Birth attendants’ hand hygiene compliance in healthcare facilities in low and middle-income countries: a systematic review

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Abstract

Background: With an increasing number of women delivering in healthcare facilities in Low and Middle Income Countries (LMICs), healthcare workers’ hand hygiene compliance on labour wards is pivotal to preventing infections. Currently there are no estimates of how often birth attendants comply with hand hygiene, or of the factors influencing compliance in healthcare facilities in LMICs.

Methods: We conducted a systematic review to investigate the a) level of compliance, b) determinants of compliance and c) interventions to improve hand hygiene during labour and delivery among birth attendants in healthcare facilities of LMICs. We also aimed to assess the quality of the included studies and to report the intra-cluster correlation for studies conducted in multiple facilities.

Results: We obtained 797 results across four databases and reviewed 71 full texts. Of these, fifteen met our inclusion criteria. Overall, the quality of the included studies was particularly compromised by poorly described sampling methods and definitions. Hand hygiene compliance varied substantially across studies from 0 to 100%; however, the heterogeneity in definitions of hand hygiene did not allow us to combine or compare these meaningfully. The five studies with larger sample sizes and clearer definitions estimated compliance before aseptic procedures opportunities, to be low (range: 1–38%). Three studies described two multi-component interventions, both were shown to be feasible.

Conclusions: Hand hygiene compliance was low for studies with larger sample sizes and clear definitions. This poses a substantial challenge to infection prevention during birth in LMICs facilities. We also found that the quality of many studies was suboptimal. Future studies of hand hygiene compliance on the labour ward should be designed with better sampling frames, assess inter-observer agreement, use measures to improve the quality of data collection, and report their hand hygiene definitions clearly.

Keywords: Hand hygiene, Maternal and newborn health, Labour, Healthcare workers

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Background
Globally, infection contributes to at least 9% of maternal deaths [1] and 16% of neonatal deaths [2], the vast majority of this burden concentrates in low and middle income countries (LMICs). Hand hygiene during birth has been long recognised as a key infection prevention opportunity [3, 4]. With an increasing number of women delivering in healthcare facilities in LMICs [5], appropriate hand hygiene compliance of healthcare workers on the labour wards is pivotal to preventing infections.

Several systematic reviews have been published on the compliance, determinants and interventions to improve healthcare workers hand hygiene across the facility environment [6–10]; only two of these reviews include studies from low resource healthcare facilities, none of which provide estimates for the labour ward [7, 8]. Erasmus et al. report a median hand hygiene compliance of 40% for studies from high-income countries [6]; the other, more recent, reviews focus on evaluating existing interventions and do not report summary estimates of compliance, but there is value in collating estimates from observational studies too.

Currently there are no estimates of how often birth attendants comply with hand hygiene, or of the factors influencing their compliance in healthcare facilities in LMICs. Hand hygiene compliance in LMICs may differ in levels and determinants compared to those in high-income countries (HICs), where most published evidence is. For example, there are cultural and contextual elements around the process of labour and delivery that might influence hand hygiene compliance of healthcare workers such as unpredictable workloads, unreliable water supplies, or the concept of pollution and purity around delivery – important among healthcare workers in India and Bangladesh [11, 12]. Finally, detailed estimates on compliance in LMICs and their determinants are useful to inform whether interventions are needed, and how to tailor them.

The aim of this paper is to systematically review the literature from LMICs to:

1. Estimate birth attendants’ hand hygiene compliance during labour and delivery in healthcare facilities
2. Assess the quality of the studies reporting these estimates
3. Investigate what factors influence hand hygiene compliance
4. Estimate the effectiveness of interventions aimed at increasing hand hygiene compliance
5. Estimate intra-cluster correlation for hand hygiene compliance comparing variation within and between facilities

Methods
The search was conducted on the 1st of September 2020, updating earlier searches on the 24th of April 2018 and on the 27th of January 2016 over EMBASE, MEDLINE, CINHAL, and the WHO regional databases (the website we used for the latter was not accessible during the last search in spite several attempts). We used a comprehensive set of search terms based on previous systematic reviews [8, 13, 14] and consulted the London School of Hygiene and Tropical Medicine librarian. The search themes included hand hygiene and maternity ward terms with international spelling variations, and it was restricted to LMICs. Additional file 1 details the strategy. Peer reviewed articles were eligible for inclusion, while abstracts and conference proceeding were not. All texts were reviewed using Endnote X7. No protocol was registered for this review.

Duplicates were removed, and titles and abstracts screened for any mention of hand hygiene compliance in labour wards. Two reviewers independently applied the inclusion criteria to the selected full texts. Any discrepancy was resolved through discussion. Once full texts were selected, one author screened references to search for other relevant studies that might be eligible for inclusion. The inclusion criteria were:

- Studies with either of the following estimates for the specific group of healthcare workers attending labour and delivery or working on the labour ward:
  - A measure of frequency for hand hygiene compliance (observed or other objective method; self-reports were not included)
  - OR an effect size (odds ratio, rate ratio, risk ratio) of factors driving hand hygiene (observed or other objective method; self-reports were not included)
- LMICs based studies
- Peer-reviewed studies
- Intervention or observational studies
- Quantitative studies
- Studies in any language

Data extraction was done by one author and checked by another. The data extraction form included study type, intervention details, country, urban-rural location, type of healthcare facility, staff cadre, facility ward specification, availability of hand hygiene infrastructure (soap, water, handrub), sample size, sample selection, analysis methods, measurement tools, and the effect size of hand hygiene determinants. We extracted the estimates of hand hygiene compliance by healthcare workers before aseptic procedures (or compliance estimates which were likely to include before aseptic procedure opportunities) for a) types of patient-attendant interactions that could
occur during labour and delivery, or b) healthcare workers working in the labour ward. We specifically focused on estimates reflecting hand hygiene opportunities before aseptic procedures these because these are the most pivotal to infection prevention. For each estimate we extracted the hand hygiene definition, the numerator, denominator, the percentage compliance estimates, the number of staff or women observed, the staff cadre, the number of facilities, and the intervention stage details underpinning the individual estimate. We calculated the percentage compliance for each included study where this was possible. We contacted the corresponding author (or if this was not published, the first or senior author whose email we found via their department or on researchgate) when it was not clear from the paper whether a) their observation included procedures around labour and vaginal delivery; or b) when the hand hygiene definition was unclear and the tool used was not available.

Key measures of bias and quality were included in the data extraction. For randomised controlled trials we intended to use the CONSORT guidelines to assess quality. For observational studies, we assessed quality using checklist we developed using eight items adapted from the STROBE guidelines’ [15] methods section (as recommended by Sanderson and colleagues) [16], to the specific context of observing hand hygiene in healthcare settings. Items included assessing 1) sampling methods, 2) quality of data collection, 3) description of the data collectors background, 4) whether inter-observer agreement was estimated, 5) the definition of hand hygiene compliance, 6) details of the tool used for observation, 7) whether study aims were concealed from the study participants and 8) whether the statistical procedures were described. Items were scored positively or negatively, except for items 1, 3 and 6 and where we added an extra option of partially met when only one of two criteria was met, and item 7 which could also be scored as unclear.

Intra-cluster correlation (ICC) accounts for the relatedness of data by comparing the variance within clusters with the variance between clusters; it is useful for designing and analysing observational and intervention studies. To obtain the ICC for hand hygiene compliance of the included studies comparing the variation in compliance between and within facilities, we also contacted the authors of studies with multiple facilities (clusters) to ask for:

- Either, the following single measures:
  - The standard deviation exhibiting how the cluster means vary from the population mean from cluster to cluster $\sigma_b$ (between-cluster variation)

- The overall estimated ICC ($\rho = \sigma_b^2 / (\sigma_b^2 + \sigma_w^2)$)

We aimed to conduct pooled analysis of the estimates by hand hygiene compliance estimated using similar outcome definitions, measurement tools or investigating similar interventions, unless there are differences in setting or risk of bias; where studies did not use similar outcomes, measurement tools or investigate similar interventions, estimates were described.

We followed the PRISMA guidelines for systematic reviews to report our methods and findings (see Additional file 2) [17].

**Results**

After removing duplicates (100), we obtained 697 results across the four databases and reviewed 71 full texts of which 4 are from reference searching (Fig. 1). We ultimately included fifteen that met our inclusion criteria. The reasons for excluding the fifty-seven studies are in Fig. 1, with the most common being that the study did not report on the outcome of interest, i.e. hand hygiene of healthcare workers during labour or delivery, or in the labour ward. In two articles which were identified via reference searching, it was unclear whether labour and delivery were being studied, and the author of the paper did not reply to enquiry, so these papers were not included.

Of the fifteen included studies, seven were in Sub-Saharan Africa (Zanzibar-Tanzania, Zimbabwe, two in Ghana, and three in Nigeria), two were in Iran, the rest were located in in South-East Asia: three in India, one in Vietnam, one in the Thai-Myanmar border, and one spanned several countries (Cambodia, Lao People’s Democratic Republic, Mongolia, Papua New Guinea, Philippines, Solomon Island, and Vietnam) – see Table 1. The studies were published between 1993 and 2020, with only one study being published prior to 2008. Four studies were conducted in a single facility. Six of the nine studies did not report any information on hand hygiene infrastructure (Table 1); one study discussed how inconvenient the sink location was; one study selected the hospital based on it generally having supplies to provide good quality of maternal care; three studies reported on the general availability of supplies (two positively and one negatively), but it is unclear what elements of hand hygiene infrastructure were surveyed if any. Only four studies reported specifically on the availability of hand hygiene infrastructure. Two of these
studies reported that needed supplies were present, except for handrub in the first study [32], and disposable towel in the second [19]; one reported that not all the facilities had needed supplies, but the percentage refers to a wider set of facilities compared to the one observed for hand hygiene [27]; and one reported the availability of 24-h running water (52% of facilities) and soap (65% of facilities) (Table 1) [24].

Quality of primary studies
All studies used observation as their primary method of data collection. The methods were described in most articles only partially. The lowest ranked quality indicators were 1) sampling, 2) methods to enhance data quality during data collection, 3) measurement of inter-observer agreement, and 4) the level of description of the hand hygiene compliance definition – see Fig. 2.

Sampling
We required two aspects of the sampling methods to be described: a) how the unit of observation (e.g. woman, procedure or healthcare worker) was sampled and b) how the timing of facility visits were scheduled. None described both aspects sufficiently; five articles did not describe them at all. As detailed in Table 1, it was often unclear how different women or healthcare workers were selected for observation.

Quality during data collection
Only four articles directly addressed the procedures adopted to ensure a better quality of data collection. Buxton et al. report that data collection did not start until results were consistent during the training period [19]. Spector et al. included on-site reviews of all observation forms within 72 h by the local study coordinator, and in-built data management checks confirming the data collected were logical [30]. Gon et al. provided tailored feedback to data collectors based on the results of the inter-observer exercise run in the first month [25]. Tyagi et al. incorporated quality checks in their tool as a results of the training [31].

Inter-observer agreement
Gon et al. is the only study that reports the results of interobserver agreement. This was calculated between pairs of data collectors in the first month of the study; the range of kappa statistics results was 0.73–0.93 for three pairs of data collectors [25]. Buxton et al. report that inter-rater reliability was monitored during the training period but do not report their results [19].
| Country/site | Study design | Facility type | Unit/ward | Effect size | Intervention |
|--------------|--------------|---------------|-----------|-------------|--------------|
| Nigeria; Lagos | Cross-sectional | 1 secondary and 1 tertiary maternity care facility | Maternity ward | None | None |
| Nigeria; Egor and Kogi | Cross-sectional | 2 Primary healthcare facilities | Labour ward | None | None |
| Iran, Lorestan | Cross-sectional | 2 University of Zimbabwe Central Hospital, i.e. National referral hospitals | Under care labour ward | None | None |
| Ghana, North & South Bimah Districts | Cross-sectional | 9 public hospitals | Labour & postnatal ward | Unclear | Introduction of Safe Childbirth Checklist with peer coaching |
| Zimbabwe | Cross-sectional | 1 public hospital, 6 public health posts, 5 private maternity homes | Under care labour ward | None | None |
| India; Uttar Pradesh | Cross-sectional | 15 healthcare facilities of the 60 selected for the intervention. The 60 facilities varied between primary and community health centres and first level referral units | Labour wards | None | None |
| Nigeria; Edo State | Cross-sectional | 63 healthcare facilities including primary health centers, private clinics, two secondary/ district, 2 tertiary/ teaching hospitals | Delivery wards | None | None |
| Tanzania | Cross-sectional | 1 referral hospital 1 maternity hospital 3 Cottage hospitals 1 private hospital 3 district hospitals 1 Primary Healthcare Unit | Labour wards | None | None |
| Kenya | Cross-sectional | Shikobo Malina Research Unit Clinic | Delivery wards | Labour & delivery wards | Labour & delivery wards |
| India; Tamil Nadu | Cross-sectional | 76 first level referred hospital 25 tertiary hospitals | Labour wards | Labour & delivery wards | Labour & delivery wards |
| Philippines | Cross-sectional | Hung Yung University Hospital | Delivery rooms | None | None |
| Cambodia, Lao PDR, Mongolia, Papua New Guinea, Philippines, Solomon Islands, Vietnam | Cross-sectional | Be-Bat Hospital of Samandari and Halte-Teer Hospital of Bevar | Delivery suites | None | None |
| Iran, Kurdistan | Cross-sectional | Sub-district level hospital (basic emergency obstetric care and C-sections) | Labour & delivery wards | None | None |
| India, Karnataka | Cross-sectional | 36 Public secondary healthcare facilities 4 public tertiary healthcare facilities 5 private tertiary healthcare facilities | Labour ward | None | None |
| India; Telangana, Andhra Pradesh | Cross-sectional | Kofel-Bu Teaching Hospital (tertiary healthcare facility) | Emergency Room and Labour ward | None | None |
| Ghana; Accra | Cross-sectional | The study is part of a baseline evaluation of a quality improvement intervention | Labour ward | None | None |

| Health professionals involved | Type of patient-attendant interactions | Observation period |
|------------------------------|-------------------------------------|--------------------|
| Midwives, doctors, midwives, auxiliary staff | 52 women during delivery and immediate postpartum | May 2010 |
| Midwives, midwives; assistants and lay women trained by midwives | 31 women in active labour (cervical dilation: 3) and admitted to delivery | 4 weeks in July 2017 |
| Midwives, midwives; assistants and lay women trained by midwives | 200 (low risk) pregnant women | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 18 vaginal deliveries and 2 neonatal cord care events | 2 Months, August |
| Midwives, midwives; assistants and lay women trained by midwives | 30 observations in the labour and 17 in the postnatal wards | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 1277 deliveries. Specifically pushed and then after birth. | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 781 aseptic procedures during labour and delivery | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 20 births | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 371 deliveries | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | All types of hand hygiene opportunity in the delivery suite | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 96 women with low risk pregnancies | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 405 vaginal examinations at admission and 388 deliveries | Under care |
| Midwives, midwives; assistants and lay women trained by midwives | 342 vaginal examination and 335 deliveries | Under care |

[18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32]
Table 1 Study characteristics (Continued)

| Data collectors | Tool used for observation | Study aim disclosed to participants | Sampling |
|-----------------|---------------------------|------------------------------------|----------|
| Undear          | Checklist developed for study based on protocol by Christensson et al. (2001) [33] | Undear Non-participant observation | Undear   |
| Qualified midwives | Standardised direct observation tool developed for study. Based on a previous tool developed for a qualitative case study. But it references a report [34], unclear | Study aims were explained to the participants and to the whole staff | The facilities with the highest number of deliveries were selected for each state (one primary, one secondary and one tertiary). Any woman who met inclusion criteria and gave consent was invited to participate up Non-random quota sampling used to recruit 200 women. 10–30 selected in different stages of labour in each hospital. Sample size calculations justified | Undear |
| Undear Project director and co-director (a Ghanaian nurse) | Checklist created for study using criteria from e.g., the WHO Global Programme on AIDS 1989 | Undear No participant observation | Undear |
| Undear Trained nurses | Checklist for labour ward developed for study | Undear The study was explained to the participants and it was said that they would be observed | Undear |
| Undear Trained staff | Adapted tool from a previous study based in India. Undear reference | Undear Participants were informed about the study and informed consent was required | Undear |
| Asp (2011) [18] | The WHO Safe Childbirth Checklist | Undear | Undear |
| Buerton (2019) [19] | Observation checklist developed based on WHO guidelines on hand hygiene in healthcare, 2009. | Undear Healthcare workers were aware of the observation period | Undear |
| Changaree (2014) [20] | Checklist developed for study, drawing on WHO Safe Motherhood Needs Assessment v.1.2001 | Undear Unaware of the observation period | Undear |
| Cronin (1993) [21] | Observation checklist modified checklist based on the WHO Guidelines on Hand Hygiene in Healthcare, 2009. | Undear | Undear |
| Danda (2015) [22] | Checklist using the WHO Guidelines on Hand Hygiene in Health Care, 2009. Observation checklist validity reviewed by MoH and University staff | Undear Healthcare workers were aware of the observation period | Undear |
| Delaney (2017) [23] | Tool developed for study based mainly on WHO's protocol of birth, 1996/2006. Observation checklist validity. | Undear Study aims were explained to the participants midwives | Undear |
| Fedlay (2012) [24] | Checklist using the WHO Childbirth Checklist for study. | Undear Healthcare workers were aware of the observation period | Undear |
| Gon (2018) [25] | undear "Researcher" | Undear Study aims were explained to the participants midwives | Undear |
| Hoogenboom (2015) [26] | Standard checklist adapted from EENC Module 1: Annual Implementation Review and Planning Guide. | Undear Healthcare workers were aware of the observation period | Undear |
| Mannava (2019) [27] | Checklist using the WHO Childbirth Checklist for study. | Undear Healthcare workers were aware of the observation period | Undear |
| Phan (2018) [28] | WHO Safe Childbirth Checklist presumed to have been used | Undear Healthcare workers were aware of the observation period | Undear |
| Simbar (2008) [29] | Checklist adopted from the WHO concept of five moments of hand hygiene, 2010. | Undear Healthcare workers were aware of the observation period | Undear |
| Spector (2012) [30] | Modified version of the WHO form for hand hygiene direct observation, 2010. | Undear Healthcare workers were aware of the observation period | Undear |
| Tyagi (2018) [31] | | Undear Healthcare workers were aware of the observation period | Undear |
| Yawson (2013) [32] | | Undear Healthcare workers were aware of the observation period | Undear |

Study aim disclosed to participants:
- Undear: The study aim was not disclosed to the participants.
- Participant: The study aim was disclosed to the participants.

Sampling:
- Undear: The sampling method was not described.
- Non-random quota sampling: A predetermined number of participants were selected based on certain criteria.
- Random selection: Participants were selected randomly from a defined population.
- Systematic sampling: Participants were selected at regular intervals from a list.
- Convenience sampling: Participants were selected based on availability.
- Quota sampling: Participants were selected to meet specific criteria.
- Snowball sampling: Participants were selected through referrals from existing participants.
- snowballing: Participants were selected through referrals from existing participants.

Tool used for observation:
- Checklist: A structured list of items or criteria used to assess performance.
- Observation checklist: A tool used to record observations.
- Modified checklist: A checklist adapted from another checklist.
- Standardised observation tool: A tool developed based on standardised criteria.
- Developed tool: A tool developed specifically for the study.

Data collectors:
- Undear: The data collectors were not specified.
- Qualified midwives: Midwives with training and experience.
- Project director and co-director: A Ghanaian nurse with training and experience.
- Trained nurses: Nurses with training and experience.
- Trained staff: Professionals with training and experience.
- Trained doctors, nurses, midwives or public health professionals: Professionals with training and experience.
- Project staff: Staff involved in the project.
- Researchers: Researchers involved in the study.
- Staff: Staff members involved in the project.
- Study supervisor: A member of the team responsible for the study.

Study aim disclosed to participants:
- Undear: The study aim was not disclosed to the participants.
- Participant: The study aim was disclosed to the participants.

Sampling:
- Undear: The sampling method was not described.
- Non-random quota sampling: A predetermined number of participants were selected based on certain criteria.
- Random selection: Participants were selected randomly from a defined population.
- Systematic sampling: Participants were selected at regular intervals from a list.
- Convenience sampling: Participants were selected based on availability.
- Quota sampling: Participants were selected to meet specific criteria.
- snowball sampling: Participants were selected through referrals from existing participants.

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- Researchers: Researchers involved in the study.
- Staff: Staff members involved in the project.
- Study supervisor: A member of the team responsible for the study.
Table 1 Study characteristics (Continued)

| Study characteristics | Assp (2011) [18] | Buxton (2019) [19] | Changae (2014) [20] | Cronin (1993) [21] | Danda (2015) [22] | Delaney (2017) [23] | Fedday (2012) [24] | Gorn (2018) [25] | Hoogenboom (2015) [26] | Mannava (2019) [27] | Phan (2018) [28] | Spector (2012) [30] | Tyagi (2018) [31] | Yawson (2013) [32] |
|-----------------------|------------------|---------------------|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|
| **Study characteristics** | to 5 woman per facility. | labour or women and timing of visits were selected | expected, not clear how the timing of facility visits for observation were scheduled | facility: A mother was observed for as many pause points as possible. Not clear how the timing for facility visits were scheduled | scheduled and how many deliveries were observed | during observation. Not very clear how they selected which health care worker to observe. Sample size calculations justified | delivery observation period; but it mentioned observation was limited to the time of the assessments. Not clear how the timing for facility visits were scheduled | women were selected each stage | woman was observed at the time | healthcare worker to observe |
| **Water/Soap/handrub availability** | Unclear. Sinks were not located in convenient locations | All facilities had soap and water in the delivery unit but during observation there was no soap. All delivery units had a sink with connected tap available but 2 used veronica buckets. No disposable towels | Unclear. Only reported missing items. Water, soap, handrub were not mentioned as missing | Unclear. They report broadly that basic supplies were often unavailable (not clear if specific to hand hygiene supplies) | 24 h running water was present in 52% of the observed facilities. Soap in 69% of facilities. | Unclear | Unclear | All essential equipment for standard antenatal care and essential care of obstetric complications was present. | 147 hospitals assessed for WASH services; 72% of hospitals had clean sinks with running water, soap or handrub in the delivery rooms | Data is not specific for the 101 hospital where deliveries were observed | None | None | Unclear. Hospitals selected based on general availability of supplies | unclear |

*Unsure if all mentioned cadres were observed during labour and delivery

*Unclear whether hand hygiene was observed for all of these
Spector et al. [30] attempted to examine agreement between observers – specifically, they reported that periodic assessments were used to confirm that data collectors achieved 100% concordance on a sample of three observations. Yawson and Hesse only report that different pairs of technical personnel visited the unit each day in order to limit intra-observer bias [32].

Definition of outcome

Hand hygiene compliance was not defined clearly in most studies. Each definition is reported in detail in Table 2. Some studies did not report whether soap use or handrub was necessary to achieve adequate hand hygiene and did not refer to guidelines that specifically do [20, 22, 24, 26, 27, 29]; in addition often studies did not report if other aspects of hand hygiene such as the sequence of actions preceding or following hand washing/rubbing, technique or duration were assessed in the summative compliance estimates – except for Gon et al. and Buxton et al. We describe here the studies where definitions presented additional anomalies. Yawson and Hesse, and Phan et al. mentioned that they followed the hand hygiene guidelines by the WHO but it was not clear which aspects of the guidelines they included. Buxton et al. also mentioned that they followed the WHO guidelines but created their own categories of hand hygiene ranging from the least hygienic (category 5) to the most hygienic (category 1) which included hand washing with soap, new gloves applied and no potential recontamination. Cronin et al., Danda et al., Friday et al. and Hoogenboom et al. chose a less informative definition of hand hygiene compliance because their denominator referred to whole individuals, group of individuals or facilities rather than specific patient-healthcare worker interactions (e.g. hand washed at least once or at least one birth attendant washed hands). In Changae e et al., it was not clear how they calculated their estimate of desirable hand washing.

Another aspect of the definition is the type of hand hygiene opportunity (when hand hygiene should occur). The WHO hand hygiene guidelines refer to five key hand hygiene opportunities: before clean/clean procedures, after exposure to body fluids, before touching the patient, after touching the patient, after touching the patient’s surrounding. Studies did not always report what the type of contact (before vs. after; contact with intact skin i.e. “touching a patient” or non-intact/mucous membrane i.e. clean/aseptic procedures). Indeed, Changae e et al., and Simbar et al. were contacted for further information on their hand hygiene definition as it was unclear if it was before after the procedure/contact, but did not reply [29, 32]. Further enquires were also made to Yawson and Hesse, and Friday et al. on their definitions but with no reply [24, 32]. Another unclear area is what procedures during labour or delivery were captured. Studies that clearly outline this are Gon et al. and Buxton et al. [19, 25]

Hand hygiene compliance estimates during labour and delivery

We extracted estimates that were clearly for aseptic procedures, and estimates for which this was not clear or where aseptic procedures were not the exclusive focus. Definitions across the studies were extremely heterogeneous and hence we did not combine their estimates; compliance estimates varied from 0% to 100%. Spector et al. reported a baseline compliance of 1.3% before vaginal examinations during admission and 10.6% before
| Outcome definition | Asp (2011) [18] | Buxton (2019) [19] | Changae (2014) [20] | Cronin (1993) [21] | Danda (2015) [22] | Delaney (2017) [23] | Friday (2012) [24] | Gon (2018) [25] | Hoogenboom (2015) [26] | Mannava (2019) [27] | Phan (2018) [28] | Simbar (2008) [29] | Tyagi (2016) [30] | Yawson (2013) [31] |
|-------------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 1st Estimate      |                |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| Outcome definition | Hand washing with soap or hand disinfection | Hand hygiene compliance before aseptic procedures performed with soap and new gloves applied without potential recontamination | Unknown; Desirable hand washing; Estimated % compliance was measured as 100% | Number of midwives who hand scrubbed with Dettol or soap and water | Whether each midwife washed her hands at least once; Unknown if with soap | Hand hygiene compliance measured by independent observers during non-intervention days; Hand washing with soap and water or alcohol rub or handrub allowed | Unknown; Hand hygiene compliance at the facility level; Unknown if necessary and if handrub allowed | Hand hygiene compliance before aseptic procedures. Steps included hand washing with alcohol-based hand rub or wash hands with soap and water, avoided recontamination and donning gloves | Hand washing of at least one of the birth attendant present; Unknown if with soap | Hand hygiene compliance. Under if with soap | Hand hygiene compliance is the ratio of the number of performed actions to the number of opportunities. Presumably, soap & water or handrub necessary. | Hand washing with clean or hand disinfection | Unknown; Hand hygiene compliance. Hand washing with soap and water or waterless alcohol-based hand rub. | Hand hygiene compliance (% of times performed hand hygiene at all observed moments when required). Presumably, soap or hand disinfection necessary. |
| Opportunity type   | Before contact with patient during delivery | Before aseptic procedures during labour and delivery (including vaginal examination) | Second stage of labour, under if before or after what type of contact | Before delivery | Before procedures in the labour and postnatal ward | Before examining patients | Before aseptic procedures during labour and delivery | Before or after delivery | Before gloving for delivery | 5 types of WHO hand hygiene opportunities in the delivery suite e.g. before patient contact | Before delivery | Before delivery | Before delivery | Before aseptic/ clean procedures in the labour and emergency room |
| Numerator          | 1              | 7                | 0                | 14              | 37              | 30               | 75               | 15              | 300              | 142             | Under if         | Under if         | 41              | 80              | 31              |
| Denominator        | 52             | 201              | 18               | 37              | 1027            | 63               | 781              | 20              | 37               | 507             | Under if         | Under if         | 38              | 235             | 116             |
| Compliance %       | 1.9%a          | 4.0%             | 11.5%            | 0%              | 37.8%a          | 36%              | 48%              | 9.6%            | 75.0%            | 81.0%           | Under if         | Under if         | < 200%          | 10.6%           | 34.0%           | 27.0%           |
| N individuals      | 52 women       | 31 women         | 200 women        | 18 women        | 1277 deliveries | 104 birth attendants | 371 women | 96 women | Under if         | 235 deliveries | Under if         | 35              | 1               |                  |                  |
| N facilities       | 2              | 6                | 9                | Undead          | 2               | 15               | 68               | 10              | 101              | 1               | Before the intervention | Before the intervention | NA              | Doctors          |                  |
| 2nd Estimate       | As above        | As above          | As above          | As above        | As above        | As above          | As above          | As above        | As above          | As above          | As above          | As above          | As above          | As above          | As above          |
| Outcome definition | Hand washing with soap or hand disinfection | Hand hygiene compliance before aseptic procedures performed with soap and new gloves applied without potential recontamination | Unknown; Desirable hand washing; Estimated % compliance was measured as 100% | Number of midwives who hand scrubbed with Dettol or soap and water | Whether each midwife washed her hands at least once; Unknown if with soap | Hand hygiene compliance measured by independent observers during non-intervention days; Hand washing with soap and water or alcohol rub or handrub allowed | Unknown; Hand hygiene compliance at the facility level; Unknown if necessary and if handrub allowed | Hand hygiene compliance before aseptic procedures. Steps included hand washing with alcohol-based hand rub or wash hands with soap and water, avoided recontamination and donning gloves | Hand washing of at least one of the birth attendant present; Unknown if with soap | Hand hygiene compliance. Under if with soap | Hand hygiene compliance is the ratio of the number of performed actions to the number of opportunities. Presumably, soap & water or handrub necessary. | Hand washing with clean or hand disinfection | Unknown; Hand hygiene compliance. Hand washing with soap and water or waterless alcohol-based hand rub. | Hand hygiene compliance (% of times performed hand hygiene at all observed moments when required). Presumably, soap or hand disinfection necessary. |
| Opportunity type   | Before vaginal examination | Before wound care for episiotomy and vaginal tears | Before putting on gloves | Before touching delivery area surfaces and equipment | Before vaginal examination | Before per-vaginal examination | Before aseptic/ clean procedures in the labour and emergency room |
| Numerator          | 6              | 4                | 32               | 289             | 5.3             | 92               | 4                |
| Denominator        | 121            | 4                | 68               | 406             | 242             | 106             | 18              |
| Compliance %       | 5.0%           | 100%             | 51.0%            | 78.0%           | 1.3%            | 38.0%           | 21.2%           |
| N individuals | N facilities | Cadre/ intervention | Outcome definition | Opportunity type | Numerator | Denominator | Compliance % | N individuals | N facilities | Cadre/ intervention |
|---------------|-------------|---------------------|--------------------|------------------|------------|-------------|--------------|---------------|-------------|---------------------|
| 31 women      | 6           | NA                  | Hands were washed, unclear if with soap | Cord care; unclear if before/after | 9          | 22          | 40.9%a       | 22 newborns   | Unclear     | Nurses             |
| 4 women       | Unclear     | NA                  |                     |                  | 63         | 101         |              | 1             | 35          | 1                  |
| 371 women     | 1           | 1                   | Before the intervention |                  | NA         | NA          |              |               |             |                    |

*a Estimates imputed by systematic review authors.
*b Less than 20% was considered a level that is "not acceptable". No exact estimate provided — estimated from Fig. 1 of Simbar et al.
*c Followed WHO guidelines 2009 "WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care is Safer Care" or "Hand Hygiene Technical Reference Manual"
deliveries [30]. A follow up study of the same intervention by Delaney et al. reported compliance before delivery at 36% after 2 months of intervention measured by independent observers during non-intervention days [23]. Buxton et al. found an overall compliance of 4% before aseptic procedures during labour and delivery, and a compliance of 5% before vaginal examination [19]. Gon et al. reported overall compliance with hand rubbing/washing, glove use and avoiding recontamination in 9.6% of opportunities before aseptic procedures during labour and delivery [25]. Yawson and Hesse reported hand hygiene compliance before aseptic procedures across both the labour and emergency room (we assumed that the emergency room was primarily dedicated to pregnant women); among doctors, compliance was 27.0%, whereas among nurses it was 21.2% [32]. Phan et al. reported the baseline compliance to be 28% across five types of WHO hand hygiene opportunities (before patient contact, before aseptic task etc.) observed in the delivery suite [28]. Mannava et al. reported a compliance 81% before gloving for delivery [27]. Simbar et al. [29] and Changaaee et al. [20] reported on compliance during second stage of labour, although it was unclear whether compliance was before or after interaction with the patient or which type of interaction i.e. aseptic procedure, touching the patient. Simbar et al. reported a compliance level below 20.0%, which they describe as unacceptable [29]. We could not interpret the estimate by Changaaee et al. because the definition of compliance was ambiguous [20]. Asp et al. report a compliance of 1.9% before contact with patient during delivery or immediate post-partum; it is unclear if this includes aseptic procedures or not [18]. Hoogenboom et al. found that in 75.0% of deliveries, either before or after the delivery, at least one birth attendant present hand washed [26]. Danda et al. reported compliance before procedures (not clear what type) across the labour and postnatal wards – here, 37.8% of midwives washed their hands at least once [22]. Friday et al. measured compliance before examining patients in the labour ward (48%) and before putting on gloves (51%). However, the compliance represents the percentage of facilities, rather than opportunities or individuals, that comply [24]. Finally, Cronin et al. reported that the midwives scrub hands in none of the 18 deliveries they observed (currently this practice is not necessary before delivery); however, all used either water and soap, or Dettol to perform hand hygiene [21]. All the four observations of wound care in this study were preceded by hand washing (100%) but only 40.9% of the cord-care observations (not clear if before or after cord care).

Table 3 describes the estimates extracted related to “before aseptic procedures” opportunities, from the smallest to the largest, as well as whether we considered their sample size adequate, their definition sufficiently good and whether the authors provided isolated estimates specifically for opportunities before aseptic procedures during labour and delivery. Five studies presented better definitions and larger sample sizes, and were specific to aseptic procedures during labour and birth: Spector et al. [30]; Gon et al. [25]; Buxton et al. [19]; Tyagi et al. [31]; Delaney et al. [23].

**Technique and duration of hand hygiene, and avoiding recontamination**

Only three studies [21, 25, 32] reported on aspects of hand hygiene quality such as technique and duration. Cronin et al. reported qualitatively that hand washings were generally not timed (not within the expected duration). Yawson and Hesse reported that on the labour ward, 50% or more of staff used soap and running water for hand washing, and dried hands with clean single use towels. Less than 50% washed hands for 40–60 s, or cleaned hands with alcohol handrub, or performed the appropriate handwashing technique [32]. Gon et al. reported the level of adequate rubbing/washing technique at 30.7% [25] defined as one of the hand gesture required by the WHO technical reference manual [35] i.e. “right palm over left dorsum with interlaced fingers and vice versa”; adequate duration was at 14.6% defined as ≥10 s based on the local guidelines for infection prevention [25].

Cronin et al. discuss qualitatively the concept of avoiding hand or glove recontamination before a procedure. This is a quote from their article.

> “frequent breaks in technique included ... the midwife’s gloved hands touching the patient’s bed, leg, abdomen, and perineal pad before the delivery.” [37].

Gon et al. defined recontamination of hands or gloves as any touch on potentially contaminated surfaces within the workflow after glove donning or hand rubbing/washing when preparing for a an aseptic procedure e.g. touching an unclean delivery surface, unclean hand-drying material, the woman and newborn outside the defined patient zone, the woman’s bed, trolley, unclean objects used during hand hygiene, and other unclean surfaces, unless classified as outside the workflow and provide an exhaustive list of these actions and that of patient zone within which touching surfaces is allowed [25]. They report that birth attendants risked recontaminating their hands or gloves in 45.3% of the opportunities when rubbing/washing or glove donning occurred [25].

Buxton et al. reported avoiding recontamination as part of hand hygiene compliance in the most hygienic
category but did not specify the definition of what behaviours are included in recontamination [19].

**Interventions, effect size for hand hygiene determinants and ICC**

Three studies report interventions aimed at increasing hand hygiene compliance. Two studies relied on a pre-post intervention design, without randomization or control wards; one only reported the intervention period without baseline. The three studies reported on interventions including several components – two of these studies discuss the same intervention. Phan et al. [28] tested an educational program on hand hygiene provided to healthcare workers over two 3 h sessions. The educational model used experiential learning and incorporated novel techniques of learning that allowed for consideration of past hand hygiene experiences. Fifty two out of 53 healthcare staff in the delivery suite participated in the intervention. The intervention improved hand hygiene overall in the selected wards, but the effect was largest in the delivery suite increasing from 28 to 61.8% across all five types of WHO hand hygiene opportunities [28]. The improvement was sustained over a period of 6 months of post intervention follow-up. Given the nature of the intervention, we assumed that participants were not blinded to the aim of the intervention.

Spector et al. tested a four-components childbirth safety program based on the WHO Safe Childbirth Checklist [30]. After the intervention, hand hygiene compliance increased respectively from 1.3 to 97.8% before vaginal examination during admission and from 10.6 to 99.5% before delivery. The checklist included prompts on elements of hand hygiene; therefore, the healthcare workers were not blinded to the aim of the intervention. Delaney et al. [23] also describes the introduction of the WHO’s Safe Childbirth Checklist. This was part of a large randomised control trial, but the article included here focuses on the 60 facilities that

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**Table 3 Selected compliance estimates summarised**

| Compliance % | Author | Type of opportunity | Sample size | Definition | Specific estimate before aseptic proc. during labour and delivery |
|--------------|--------|---------------------|-------------|------------|---------------------------------------------------------------|
| 0            | Cronin [21] | Before delivery     | Small       | Suboptimal | No                                                             |
| 1.3          | Spector [30] | Before vaginal exam. | Adequate    | Good       | Yes                                                           |
| 1.9          | Asp [18]     | Before contact       | Adequate    | Suboptimal | No                                                             |
| 4.0          | Buxton [19]  | Before aseptic procedures | Adequate   | Good       | Yes                                                           |
| 5.0          | Buxton [19]  | Before vaginal examination | Adequate   | Good       | Yes                                                           |
| 9.6          | Gon [25]     | Before aseptic procedures | Adequate   | Good       | Yes                                                           |
| 10.6         | Spector [30] | Before delivery     | Adequate    | Good       | Yes                                                           |
| 11.5         | Changaee [20] | II stage of labour | Adequate    | Suboptimal | No                                                             |
| < 20         | Simbar [29]  | II stage of labour  | Adequate    | Suboptimal | No                                                             |
| 21.2         | Yawson [32]  | Before aseptic (doct.) | Adequate   | Satisfactory | Unclear<sup>a</sup> |
| 27.0         | Yawson [32]  | Before aseptic (nurs.) | Adequate    | Satisfactory | Unclear<sup>a</sup> |
| 28.0         | Phan [28]    | All 5 types of opp. | Adequate    | Satisfactory | No                                                             |
| 34.0         | Tyagi [31]   | Before delivery     | Adequate    | Good       | Yes                                                           |
| 36.0         | Delaney [23] | Before delivery (independent observers) | Adequate | Good | Yes |
| 37.8         | Danda [22]   | Before procedures   | Small       | Suboptimal | No                                                             |
| 38.0         | Tyagi [31]   | Before vaginal examination | Adequate   | Good       | Yes                                                           |
| 40.9         | Cronin [21]  | During cord care    | Small       | Suboptimal | Yes                                                           |
| 48.0         | Friday [24]  | Before examining patients | Unclear   | Suboptimal | Unclear |
| 51.0         | Friday [24]  | Before putting on gloves | Unclear   | Suboptimal | Unclear |
| 75.0         | Hoogenboom [26] | During delivery | Small       | Suboptimal | No                                                             |
| 78.0         | Mannava [27] | Before touching any delivery areas or surface | Adequate   | Satisfactory | Yes |
| 81.0         | Mannava [27] | Before gloving for delivery | Adequate | Satisfactory | Yes |
| 100          | Cronin [21]  | Before wound care   | Small       | Satisfactory | Yes |

<sup>a</sup>Emergency room may not only cater for labouring women
received the intervention. There is no control or baseline group for comparing hand hygiene without the intervention. The main comparison is between the first month of intervention and the latter 7–8 months carried out by the same peer-coaches who run the intervention – compliance before delivery was respectively 76% and 94%. The independent assessment of hand hygiene described above showed compliance at 36% between 2 and 5 months of the intervention period. Given the presence of peer coaching, participants were not blinded to the aim of the intervention.

A few studies looked quantitatively at the association between potential determinants and hand hygiene compliance (measured via observation or other objective method) – but none of these were individual level determinants except for cadre. These appear to be all unadjusted associations. Mannava et al. reported that hand hygiene compliance before touching any delivery surface was in tertiary hospitals at 71%, vs 83% for first-level referral hospitals ($p$-value < 0.001), and higher in hospitals where all delivery rooms had soap and a sink with water compared to hospitals where needed supplies was not available in all rooms (50% vs 39%, $p$-value = 0.29) [27]. Buxton et al. tested the association between hand hygiene compliance and cadre, national state, and facility type - these were not found to be associated; they do find an association with shift – with the morning shift having higher compliance compared to the afternoon ($p$-value = 0.0034) and night ($p$-value = 0.008) [19]. Tyagi et al. described hand hygiene compliance by facility type, reporting a compliance of 100% in private facilities compared to 27% in public facilities ($p$-value = 0.011) [31]. They do not find an association with facility level and facility load [31]. Gon et al. report that hand hygiene compliance did not vary much by observer or by shift, indeed the confidence intervals overlapped across the of these categories [25].

With regards to the ICC, we present here the results we gathered from studies with the larger sample size and clearer definitions, involving more than two facilities, and where authors replied to our request. Estimates of rho in Buxton et al. [19] and Gon et al. [25], are both closer to 0 than 1 indicating that variance within facilities appear higher than between facilities (Table 4). ICC for the variation between and within individuals is also provided by Gon et al. and reports higher variance within than between individuals [25].

### Discussion

We performed a systematic review of published studies reporting estimates of birth attendants’ hand hygiene compliance conducted in healthcare facilities in LMICs. We found fifteen studies that met our inclusion criteria. Hand hygiene compliance estimates were extremely diverse, ranging from 0 to 100%; the heterogeneity in definitions of hand hygiene did not allow us to combine or compare these meaningfully. Four studies (Cronin et al., Hoogenboom et al., Friday et al., and Mannava et al.) reported higher compliance. Except for Mannava et al., these with higher compliance also had a very small or unclear sample, and used an individual level or group level definition for the denominator rather than the number of patient-attendant interactions (hand hygiene opportunities) as recommended by the WHO hand hygiene guidelines [21, 22, 26]. The studies [19, 23, 25, 28, 30–32] with larger sample sizes and clearer definitions suggest compliance to hand hygiene before aseptic procedures to be low, between 1.3 and 38.0%. We have three estimates for hand hygiene before vaginal examination which spans between 1.3% [30] and 38% [31]; and we have five estimates for hand hygiene before labour/ delivery-related procedures spans between 4 and 36% [23]. Overall, the quality of the included studies was particularly compromised by poorly described sampling methods and definitions.

The studies included were published in the last 18 years and spanned 14 countries between Sub-Saharan Africa, South East Asia and the Middle East. Four studies only included one facility, limiting their generalizability. The supplies of key hand hygiene infrastructure were poorly described, except in four studies. The quality of the studies included was generally poor with a high risk of bias with a few exceptions. The weakest aspect of the studies was their description of the sampling strategy, as most studies did not describe how the unit of observation was sampled (whether women, healthcare workers or specific procedures). Also, the reported definitions of hand hygiene were often

**Table 4** ICC results

| Outcome is hand hygiene during: | Buxton et al. [19] | Gon et al. [25] |
|--------------------------------|------------------|---------------|
| Facilities                      | Before aseptic procedures during labour/delivery | Before aseptic procedures during labour/delivery |
| Numerator                       | 6                | 10            |
| Denominator                     | 7                | 75            |
| Rho                             | < 0.0001         | 0.13          |


incomplete. For most studies it was unclear whether the use of soap was a necessary condition to achieve hand washing compliance. In addition, the type of hand hygiene opportunity was often poorly described i.e. before or after the interaction with the patient; aseptic procedures vs. contact with the patient intact skin. Finally, in four studies the denominator did not rely on patient-worker interactions but on the overall performance of an individual or a group, or on the number facilities were hand hygiene was observed. This finding, of poor methods in conducting and reporting of observational studies on hand hygiene and more broadly of healthcare workers, was reported elsewhere [6, 36].

Beyond the basic aspects of quality required for any observational study and described by the STROBE guidelines [15], future studies focusing on hand hygiene during labour and delivery should design and report the following more clearly:

a) what sampling strategy was used to observe either workers, women, or patient-worker interactions; and how facilities visits were scheduled;
b) the methods used to ensure the quality of data collection in the study e.g. data monitoring;
c) the inter-observer agreement where multiple observers are employed;
d) the definition of hand hygiene using the WHO hand hygiene guidelines [37] (i.e. soap necessary for hand washing; which type of hand hygiene opportunity e.g. before vs. after, touching intact skin vs. aseptic procedure; denominator based on patient-worker interactions rather than individual or group level performance; types of procedures involved in the aseptic procedure; sequence of actions required to comply to hand hygiene);

e) the definition of hygiene compliance using the WHO hand hygiene guidelines [37] (i.e. soap necessary for hand washing; which type of hand hygiene opportunity e.g. before vs. after, touching intact skin vs. aseptic procedure; denominator based on patient-worker interactions rather than individual or group level performance; types of procedures involved in the aseptic procedure; sequence of actions required to comply to hand hygiene);

f) the definition of hygiene compliance using the WHO hand hygiene guidelines [37] (i.e. soap necessary for hand washing; which type of hand hygiene opportunity e.g. before vs. after, touching intact skin vs. aseptic procedure; denominator based on patient-worker interactions rather than individual or group level performance; types of procedures involved in the aseptic procedure; sequence of actions required to comply to hand hygiene);

Our findings of low birth attendants’ hand hygiene compliance are consistent with other systematic reviews or multi-country studies in LMICs of hand hygiene among healthcare workers more generally, which report compliance estimates ranging from 22 to 35% during non-intervention periods [38, 39]. Similarly to these studies, our estimates point to a slight lower compliance in LMICs compared to high-income settings. With approximately 140 million women delivering worldwide, most of which are in LMICs and at least half of which occur in healthcare facilities where quality of care is suboptimal, these low estimates of hand hygiene compliance during labour/delivery are worrisome [5, 40, 41]. If correct, these estimates pose a substantial risk to infection prevention during birth in LMICs where both mothers and newborns are still largely affected by infection [1, 2, 42].

None of the included studies specifically investigated the wide range of individual determinants of hand hygiene compliance – except for cadre examined in one study. Four however report compliance estimates by study or facility characteristics. Three studies [30, 32] investigated the effect of two different interventions on hand hygiene, a checklist on quality of care at birth and an education program. Both were successful in increasing substantially the hand hygiene compliance during labour/delivery. Given the nature of their study design – pre-post intervention without a control ward, or without baseline, and with study participants who are no blinded – these interventions tell us more about the feasibility of these interventions in these specific contexts compared to anything conclusive about their scope for improving hand hygiene more widely in LMICs. With regards to ICC, from 2 studies we find that variation is greater within than between facilities.

Our systematic review covered four separate databases, has a clearly reported search strategy adapted from previous systematic reviews on the topic, did not pose any restrictions based on language, and used independent double full text screening and article extraction. A potential weakness is that our search might have missed articles which included hand hygiene in the broader framework of quality of care during birth or infection prevention and control and which did not mention hand hygiene in their title or abstract. We did not assess publication bias, but this would be more of an issue for intervention studies that found negative results for example than for observational studies reporting on compliance estimates. Finally, the set of health care facilities included in this systematic review is unlikely to represent health care facilities across LMICs. Without random sampling from the reference population of health care facilities, estimates of hand hygiene may be subject to selection bias stemming from researchers non-random decisions about which facilities to study. For example, researchers may be more likely to sample from higher volume facilities where deliveries are frequent than to sample from lower volume facilities. Studies suggest that higher volume facilities are better equipped for attending deliveries, but they maybe more prone to crowding which in turn makes hand hygiene more challenging [43]. Only Gon et al., Mannava et al., Tyagi et al. [25, 27, 31] can be regarded representative of the reference population which they targeted, respectively: high-volume labour wards in Zanzibar, hospitals implementing EENC in the countries included from South East Asia, hospitals with a newborn unit in Andhra Pradesh and Telengana regions of India who did not receive a quality improvement intervention. It is hard to make this inference for Friday et al. because of their group level definition of hand hygiene. [24]
Conclusions
In conclusion, we found fifteen articles reporting the hand hygiene compliance of healthcare workers during labour and delivery in LMICs. Compliance including before aseptic procedures opportunities for studies with larger sample sizes and clear definitions was low, ranging between 1 and 38%. This is an opportunity for infection prevention reduction during birth in LMICs facilities since effective interventions in this area are likely to reduce infection rate among mothers and newborns. We also found that the quality of many studies was suboptimal. In particular, future studies of hand hygiene compliance during the labour ward should be designed with better sampling frame, assess inter-observer agreement, use measures to improve quality of data collection and report their hand hygiene definitions clearly.

Availability of data and materials
All data generated or analysed during this study are included in this published article.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Abbreviations
CONSORT: Consolidated Standards of Reporting Trials; HICs: High Income Countries; ICC: Intra-cluster correlation LMICs; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; STROBE: Strengthening the Reporting of Observational studies in Epidemiology; WHO: World Health Organisation

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Authors’ contributions
Conceived and designed the study: GG OC. Analysed the data: GG first reviewer, MDB and LD second reviewers. Wrote the paper: GG MDB SN OC LD. Data interpretation: GG MDB SN OC LD. The authors have read and approved the manuscript.

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Supplementary Information
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Additional file 1. “Systematic review search strategy” – it includes the search strategy for each database used in our review.

Additional file 2. “PRISMA 2009 Checklist” – it includes the details of our manuscript against the PRISMA checklist.
