Health Systems Interventions for Prevention of Maternal Peripartum Infection in Low and Middle Income Countries: A Systematic Review

Roseline Abwao (aroseline1788@stu.kemu.ac.ke)
Aga Khan University Hospital Nairobi
Job Mapesa
Kenya Methodist University
Wanja Tenambergen
Kenya Methodist University
David Odada
Aga Khan University Hospital Nairobi
Nasra Gathoni
Aga Khan University Nairobi
Felix Riunga
Aga Khan University Hospital Nairobi

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Abstract

Background

Maternal peripartum infection is still a widespread avoidable problem in Low and Middle Income countries (LMICs) despite developments in postnatal care. Lately systems approach, encompassing all the factors in the health system, is being recognized as ameliorate option for the improvement of maternal health and prevention of maternal mortality.

Objective: The aim of this systematic review was to identify and evaluate interventions to prevent maternal peripartum infection in LMICs.

Methods -The Cochrane Library, CINAHL, MEDLINE (via PubMed) and Scopus,World Health Organization (WHO) ,the National Institute for Health and Care Excellence (NICE) websites were searched to identify interventional studies to prevent maternal peripartum infection using the PRISMA model. The article searching was conducted for a period of 3 months (01/08/2022 to 30/10/2022). Search terms were “Peripartum”, “Infection”, “Genital tract”, and their MESH terms. The inclusion criteria were primary studies that reported interventions for the prevention of maternal peripartum infection, studies from LMICs and those written in English language. Cochrane Risk of Bias tools were used to appraise the quality of the studies.

Results – From 1662 article results,29 articles were included covering 56,151 participants. The interventions were grouped into six domains: antibiotic prophylaxis 11(37.9% of studies), self-care training 6 (20.6%), skin preparation 6 (20.6%), systems approach 2 (6.9%), Traditional Birth Attendant training (6.9 %) and use of Clean Delivery Kit 2(6.9%).12 studies reported a significantly lower risk of infection. Six studies reported a significantly improved knowledge and practice of women regarding maternal peripartum infection. Two studies reported no change in the risk of infection.

Conclusion- There is limited research from LMICs on interventions to prevent maternal peripartum infection, however the studies are of good quality. The study identified six domains of interventions which were mainly inpatient settings targeting maternal peripartum infection in isolation without consideration of other system components. This provides an opportunity for achieving optimum reduction in maternal peripartum infection though systems approach. Health systems interventional studies are therefore needed to further the gains in maternal peripartum infections prevention in LMICs.

Study registration: PROSPERO CRD42022342550

1. Background

Globally, there is increased recognition of the importance of a functional health system in the improvement of maternal health and the reduction of maternal mortality. By considering a detailed understanding of the dynamics among processes, people, and technology, systems thinking helps in the adoption of effective interventions in the healthcare system [1].

Maternal Peripartum Infection defined by the World Health Organisation [2] as ‘Bacterial infection of the genital tract and surrounding tissues occurring any time between the onset of rupture of membranes or labour and the 42nd day postpartum in which two or more of the following are present: Pelvic pain, Fever, Abnormal vaginal discharge, Abnormal smell/foul odour of discharge, Delay in uterine involution’ is a major cause of morbidity and mortality in the world and the third cause of maternal mortality in LMICs [3]. The risk factors are known and the infection is preventable [4–11]. Several interventions have been documented [12–20] however, maximum effectiveness and further reduction of the infection can be achieved if the existing interventions are aligned through a health systems approach [1]. It is from this ground that a health systems evaluation of the available interventions of prevention is necessary however, evidence on health systems interventions is less well documented. Drawing from maternal peripartum infection literature, this paper reviews the available evidence on health systems interventions to prevent maternal peripartum infection.

2. Methods

The systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [21]. The systematic review protocol was prospectively registered on PROPERO (CRD42022342550).

2.1 Search strategy and selection process

The study took place from 1st August to 30th Oct 2022 during which an expert subject librarian assisted with formulating the review search strategy. The databases used in the search were: The Cochrane Library, CINAHL, MEDLINE (via PubMed), Scopus and EBSCO Host Academic Search Complete and Websites, such as the World Health Organization (WHO) and the National Institute for Health and Care Excellence (NICE). Key terms (“Peripartum”, “Infection”, “Genital tract”) in the research questions were checked for alternative terms using the controlled vocabulary Medical Subject Heading (MeSH) and free text searching (Supplement 1). References lists of the publications retrieved were manually searched and the search was limited to English language. The findings from the online data bases were transferred into endnote. Two reviewers independently assessed the titles and abstracts (RA and DO) of the identified publications according to the predetermined inclusion criteria and differences were resolved through discussion by involving the third reviewer (AR). All full text articles were double screened by RA and DO and all the processes in study selection recorded in sufficient detail to complete a PRISMA flow diagram (Fig. 1) and a table created for ‘Characteristics of Included Studies’ (Table 1).

Table 1
Summary of included studies and quality assessment (n = 29)

No.	First author; year of publication; country	Intervention	Study Design	Target Population	Duration	Key Findings
1.	Dlamini Uganda 2015	Antibiotic prophylaxis	RCT single-blinded	464 Women for CS	3 months	Significantly lower risk of infection when prophylaxis is given 1 hour before skin incision than I hour after skin incision
2.	Bagratee, 2001 South Africa	Antibiotic Prophylaxis	RCT prospective ,double blind, placebo-controlled	480 Women for elective CS	6 weeks-as inpatient and at post-natal visit	No difference in SSI risk with pre-op cefoxitin (intervention) versus placebo..
3.	Igwemadu 2022 Nigeria	Antibiotic Prophylaxis	RCT Open Label	162 Women for CS	11 Months	No significant difference between single-dose ceftriaxone and metronidazole and multiple doses for antibiotic prophylaxis for wound infection. Clinical endometritis was statistically significant and none reported in the single-dose arm
4.	Ijarotimi AO 2013 Nigeria	Antibiotic prophylaxis	RCT	200 Women for CS	6 months	No significant difference in the incidence of infection between short term and long term prophylactics, but short term cheaper
5.	Jyothirmayi 2017 India	Antibiotic Prophylaxis	randomized controlled double blinded trial	1106 Women for CS	7 months	Significantly lower risk of infection with pre incision antibiotic prophylaxis as compared to the post incision. decreased the hospital stay significantly
6..	Lyimo 2013 Tanzania	Antibiotic Prophylaxis	a randomized, equivalence, non-blinding clinical trial	500 Women for CS	7 months	Pre-op single-dose gentamicin and metronidazole was associated with significantly less risk of infection than prolonged therapy
7.	Mivumbi 2014 Rwanda	Antibiotic Prophylaxis	Prospective, randomized, open-label, single-site study	132 Women for CS	3 months	Significantly lower risk of infection with prophylaxis cefazolin than with ampicillin
8.	Mohamed 2020 Nigeria	Antibiotic Prophylaxis	RCT	160 Women for CS	5 months	No significant difference in infection risk between two doses of amoxicillin-clavulanic acid and a 7 days' course of prophylactic antibiotic. The use of two doses of amoxicillin-clavulanic acid has the advantages of reduced cost and some maternal side effects.
9.	Oluwalana, 2017 Gambia	Antibiotic Prophylaxis	RCT,double-blinded, placebo-controlled	829 Women in labour	12 months	Arithromycin given in labour is associated with significantly less risk of infection than no antibiotic (control).
10.	Osman,Sudan 2013	Antibiotic Prophylaxis	Opened RCT	180 Women for CS	4 month	There was no difference in the two regimens (pre-incision or post-clamping of the umbilical cord) of ceftizoxime as prophylactic for elective cesarean delivery
11.	Vathana, 2018 Sri Lanka	Antibiotic Prophylaxis	RCT, non-blinded	369 women for CS	3 months	No statistically significant differences between single dose and multiple dose antibiotic regimens with the incidence hospital stay
12.	Abdelfattah,. 2022 Egypt	Self-care training	Quasi experimental design (one group pre and post-test)	120 Postpartum Women.	4 months	Significant Improvement in the knowledge and practices of postpartum women regarding puerperal sepsis
13.	Elsayed 2021, Egypt	Self-care training	A quasi experimental design with pre and post intervention	100 women before CS	4 months	Significant improvement on women's knowledge and practice regarding puerperal sepsis.

No.	First author; year of publication; country	Intervention	Study Design	Target Population	Duration	Key Findings
14.	Gamel 2020 Egypt	Self-care training	Interventional quasi-experimental, pre-posttest, research design	100 Postpartum women	2 months	Significant improvement on women's knowledge and practice regarding puerperal sepsis.
15.	Sarkar India 2021	Self-care training	A quasi experimental study	64 Women before CS	1 month	Significant improvement in the knowledge and practices scores among the experimental group
16.	Ramadan 2018 Egypt	Self-care training	An intervention (Quasi-Experimental)	120 Postpartum women	7 months	It was found that self- care guideline has a positive effect on improving the quality of life among women undergoing cesarean section
17.	Zarei 2021 Iran	Self-care training	a quasi-experimental clinical trial	72 women Before CS	2 months	A significant acceleration of wound healing 9 days after CS In the intervention group compared to the Control group
18.	Elsharkawy 2022,Egypt	Skin Preparation	RCT, Non blinded	54 Women	6 months	Preoperative skin preparation with povidone iodine was associated with a significant less wound infection than no skin prep
19.	Lukabwe 2022 Uganda	Skin Preparation	RCT Single blind Control Goup Routine care	96 women before Emergency c/s	1 month	Significant lower risk of infection with chloroxylenol bath than no antiseptic (Control)
20.	Luwang 2021	Skin Preparation	RCT	311 Women for CS	3 months	Significant lower risk of infection with chlorhexidine–alcohol skin antiseptic compared to povidone–iodine.
21.	Ahmed Egypt 2022	Skin Preparation	RCT	90 women undergoing elective CS	8 months	Significant lower risk of infection with povidine or iodine or chlorhexidine group than the none (Control group) No statistically significant difference between Povidine-iodine and the chlorhexidine group
22.	Ogah, Nigeria 2020	Skin preparation	Prospective RCT Control group-Routine Care	322 Women Before Emergency	4 months	Vaginal cleansing with 1.0% chlorhexidine gluconate solution was associated with a Significant reduction in infection
23.	Taha, 1997 Malawi	Skin Preparation	Clinical trial Control group Routine care	6965 Before delivery	6 months	Cleansing the birth canal with chlorhexidine is associated with significant reduction in infection.
24.	Ernest EC 2021 Tanzania	Systems Approach	A pre-cross-sectional/post-cross-sectional study design	Interprofessional Surgical teams 279 Women	3 months	Significant improvement in the SSC utilization /Reduction in SSI/ Drop in CS related POMR
25.	Gentilotti et al 2020 Tanzania	Systems Approach	Before-after intervention cohort study	1037 women	24 months	Significantly increased use of antibiotic prophylaxis, more qualified operators performed the CS and a significant reduction of SSI
26.	Goodburn, 2000 Bangladesh	TBA training	Before and after intervention	TBAs 800 2099 post-partum women	18 months	No significant difference in the risk of infection between trained and untrained TBAs. Other factors, such as pre-existing infection, long labour and insertion of hands into the vagina were found to be highly significant.
27.	Shaieb 2020 Sudan	TBA training	Semi-experimental	37 TBAs	7 months	Significant improvement in the knowledge after training than before the training .

No.	First author; year of publication; country	Intervention	Study Design	Target Population	Duration	Key Findings
28.	Darmstadt, 2009,Egypt	Clean Delivery Kit (CDK) use	cross-sectional cohort study	334 Postpartum women	1 month	Significant low risk of infection with the use of CDK
29.	Seward 2015 Bangladesh, India & Nepal	Clean Delivery Kit (CDK) use Promotion of Hand wash	Cluster RCT, open cohort.	Postpartum Women Bangladesh 25,591 India 11,063 Nepal 3948	Bangladesh 24 months India 36 months Nepal 24 months	Significant reduction in infection with hand wash.,CDK use does not improve maternal survival

2.2 Criteria for study inclusion and exclusion

Inclusion criteria –The systematic review included primary studies that reported interventions for the prevention of maternal peripartum. infection. Studies from LMICs and those written in English language were included. There were no year restrictions in ordered to maximize the breadth of data included.

Exclusion criteria -Primary studies were excluded if there was a composite outcome from which it was not possible to extract data on maternal peripartum infection alone, systematic reviews and meta-analysis, studies not in the genital tract and surrounding tissues, studies not in LMICs and non-English studies.

2.3 Data extraction and critical appraisal

Data from included studies were extracted using a predefined data extraction sheet. Fields included: first author; year of publication; country, study design, population, sample size, duration of study, intervention and critical appraisal summary. Two reviewers (RA and DO) independently assessed the methodological quality of the studies. The Cochrane risk of bias tool [22] was used to appraise studies using randomized study designs and [23] ROBINS-I (Risk Of Bias In Nonrandomised Studies - of Interventions) for studies using non-randomised study designs. Disagreements were resolved by consensus and involvement of the third reviewer (AR).

3. Results

3.1 Search findings

The search process identified a total of 1662 titles and abstracts including those sourced through manual searching for screening. A total 1260 remained following the removal of duplicates which were then screened by title and abstract applying the inclusion and exclusion criteria and 59 articles were included for full text screening.27 articles were excluded in the full text screening and the reasons provided for exclusion. Supplement 2 shows the excluded studies with the reasons for exclusion. This left a total of 29 papers (Table 1) which were critically appraised by the research team and agreement reached for their inclusion in the systematic review.

3.1.1 Characteristics of the included studies

The 29 papers that met the aim of the review are detailed in Table 1. The studies covered a wide geographical area with a majority in inpatient settings. Seven studies were conducted in Egypt [15, 24, 25, 26, 27, 28, 29], five studies in India [12, 14, 30, 31, 32], four studies in Nigeria [33, 34, 35, 36], three studies in Tanzania [8, 37, 38, 39], two studies each in Sudan [40, 41], Uganda [13, 42] and Bangladesh [30, 43]. While one study each in South Africa [44], Gambia [46], Malawi [47] and Iran [48]. Of the 29 studies, only one was a multicenter done in India, Nepal and Bangladesh [30]. The oldest study in the review was published in 1997. More than half of the studies (n = 19) were published after 2015 with most of the studies (n = 15) being published in 2020,2021 and 2022. The most employed design used was randomized controlled studies 19 (65.5%) followed by Quasi experimental 7(24), cross-sectional 2 (6.9%) and before and after study design (0. 03%).The intervention duration varied widely with the shortest at 2 weeks which tested the effect of antibiotic prophylaxis and the highest was 36 months that tested the use of clean delivery kit (CDK). The interventions were mainly implemented in hospitals except for two studies that involved the use of CDK by TBAs in the community.

3.1.2 Domains of the interventions to prevent maternal peripartum infection

Figure 2 presents the domains of the interventions identified in the included studies. The interventions targeted either the woman or health care workers and were grouped into six domains; antibiotic prophylaxis, self-care training, skin preparation, system approach. Traditional Birth Attendant (TBA) training and the use of clean birth kits (CDKs).

Antibiotic prophylaxis 11(37.9%) was the most common intervention, followed by self-care training 6 (20.6%) and skin preparation 6 (20.6%), system approach 2 (6.9%) TBA training 2(6.9%) and CDK 2(6. 9%).Majority of the interventions (n = 27) were implemented in the inpatient settings and therefore the implementations were majorly by health care professionals and a few (n = 2) were by non-healthcare professionals.

Risk of bias

Of the 17 RCTs (Table 2) assessed by using RoB2 all the 17 (100%) were considered low risk. Notably three studies [34, 47, 42] had some concerns of bias due to randomization process. The ROBINS-I tool was used to assess the risk of bias in non RCTs in 11 non-RCT (Table 3). Of the non RCTs 11(92%) were considered low risk. One study [37] was judged to have some concerns in the overall rating in view of high risk of bias as a result of missing data (e.g. some files could not be located) and in selection of the reported results. Moreover, there were some concerns in the selections of participants (e.g the intervention sites were based on another evaluation that was taking place at the same time, sampling of CS files was erratic).

Table 2 Randomized studies

Study	Risk of bias domains					
	D1	D2	D3	D4	D5	Overall
Taha et al, 1997	-	+	+	+	+	+
Bagrate et al, 2001	+	+	+	+	+	+
Ijarotimi et al, 2013	+	+	+	+	+	+
Lyimo et al, 2013	+	+	+	+	+	+
Osma et al, 2013	+	+	+	+	+	+
Mivumbi et al, 2014	+	+	+	+	+	+
Dlamini et al,2015	-	+	+	+	+	+
Jyorthimayi et al, 2017	+	+	+	+	+	+
Oluwalana et al,2017	+	+	+	+	+	+
Vathana et al,2018	+	+	+	+	+	+
Mohammed et al,2020	-	+	+	+	+	+
Ogah et al,2020	+	+	+	+	+	+
Luwang et al,2021	+	+	+	+	+	+
Elsharkwa et al,2022	+	+	+	+	+	+
Lukabwe et al,2022	+	+	+	+	+	+
Ahmed et al, 2022	+	+	+	+	+	+
Igwemadu et al, 2022	+	+	+	+	+	+

Judgment
- Some Concerns
+ Low

Domains

D1: Bias arising from the randomization process

D2: Bias due to deviations from intended interventions

D3: Bias due to missing outcome data

D4: Bias in measurements of outcome

D5: Bias in selection of report

Table 3 Non Randomized studies

Study	Risk of bias domains							
	D1	D2	D3	D4	D5	D6	D7	Overall
Darmstard et al,2009	+	+	+	+	+	+	+	+
Goodburn ,2000	+	+	+	+	+	+	+	+
Seward et al,2015	+	+	+	+	-	-	+	+
Ramadan et al,2018	+	+	+	+	+	+	+	+
Gamel et al ,2020	+	+	+	+	+	+	+	+
Gentilotti et al,2020	+	+	+	+	+	+	+	+
Shaelb et al,2020	+	+	+	+	+	+	+	+
Elsayed et al,2021	+	-	+	+	+	+	+	+
Ernest et al,2021	+	-	+	+	x	+	x	-
Sarkar et al,2021	+	-	+	+	+	+	+	+
Zarel et al,2021	+	+	+	+	+	+	+	+
Abdelfattah et al,2022	+	+	+	+	+	+	+	+

Judgement
x High
- Moderate
+ Low

Domains

D1: Bias due to confounding

D2: Bias due to selection of participants

D3: Bias in classification of interventions

D4: Bias due to deviations from interventions

D5: Bias due to missing data

D6: Bias in measurements of outcomes

D7: Bias in the selection of the reported results

4. Discussions

The aim of this study was to identify and evaluate interventions to prevent maternal peripartum infection in the LMICs. We found 29 studies, the summary of the findings and the effectiveness of the six domains of interventions found in the review are discussed.

4.1 Antibiotic prophylaxis

The largest number of studies identified were on antibiotic prophylaxis for women undergoing Cesarean Section (CS). Ten studies [12, 31, 34, 35, 36, 39, 40, 42, 44, 45] with a total of 3753 women for CS while one study [46] focused on 829 women during labour. The studies were all randomized control covering mainly African countries (n = 9) and South Asia (n = 2). Although [2] recommendation supports prophylaxis for all women undergoing CS, we identified one study challenging this. The South African prospective, double-blind randomised placebo-controlled trial [44] with 480 women undergoing elective caesarean section had cefoxitin or placebo administration after umbilical cord clamping. The authors found that the antibiotic prophylaxis with cefoxitin in elective CS did not reduce post-operative infectious morbidity. Their suggestion was to restrict use of prophylactic antibiotics for women who have a high body mass index and where the baseline infectious morbidity was 15% and adherence to correct surgical procedures. Regarding the timing of antibiotics prophylaxis for CS, there were evidence from two studies [12, 42] supporting the [2] recommendations for antibiotic prophylaxis before start of operation. However, [40] study failed to show significant differences in rates of infection of post-operative infectious morbidity with different antibiotic timings. In this opened RCT study, 90 women received intravenous 1 gm of ceftizoxime either pre incision or after clamping of the umbilical cord and the authors found no difference in the two timings of antibiotic use. We identified five studies [31, 34, 35, 36, 39] that evaluated the duration of antibiotic prophylaxis. These studies supported single and not multiple or prolonged doses. One study in Rwanda, [47] compared different antibiotics regimen. The comparison was between first generation cephalosporin (cefazolin) and a penicillin (ampicillin), the study showed significantly lower risk of infection with prophylaxis cefazolin than with ampicillin. The authors recommended implementation of a general protocol of first generation. [2] recommendations do not support the routine use of antibiotics for normal deliveries, only in high risk deliveries. In contrary use of antibiotic prophylaxis during labor was considered in a Gambian study [46] where women in labor were given either an oral dose of azithromycin (2 g) or placebo. Follow-up was conducted for 8 weeks after delivery. The authors found maternal infections to be lower in the azithromycin group (3.6% vs 9. 2%) and recommended the routine use of antibiotic routinely in labour in view of High maternal and neonatal mortalities in Gambia.

Overall, most of the studies on antibiotic prophylaxis have supported the current [2] recommendation on the use of antibiotics in the prevention of maternal peripartum infection. Implications for policy makers and practitioner's in health systems and for better public health outcomes is to recognize the importance of protocols on prophylaxis antibiotic use in maternity units based on the best available evidence, conformance to the standards of infection prevention and control as well as observance of surgical procedures [49]. In addition, policy makers and practitioners should consider systems approach in the prevention of maternal peripartum infections apart from antibiotic prophylaxis alone.

4.2 Self-care training

We identified six studies [24, 25, 26, 27, 32, 48] that evaluated the effects of self-care training on women's knowledge and practice about maternal peripartum infections: with a total of 576 women (Table 1). They were all quasi experimental with four pre-posttests and two posttest control studies Majority of the studies were done in Egypt (n = 4), one each in Iran and India.

The studies employed purposive sampling (n = 4) and convenient (n = 1) sampling with a focus on postpartum women, two studies targeting antenatal women before CS. The main intervention was teaching and provision of a booklet or written materials with the information regarding self-care to prevent infection. The outcome measures were knowledge improvement (n = 4) with one study looking at the rate of wound healing and another the overall quality of life after CS.In support of the [50] self-care agenda in health, the training and provision of the booklet with information and instructions improved the knowledge and self-care practices regarding maternal peripartum infection prevention among the women.

Implications of the findings for policy makers and practitioners is to recognize the importance of maternal peripartum infection prevention guidelines teachings during the antenatal period and immediately after delivery, as part of routine antenatal and post-natal care [25, 26, 27, 48]. The women should be given written instructions to go home with four reference. A similar concept of can be used to develop selfcare guidelines on other post-partum health complications. Moreover, policy makers and practitioners should embrace the empowerment of nurses and midwives working in maternity units to enable them train women on self-care as part of postpartum education as well as streamline the induction of newly recruited staff and students in colleges, on attachment and interns.

4.3 Skin Preparations

Six studies [13, 14, 15, 28, 33, 47] evaluated the effect of skin preparation in the prevention of maternal peripartum infection with a total of 8538 women (Table 1). For the administration of the antiseptics, the studies used vaginal preparations via sterile gauzes, sponge sticks and a full bath with soap containing antiseptic. There was further recent evidence to support the [51] recommendations for vaginal preparation with chlorhexidine gluconate or povidone-iodine immediately before CS. [33] prospective RCT study in Nigeria of 322 women who were randomized into two groups; the interventional group received vaginal cleansing and the control group did not. Women in the intervention group had lower infections (12%) than those in the control (36.8%). In a similar study in Egypt, [15] involving 54 women split into two groups with one group receiving preoperative vaginal cleansing with povidone- iodine and the other none. The rate of infections was reduced in the treatment group (7.4%) than in the control (37%). [28] RCT trial in Egypt, 90 women were allocated in three groups: control, vaginal cleansing with povidone-iodine or chlorhexidine. The authors found lower infection rates in the groups that had vaginal cleansing and no significant difference in the rates of infections between povidone-iodine or chlorhexidine. [48] pilot randomized study comparing the efficacy of chlorhexidine

and povidone iodine in skin antisepsis before CS with 311 women: 153 -chlorhexidine group and 158- povidone iodine group found the rate of infections lower in chlorhexidine (5.4%) group than in povidone-iodine (8.6%). The researchers highlighted that it did not reach a statistical significance. Evidence of a preoperative bath before CS was identified in in one study. In this Ugandan study, [13] randomized 96 women into two groups: Intervention (preoperative bath with chloroxylenol) and a control (without antisepsis bath) group. Incidences of infections was lower in the intervention group (6.25%) than in the control group (54. 17%).The evidence support the [51] recommendation of a preoperative bath with or without antisepsis. The effect of birth canal cleansing with antiseptic was evaluated in one study. In this trial involving 6965 women [47], intervention and control groups were enrolled in the trial time periods not individually due to the busy labour unit. The intervention group received manual wipes of the birth canal with chlorhexidine at every vaginal examination while the control group received routine delivery procedures. The authors found the admissions related to delivery were reduced in the interventional group.

Implications of the findings to policy makers and practitioners in health systems and public health outcomes is that preoperative vaginal cleansing with povidine or chlorhexidine is a simple and a cost effective intervention that may be considered before performing CS and should be part of the hospital routine care to reduce the risk of post-CS infection [13, 15, 28, 33, 47].

4.4 Systems Approach

Evidence of a system approach in the prevention of maternal peripartum infection was identified in two Tanzanian studies [37, 38]. [37] evaluated the impact of a multicomponent safe surgery intervention that comprised of WHO Surgical Safety Checklist (SCC) utilization, Surgical Site Infections (SSI) rates and CS-related perioperative mortality rates (POMR) before and 18 months after implementation. The interventions included training of inter-professional surgical teams, promoting use of the WHO SSC and introducing an infection prevention (IP) bundle for all CS patients. The intervention led to improved utilization of the WHO SSC, reduced SSIs and a drop in CS-related POMR. [38] system approach targeted inter professionals with staff formal and on-job trainings on IPC, evidence based education on antimicrobial resistance and good antimicrobial prescribing practice with a combined IPC antimicrobial stewardship joint program. The intervention was a multidisciplinary collaborative strategy involving, the hospital management, the pharmacist, the microbiologist and a dedicated nurse. Notably the multidisciplinary team worked to improve the prevention of infection and safe surgical procedures.

Implications of the findings to health systems managers, policy makers and funders is the need to recognize the importance of system approach in the reduction of maternal peripartum infection. This calls for the national government to develop policies to guide systems intervention and outline the multidisciplinary approach with functional IPC committees responsible to ensure that all these measures are coordinated. On the other hand, the subnational governments should ensure that the policies are disseminated to all health service delivery levels and are implemented. The national and subnational level should ensure that enough resources are available to sustain the systems approach and training of all stake holders with monitoring systems to evaluate performance periodically.

4.5 TBA Training

We identified two studies that evaluated the effects of Traditional Birth Attendants (TBA) trainings [38, 41] on infectious morbidity and knowledge levels with a total number of 837 TBAs (Table 1). [38] Bangladesh study involved 800 TBAs and 2099 women, the training covered the three ‘Cs’ handwashing with soap, cord care and clean surface. The researchers found no significant difference in the risk of infection between trained and untrained TBAs and concluded that other factors, such as pre-existing infection, long labour and insertion of fingers to examine- the vagina were found to be highly significant. In a Sudanese study, the effectiveness of a designed guidelines for TBAs regarding postnatal sepsis management was considered. In this semi experimental pretest posttest, [41] found an improvement in knowledge of TBAs after the guideline training intervention.

Implications of the findings in health systems and public health outcomes is that every delivery, including those at home, should be assisted by a skilled birth attendant (a midwife, nurse, or a doctor) who have been trained to proficiency in basic techniques for a clean and safe delivery [52]. In support of the World Health organization recommendations on working with TBAs [53], policy makers and practitioners need to have protocols that define their new roles, and ensure collaboration between TBAs, skilled attendants and staff in the referral system. Moreover, they need to be trained and the other team members sensitized on their new roles. National and subnational governments need to strengthen the referral system from the community to other levels of health systems and ensure periodic monitoring and evaluation of the status.

4.6 Use of Clean Delivery Kit

Two studies [29, 30] examined the impact of the use of Clean Delivery Kit (CDK) on maternal peripartum infection. [29] cross sectional study in Egypt with a population of 334 women confirmed lower rates of infections associated with the use of CDK. On the contrary, [30] cluster RCT multicenter study in Bangladesh, India and Nepal with a population of 40,602 over a period of 24,36 and 24 months respectively showed that CDK does not improve maternal survival. This study had also focused on the effects of hand washing, the authors concluded that hand washing was critical for maternal survival among home deliveries in India and [30].

Implications of the findings to policy makers and practitioners in health systems and public health outcomes is that clean delivery practices should be adhered in all deliveries. The use of CDK should be implemented within the health system with consideration to resource availability, health care worker’s factors focusing on their knowledge and practice but not as a single intervention.

5. Research Implication

- Further researches are needed to better understand:
    - The potential of a community based systems approach interventions in prevention of maternal peripartum infection in LMICs
    - The potential effect of self-care training on the rate of wound healing and the quality of life after cesarean section
    - The potential use of CDK in the prevention of maternal peripartum infection.

- Studies on self-care training and provision of information booklets can be replicated on larger samples in different settings
- Need for multicentric research with larger sample sizes in LMICs comparing single- with multiple-dose antibiotic prophylaxis regimens in CS to help validate or disprove the findings for clinical recommendations.

6. Strengths And Limitations

This is the first review to report on health systems interventions for preventing maternal peripartum infection. The review's strengths include the very extensive search conducted with no year restriction. However, studies published before 2012 backwards have not contributed to the findings. The studies in the review comprised of current information considering that more than half of the studies were published after 2015 with a large proportion utmost 3 years ago. The review adopted the [2] definition of maternal peripartum infection even though many studies used the term 'Puerperal Sepsis' which therefore required the correct identification in line with the [2] definition of the term 'maternal peripartum infection'. The limitation for this study is that the scope of the review did not consider challenges which are important factors in appraising interventions.

7. Conclusion

Although little research has been published on the interventions to prevent maternal peripartum infection in LMICs, important lessons can be drawn from the existing literature. The commonly used interventions are antibiotic prophylaxis, skin preparation and educational strategies on self-care with issuance of instructional guidelines to the women and these have been used as a standalone intervention. The review identified very few system approach implementations, indicating an opportunity for achieving optimum reduction in maternal peripartum infection prevention by overcoming single target interventions through a health system approach in LMICs.

Abbreviations

CDK	Clean Delivery kit
CS	Cesarean Section
LMICs	Low and middle income countries
RCT	Randomized Control Trials
TBA	Traditional Birth Attendants
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses

Declarations

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Authors contributions

RA, JM and WT designed the study. NG developed the search strategy and running of literature searches and provided expertise for use of the Endnote. RA and DO did the title/abstract/full text screening, data extraction. RA conducted data analysis, interpretation and the first manuscript draft. JM and WT provided health systems outlook to data interpretation and manuscript revision. AR contributed to dispute resolution at screening stages of the review, clinical and infection control expertise on the write up. RA and DO contributed to quality appraisal and revision of the write up. All authors worked on editing the manuscript. read and approved the final version.

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Declarations

Ethical approval and consent to participate

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Consent for publication

N/A

Competing interest

The authors declare they have no competing interests.

Authors details

[1]Aga Khan University Hospital, Nairobi

[2]Aga Khan University, Nairobi

[3]Kenya Methodist University, School of Medicine and Health Sciences

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Supplemental Information

Supplements 1 and 2 are not available with this version.

Figures

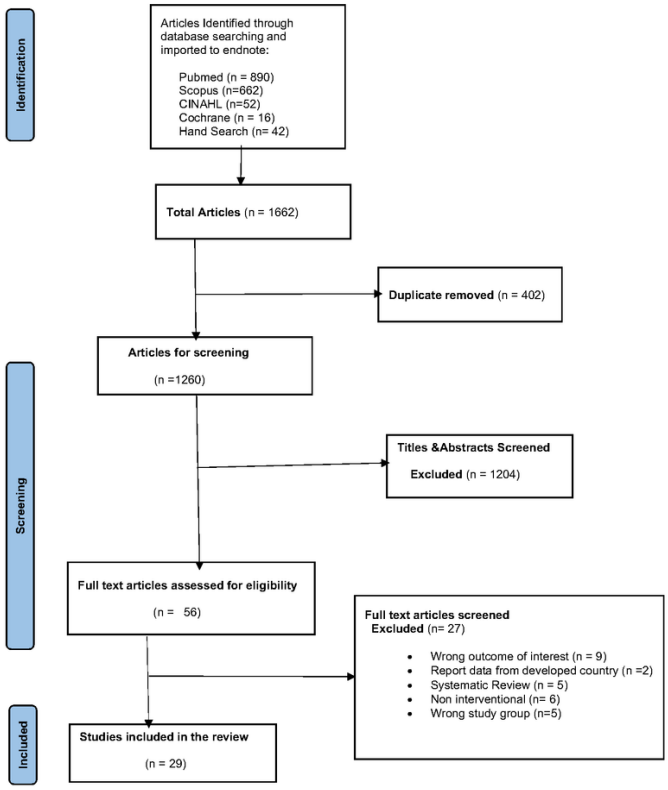

Figure 1

PRISMA FLOW DIAGRAM

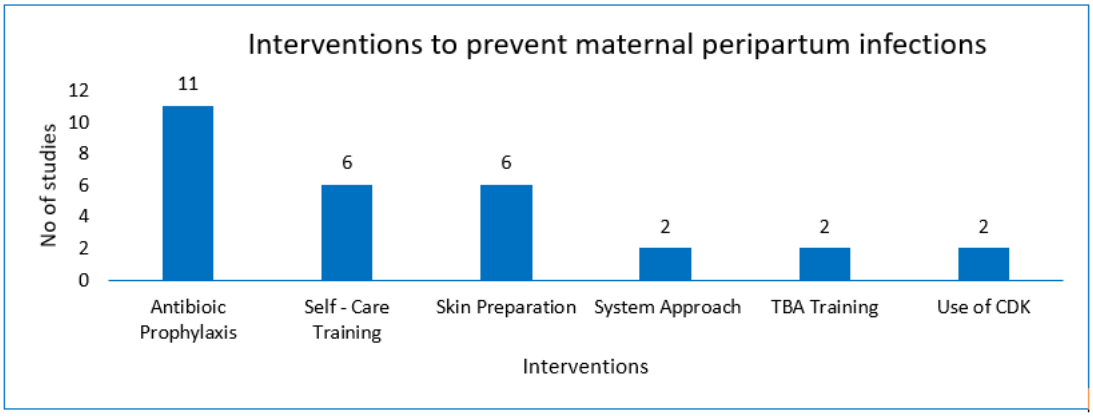

Figure 2

Interventions to prevent Maternal Peripartum Infection

Supplementary Files

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- Supplementary1PRISMA2020checklist.docx