons to be made between healthcare workers.

Conflict of interest statement

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.08.013.

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