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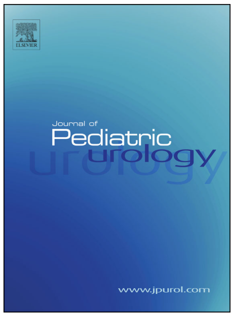

Interventions to prevent urinary catheter-associated infections in children and neonates: a systematic review

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Interventions to prevent urinary catheter-associated infections in children and neonates: a systematic review

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Interventions to prevent urinary catheter-associated infections in children and neonates: a systematic review

Summary:

Introduction

Few data are available to inform strategies for the prevention of catheter-associated urinary tract infection (CAUTI) in children and neonates. Many recommendations are derived from studies in adults and cannot be applied to the paediatric population.

Objective

We aimed to identify all studies that measured the efficacy of an intervention for the prevention of CAUTI in children and neonates.

Methods

We conducted a systematic review using the PRISMA guidelines. Eligible studies published between January 1st, 1995 and December 31st, 2017, were identified in PubMed, the Cochrane Database of Systematic Reviews, LILACS, SCIELO and DOAJ, if applying an intervention with the aim of CAUTI prevention in inpatient children, infants or neonates. The following study designs were included: controlled and non-controlled before-and-after studies, (controlled) interrupted time series analyses and randomized controlled trials. Quantitative or qualitative studies on interventions in both adults and children were eligible if data on children could be extracted. Reviews, case series, letters, notes, conference abstracts, and opinion articles were excluded.

Results

Of 99 articles identified, six were included in the final analysis, following consensus from three independent investigators. Four studies used a multimodal strategy (utilizing at least four or more different components at same time) as: aseptic rules during catheter insertion and removal; cleaning the urethral meatus with sterile water; use of a new silicone catheter per insertion with a closed sterile drainage system, using a sterile technique; daily evaluation of catheter requirement; placement of indwelling urinary catheters only for approved indications; reducing of urinary-catheter-days and positioning of the patient and collection device to assist in urine drainage. One study tested peri-urethral cleaning intervention to reduce CAUTI. One study described the association of the presence of a physician safety champion with urinary catheter device utilization ratios (DUR). CAUTI reduction rates were reported in four studies; three achieved statistically significant decreases in CAUTI rates. Positive results were only achieved when a multimodal strategy was utilized using at least four or more components. This strategy could be adopted for paediatric healthcare institutions in order to reduce CAUTI rates in children and neonates.

Conclusion

Evidence exists to support the use of a multimodal strategy for CAUTI reduction in hospitalised children and neonates.

Key words: systematic review, catheter-associated urinary tract infection, children, intervention, prevention

Introduction:

Catheter-associated urinary tract infection (CAUTI) is one of the most common, yet laregely preventable healthcare-associated infections (HAI) in hospitalized patients.[1-5] A systematic review reported that it is possible to decrease infection rates by 10% to 70%. [5]

Efforts to reduce CAUTI have been focused to adults, with positive results found in 2013 and 2014 by the US national healthcare safety network (NHSN), compared with previous years, but much less is known on the global burden of CAUTI in paediatric and neonatal populations.[1,6] Efficacy of interventions to prevent CAUTI are usually derived from adult guidelines and specific recommendations may not be applicable to neonates and children.[7-9] Interventions that have been shown to be effective in adults may require adaptation for use in the paediatric/neonatal population.

Recently, and built on the findings of the European Centre for Disease Prevention and Control (ECDC) key components [10] the World Health Organization (WHO) described eight core components for effective infection prevention and control programmes, among which figured the adoption of multimodal strategy HAI prevention. [11] A *multimodal strategy consists of several elements or components (three to five) implemented in an integrated manner, that includes tools as bundles and checklists, developed by multidisciplinary teams that take into account local conditions*.[11] By consensus, components of the multimodal strategy must be simultaneously applied to achieve sustained behaviour change and HAI reduction. [11]

Reported CAUTI prevention interventions include: hand hygiene before urinary catheter insertion, use of an aseptic technique and sterile supplies for catheter insertion, hand hygiene before and after manipulation of catheter or bag and daily evaluation for medical necessity with prompt removal of catheters when no longer indicated. [7,12]

Considering these aspects, the aim of this systematic review was to identify all studies that evaluated the efficacy of an intervention for CAUTI prevention in hospitalized children and neonates.

Material and Methods:

A systematic literature search was conducted using PubMed, Cochrane Database of Systematic Reviews, LILACS (Literatura Latino Americana em Ciências da Saúde), SCIELO (Scientific Electronic Library of Science), DOAJ (Directory of Open Access Journals) databases. Studies were searched in PubMed using the following search: strategies[All Fields] AND ("Prevent"[Journal] OR "prevent"[All Fields]) AND catheter-associated[All Fields] AND ("urinary tract infections"[MeSH Terms] OR ("urinary"[All Fields] AND "tract"[All Fields] AND "infections"[All Fields]) OR "urinary tract infections"[All Fields] OR ("urinary"[All Fields] AND "tract"[All Fields] AND "infection"[All Fields]) OR "urinary tract infection"[All Fields]); catheter-associated[All Fields] AND ("urinary tract infections"[MeSH Terms] OR ("urinary"[All Fields] AND "tract"[All Fields] AND "infections"[All Fields]) OR "urinary tract infections"[All Fields] OR ("urinary"[All Fields] AND "tract"[All Fields] AND "infection"[All Fields]) OR "urinary tract infection"[All Fields]) AND ("prevention and control"[Subheading] OR ("prevention"[All Fields] AND "control"[All Fields]) OR "prevention and control"[All Fields] OR "prevention"[All Fields]). For the other databases similar search terms were applied which concerned “strategies to prevent catheter-associated urinary tract infection” and “catheter-associated urinary tract infection prevention”. Filters applied were period: from 1 January 1995 to 31 December 2017; ages: neonates, infants, children; languages: English, French, German, Italian, Portuguese, and Spanish. We conducted this systematic review following the PRISMA guideline.[13]

Eligibility criteria

The following study designs were eligible for inclusion: controlled and non-control before-and-after studies, (controlled) interrupted time series analyses, and randomized controlled trials, quantitative or qualitative studies on interventions in both adults and children were eligible if data on children could be extracted. Reviews, case series, letters, notes, conference abstracts, and opinion articles were excluded. Studies in outpatient care, primary care, long-term care were also excluded.

Quality of articles and risk of bias

Quality of articles was assessed using the integrated quality criteria for systematic review of multiple study designs (ICROMS) tool.[14] In summary, the tool consists of two parts: the first is a scored list of quality criteria specific for each study design, as well as scored criteria applicable across all study designs; the second is a ‘decision matrix’, which determines the robustness of the study by identifying minimum requirements according to the study type and the relevance of the study to the review question. Only studies with a pre-determined minimum score and mandatory criteria, according the ICROMS methodology were included in the final analysis. (Annex)

Data collection

Data were extracted using a standardized data-extraction form which summarized the study details including authors, year of publication, country or countries where the study was performed, time frame of the study and patient population (infant or early childhood, children, or adolescents).

Article analysis:

The search was conducted by three different investigators independently (ARAS, AFM and CBB) over a 3-month period. Disagreement about inclusion of an article was resolved by consensus. Final selection of publications for inclusion was concluded in 4 phases:

a) First round: **Filters**. In this phase, age filters were applied using the pre-determined search terms in each search engine/database.
b) Second round**: Analysis of titles and abstracts**. In this phase, titles and/or abstracts were checked against inclusion and exclusion criteria.

c) Third round: **Full text analysis**. Articles were checked again against inclusion and exclusion criteria. For studies reporting on mixed adult/paediatric study populations, and settings other than acute-care hospitals, articles were excluded if paediatric data was not reported separately. **Quality assessment**. Remaining full text articles were assessed for quality. Only articles meeting the minimal score and the mandatory criteria were kept.

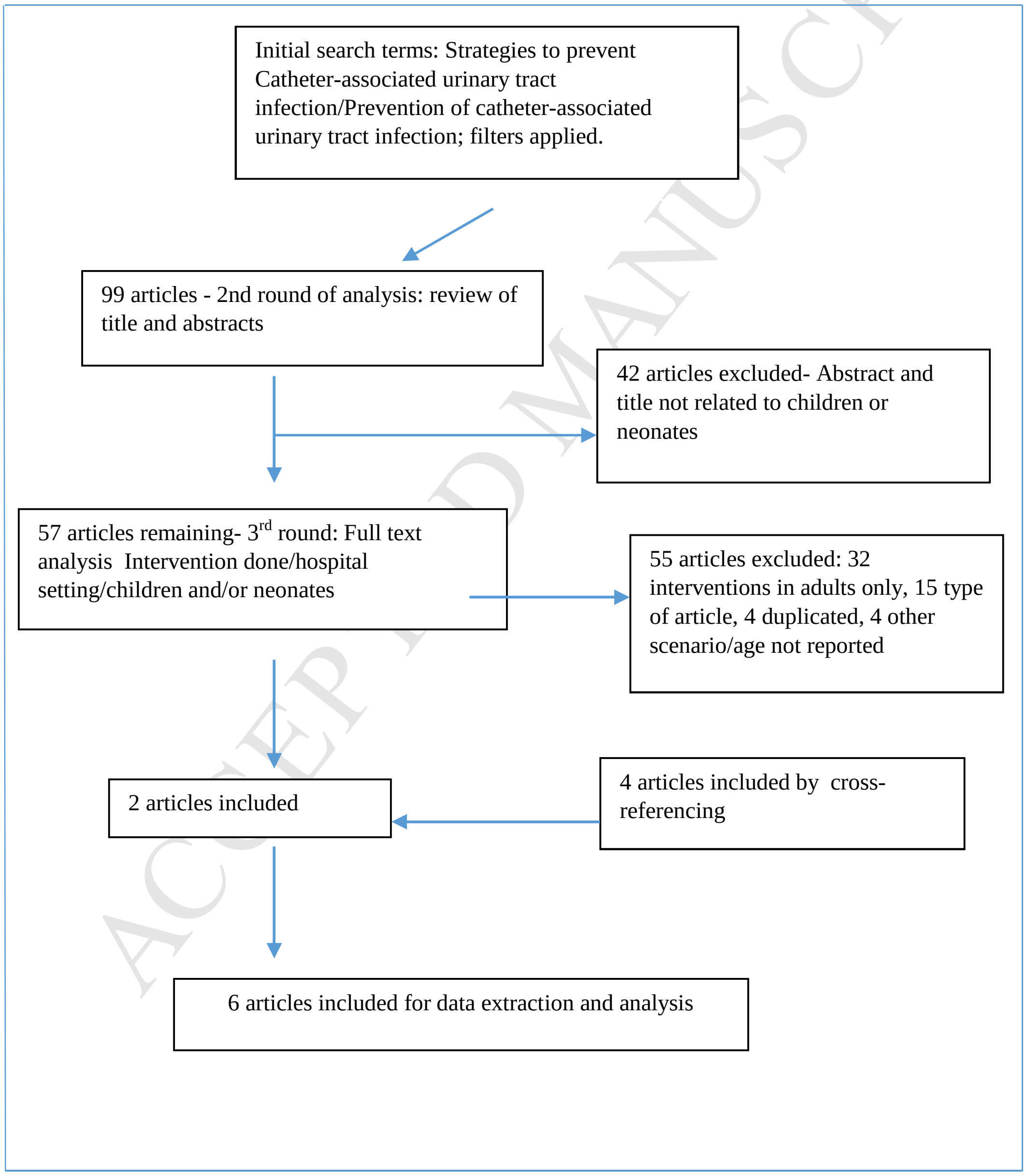
d) Final round: **Inclusion of cross-references.** Articles with interventions in children/neonates and cited by systematic reviews or in the remaining articles from the previous round were also included in the final list of articles.

Results:

Results of search:

A total of 99 titles and abstracts were identified. After full text sift and quality assessment, six articles remained for final analysis (figure 1).

Figure 1. Systematic review profile – Interventions to prevent urinary catheter-associated infections in children and neonates (1995-2017)



Included studies:

Four of the identified articles used interrupted time series analysis,[15-18] one was a randomized controlled trial,[19] and one was a non-controlled before-and-after study.[20] Characteristics of the studies are summarized in Table 1.

Study population setting:

Four studies included patients admitted to paediatric intensive care units,[15,18-20] two studies included participants from all wards of paediatric hospitals.[16,17] All six studies included patients from single centers and all of them included only patients between 0-18 years old age.

Types of intervention:

Four studies used a multimodal strategy.[16, 18-20] The first study analysed five components: aseptic rules during catheter insertion and removal, cleaning the urethral meatus with sterile water, use of a new silicone catheter per insertion with a closed sterile drainage system, using a sterile technique, and daily evaluation of catheter requirement.[20] The second study applied four components: placement of indwelling urinary catheters only for approved indications; insertion of urinary catheters using an aseptic technique /insertion checklist; maintenance of urinary catheters based on principles of asepsis and position patient and collection device to assist in urine drainage; review of urinary catheter necessity daily and prompt removal when indications are no longer valid. [16] The third study applied a hospital-wide initiative to improve patient safety by implementing high-reliability practices as part of a quality improvement (QI) program aimed at reducing all preventable harm, including reduction of CAUTI rates .[17] And the last study analysed four components: aseptic insertion; use of closed anti-reflux drainage systems; maintenance of the drainage bag under the bladder level; and closed drainage systems.[18] One study analysed efficacy of peri-urethral cleaning in preventing CAUTIs prior to indwelling urinary catheter insertion,[19] one study described the association of the presence of a physician safety champion with urinary catheter device utilization ratios (DUR).[15]

Outcome measures:

Statistically significant difference in CAUTI rates before and after intervention were reported by three studies. [16,18,19] Two studies did not find CAUTI reduction at all,[15,19] and one study described a non-significant trend.[17]

Risk of bias in included studies:

Details about the study quality are summarized in Table 2. The following components were assessed: selection bias (sequence generation and allocation concealment), performance bias (blinding of groups), detection bias (blinding of outcomes), reporting bias (selective outcome reporting), attrition bias (incomplete data outcome) and other bias. Bias was assessed using the Cochrane Risk of Bias Assessment Tool. [21]

Table 1. Strategies and interventions for CAUTI prevention in hospitalized children and neonates: systematic review 1995-2017.

Author, year, Country	Study design	Setting,	Patients	Age	**Summary of key findings**
Düskaya 2017, Turkey	RCT	Single center; PICU	122	1 Month to18 years	• **No statistically significant differences** of CAUTI rates in the 3 groups (p = 0.08) [a]
Düskaya, 2016, Turkey	NCBA	Single center;PICU	390	1 Month to18 years	• **Reduction of CAUTI** rates from 5.8 to 1.5 per 1000/UC-days (p <.001)[a] • No impact in colonization or contamination after bundle implementation
Zavalkoff, 2015, Canadá	ITS	Single center; PICU	730	Age not described	•Higher rates of urinary catheter DUR during the pre-intervention period versus post-intervention period- 0.44 (95%CI 0.42–0.45) x 0.39 (95% CI 0.38–0.40) – p<0.0001) and RR 0.89 (95%CI 0.86-0.93) •Decrease of 17% in the urinary catheter DUR when the safety champion was present (OR 0.83; 95%CI 0.77–0.90). •**The rate of catheter-associated urinary tract infections did not change.**
Davis 2014, USA	ITS	Single center; all wards (paediatric hospital)	44 (21 pre-intervention, 23 post-intervention)	All ages,	•**Reduction of 50% in mean monthly CAUTI rate after bundle implementation** (95%CI 21.28 to 20.12; p = 0.02) from 5.41 to 2.49 per 1000 UC-days. •The median monthly catheter utilization ratio remained unchanged;
Brilli, 2013, USA	ITS	Single center; all wards	76 pre-intervention, 50 post-intervention	Age not described	•**Decrease of hospital-wide CLABSI, CAUTI, and surgical site infection rates without statistical significance. Data not showed** • Decrease of observed hospital mortality decreased from 1.0% to 0.75% (P < .001). [b]
Esteban, 2013, Spain	ITS	Single center; medical and surgical PICU	851 (pre-intervention, 822 post-intervention), 940 (follow-up)	1 week to 18 years	•**Significantly lower CAUTI rate in the intervention period than in the pre-intervention period (5.8/1,000 vs 23.3/1,000 UC-days; p < 0.001)** [a] •Lower HAI rates in the intervention period than in pre-intervention period (12.5/1,000 vs 32.8/1,000 patient-days; p < 0.001). [a]

CAUTI= Catheter-associated urinary tract infection CI= confidence interval CLABSI= Central-line associated bloodstream infection DUR= Device utilization ratio HAI=Healthcare-associated infections ITS= Interrupted time series NCBA=Non-controlled before-and-after study PICU = paediatric intensive care unit RCT= Randomized controlled trial. RR= relative risk OR= odds ratio VAP= ventilator-associated pneumonia

[a] Chi-square (Fisher's exact)test [b] *t*-test

Table 2- Bias of studies included

Studies	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Düskaya 2017	+	++	+++	++	+	+	+
Düskaya 2016	+++	+++	+++	+	+	+	+
Zavalkoff 2015	+	+	+++	+	+	+	+
Davis 2014	++	+	+++	+++	+++	+	+
Brilli 2013	++	++	++	++	+++	+	+
Esteban 2013	++	++	+++	+	+++	++	+

+ Low Risk ++ Unclear risk of bias +++ High risk of bias

Summary table- Positive findings of articles included in final analysis, according strategy used to reduce CAUTI in children.

Author, year	Type of intervention	Components	Positive findings in reduction of CAUTI rates?
Düskaya, 2017	Single intervention	●Peri-urethral cleansing (10% povidine-iodine solution or 0.05% cloherexidine gluconate solution or sterile water	No
Duskaya, 2016	Multimodal strategy	● aseptic rules during catheter insertion and removal ● cleaning urethral meatus with sterile water, ●using of a new silicone catheter per insertion (with a closed sterile drainage system using a sterile technique. ● evaluation of catheter requirement daily.	Yes
Zavalkoff, 2015	Adoption of physician safety champion (PSC)	● Regular reports of CAUTI rates by PSC ● Possibility of UC removal daily ● Quartely quality improvement follow-up rounds and feedback to PICU team	No
Davis 2014	Multimodal strategy	●Insertion of UC only with approved indication; ● aseptic technique for insertion ● insertion check-list ●maintenance of UC based on asepsis principles ●daily review of UC necessity and prompt removal when indications are no	Yes
Brilli, 2013	Multimodal strategy	● Reducing urinary-catheter days ● Standardizing insertion techniques ●Compliance with insertion and maintenance	Yes*
Esteban, 2013	Multimodal strategy	● Aseptic insertion; ● Use of closed anti-reflux drainage systems; ● Maintenance of the drainage bag under the bladder level; ●Closed drainage systems	Yes

*without statistical significance UC=urinary –catheter PICU= pediatric intensive care-unit CAUTI-catheter-associated urinary tract infection

Discussion:

This systematic review identified a low number of studies on the efficacy of CAUTI prevention programs in hospitalized children and neonates. The main successful strategy was the adoption of a multimodal strategy with at least four simultaneously applied components such as placement of indwelling urinary catheters for an approved indication only, aseptic technique during catheter insertion and removal, use of a new silicone catheter per insertion attempt with a closed sterile drainage system, daily review of urinary catheter necessity and prompt removal when indications are no longer present, cleaning the urethral meatus with sterile water and maintenance of the drainage bag below bladder level.

Several guidelines on HAI prevention are available, including infections related to urinary catheter use. [7,8,22] The evidence supporting most of these recommendations has been generated in adult populations where urinary catheterization use is more frequent than in children/neonates. Our review showed that the components used as part of a multimodal strategy for CAUTI prevention in children are also found in most of adult guidelines.[7,8] Although multimodal strategies a whole were effective in CAUTI prevention, it is not possible to determine, which of the components/elements had the greatest effect on CAUTI reduction.

In the absence of evidence, there were concerns to support the application of adult CAUTI prevention guidelines in children and neonates. However, some studies have evaluated components just in adult population as: use of smallest gauge catheters; evaluation of alternative methods for measuring urine volume; avoidance of catheter irrigation to prevent of patients and family; use of antibiotic-impregnated urinary catheters; role of education programmes; choice of catheter type and documentation of catheter insertion. [7-9] The applicability of these components and role of these components for children and neonates is undefined, until the present moment.

Despite existence of well-accepted guidance on CAUTI prevention for adults, the exact disease burden and best methods for CAUTI prevention in hospitalised children and neonates is not well defined.[7] Previous studies about international infection prevention and control (IPC) guidelines have demonstrated gaps in specific recommendations for interventions necessary to prevent CAUTI and surgical site infection in children. [23]

In this study, despite finding many publications on CAUTI prevention, we identified only six papers with specific interventions to reduce CAUTI in the paediatric population. In just 4 of 6 studies, reduction of CAUTI rates was achieved. Interestingly, all 3 studies that reported significant CAUTI reduction applied a multimodal prevention strategy. Another interesting finding is that all studies included came from single-center hospitals which may limit the generalisability of these findings.

The multimodal strategy using simultaneous application of prevention components is used for HAI prevention including bloodstream infection, ventilator-associated pneumonia, catheter-associated urinary tract infection, surgical site infection among others. For example, Payne and colleagues, in a recent systematic review of the role of multimodal strategy in reducing central line-associated bloodstream infections in the neonatal unit (NNU), concluded that this strategy may reduce CLABSI rates in the NNU, though it is not clear, which bundle elements are effective in specific settings. [24]

Simultaneous interventions, used as a multimodal strategy to reduce CAUTI rates are well described in adult populations. In a multi-center study involving 13 adult ICUs in 10 Turkish cities, a 47% decrease in CAUTI rates was observed after implementation of a multi-dimensional infection control approach.[25] The importance of this strategy was also demonstrated in another multi-center study in 15 countries, using a multi-dimensional approach with 6 components: (1) bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of CAUTI rates, and (6) performance feedback of infection control practices. In this setting, the intervention achieved a 37% reduction in CAUTI rates (from 7.86 per 1,000 UC-days, to 4.95 per 1,000 UC-days [relative risk (RR) 0.63 (95 % confidence interval [CI] 0.55–0.72)]). [26]

Although our systematic review was conducted using the PRISMA statement [13], the study has some limitations. First, it is possible that some articles or reports may have been missed. This problem was minimized by cross-referencing in identified studies, reviews, and meta-analyses. Second, quality may be a concern, limiting the evidence of the findings. However, applying the rigorous ICROMS methodology selected for studies of sufficient quality.

Conclusion:

We found evidence to support the use of a multimodal strategy for CAUTI prevention in hospitalised children and neonates. Multimodal strategies for CAUTI prevention should be adopted as standard of care for paediatric healthcare facilities, and include at least four different components, applied simultaneously. We can suggest that future CAUTI prevention studies should apply a multimodal strategy, and should be organised in multiple centers. The following strategies, which form part of adult CAUTI prevention guidelines, should be assessed in future paediatric/neonatal CAUTI prevention research: practical education programmes, choice of catheter type, evaluation of alternative methods to urinary catheters, documentation of catheter insertion, catheter size, cleaning of the urethral meatus, use of antibiotic-impregnated urinary catheters and catheter irrigation.

Declaration of interests

We declare no competing interests.

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Annex - Quality criteria for application per study design- Integrated quality criteria for review of multiple study designs (ICROMS)

Quality criteria		Study design [b]						
Dimension	Specific criteria [a]	RCT	CBA	CITS	NCITS	NCBA	CS	QUAL
1. Clear aims and justification	a. Clear statement of the aims of research?	++	++	++	++	++	++	++
	b. Rationale for number of pre-and post-intervention points or adequate baseline measurement	x	x	+	++	++	x	x
	c. Explanation for lack of control group	x	x	x	+	+	x	x
	d. Appropriateness of qualitative methodology	x	x	x	x	x	x	+
	e. Appropriate study design	x	x	x	x	x	x	++
2. Managing bias in sampling or between groups	a. Sequence generation	++	x	x	x	x	x	x
	b. Allocation concealment	++	x	x	x	x	x	x
	c. Justification for sample choice	x	x	x	++	++	x	x
	d. Intervention and control group selection designed to protect against systematic difference/selection bias	x	++	x	x	x	x	x
	e. Comparability of groups	x	x	x	x	x	++	x
	f. Sampling and recruitment	x	x	x	x	x	x	++
3. Managing bias in outcome measurements and blinding	a. Blinding	++	x	x	x	x	x	x
	b. Baseline measurement- protection against selection bias	x	++	x	x	x	x	x
	c. Protection against contamination	x	++	x	x	x	x	x
	d. Protection against secular changes	x	x	++	x	x	x	x
	e. Protection against detection bias: blinded assessment of primary outcome measures	+	+	+	+	+	+	x
	f. Reliable primary outcome measures	+	+	+	+	+	+	+
	g. Comparability of outcomes	x	x	x	x	x	++	x
4. Managing bias in follow-up	a. Follow-up of subjects (protection against exclusion bias)	+	x	x	x	x	x	x
	b. Follow-up of patients of episodes of care	+	x	x	x	x	x	x
	c. Incomplete outcome data addressed	+	+	+	+	+	++	+
5. Managing bias in other study aspects	a. Protection against detection bias: intervention unlikely to	+	+	+	+	+	x	x
	affect data collection	x	x	x	x	x	+	x
	b. Protection against information bias	x	x	x	x	x	x	+
	c. Data collection appropriate to address research aims	x	x	x	++	++	x	x
	d. Attempts to mitigate effects of no control							
6. Analytical rigour	a. Sufficient data points to enable reliable statistical	x	x	++	x	x	x	x
	inference	x	x	+	x	x	x	x
	b. Shaping of intervention effect specified	+	+	+	+	+	+	+
	c. Analysis sufficiently rigorous/free from bias							

7. Managing bias in reporting/ethical considerations	a.	Free of selective outcome reporting	+	+	+	+	+	+	+
	b.	Limitations addressed	+	+	+	+	+	+	+
	c.	Conclusions clear and justified	+	+	+	+	+	+	+
	d.	Free of other bias	+	+	+	+	+	+	+
	e.	Ethics issues addressed	+	+	+	+	+	+	+

[a] Applicability of quality criteria to each study design: + Criteria to be included in quality assessment for study design; ++ Mandatory criteria to be met quality assessment; x Criteria not to be applied in quality assessment for study design.

[b] Study designs: RCT =randomised controlled trial; CBA =controlled before-after; CITS = controlled interrupted time series; CS = cohort study; NCITS =non-controlled interrupted time series; NCBA =non-controlled before-after; QUAL = qualitative.

Annex -Decision matrix e mandatory criteria and minimum score for study type to be included in review.

Study Design [a]	Mandatory criteria [b]	Minimum score
RCT, cRCT	1A, 2A, 2B, and 3A	22
CBA	1A, 2D, 3B and 3C	18
CITS	1A, 3D and 6A	18
NCITS	1A, 1B, 2C and 5D	22
NCBA	1A, 1B, 2C and 5D	22
Cohort	1A, 2E, 3G and 4C	18
Qualitative	1A, 1E and 2F	16

[a] Study Designs: RCT = randomised controlled trial; CBA =controlled before-after; CITS = controlled interrupted time series; cRCT =cluster-randomized controlled trial; NCITS = noncontrolled interrupted time series; NCBA =non-controlled before-after.

[b] Scores applicable to each criteria: Yes (criterion met) =2 points; Unclear (unclear whether or not the criterion is met) =1 point; No (criterion not met) = 0 points.

Adapted from Zingg W et al. Innovative tools for quality assessment: integrated quality criteria for review of multiple study designs (ICROMS). Public Health 2016;133:19-37.