Systematic review: The evidence for whether neckties cause healthcare-associated infections

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Declaration: We have no finacial disclosures to make. We have no conflicts of interest.

Abstract

Background: There is growing concern that neckties worn by physicians may contribute to healthcare-associated infections (HAI). As a result, UK hospitals adopted a tie-less dress-code policy. We evaluated the evidence for HAI resulting from physicians wearing neckties and whether the evidence is sufficient to warrant a similar tie-less policy in Canada.

Methods: A systematic review was performed to determine if neckties worn by physicians colonize harmful pathogenic bacteria and whether neckties contribute to the spread of infection to patients in the inpatient or outpatient setting. PubMed (1966 to 2017) and EMBASE (1980 to 2017) databases were searched. The level of evidence was appraised according to the Oxford Center for evidence based medicine. The quality of evidence and risk of bias was evaluated according to the Jadad scale or the NewCastle Ottawa scale.

Results: 1675 citations were screened; six articles were ultimately included. There was only one level 1B study. Neckties were more likely to colonize bacteria compared to shirt pockets. Limited evidence exists that neckties may be contaminated with pathogenic (*MRSA*) bacteria, and very limited evidence that contaminated neckties may transmit bacteria (in a controlled experimental setting to a mannequin).

Interpretation: There is no evidence of increased rate of healthcare-associated infections related to male physicians wearing a necktie. There is weak evidence that neckties are contaminated with pathogenic (and nonpathogenic) bacteria. The level of evidence was weak, the studies heterogeneous. Evidence to support the need for a tie-less dress code policy is lacking.

Introduction

Healthcare workers, patients and visitors are estimated to be responsible for spreading approximately 80% of common healthcare-associated infections (HAI) (1). The overall annual direct medical cost to U.S. hospitals of healthcare-associated infections (HAI) has been estimated to range between U.S. $28.4 and $45 billion. Using estimates of the effectiveness of possible infection control interventions, the predicted benefits of prevention of HAI range between $5.7 and $31.5 billion (2). There is no reason to expect the proportional costs in Canada to be different. More than 200,000 patients get infections annually while receiving healthcare in Canada and more than 8,000 of these patients die as a result of these infections (1).

The World Health Care Organization (WHO) acknowledges that this is a worldwide problem. In order to reduce HAI rates, the proper infrastructure and guidelines within hospitals needs to be in place to ensure that enough attention is paid to hygiene with proper training of healthcare workers and sterilization of equipment so modern healthcare treatment is possible (3).

Concerned that certain work attire worn by physicians may be a potential vector responsible for increasing the incidence of healthcare-associated infections, the United Kingdom Department of Health introduced a Uniforms and Workwear dress code for National Health Service (NHS) employees in 2007 (4). This policy has since become known as the “bare below the elbow” attire policy as a means for reducing the spread of nosocomial infections. It has made recommendations that NHS staff wear short sleeves,

and avoid unnecessary jewelry and garments such as neckties when carrying out clinical activities.

If indeed a physician who wears a necktie increases the risk of a patient acquiring a healthcare-associated infection, then such a policy restricting their use by health care professionals in Canada (and elsewhere) would be warranted. We performed a systematic review of the published literature to measure the evidence that a health care professional who wears a necktie colonizes harmful pathogenic bacteria, and whether this contributes to the spread of infection to their patients.

Methods

Search strategy:

A systematic review was performed according to the PRISMA guidelines (5). We searched PubMed (1966 to November 7, 2017) and EMBASE (1980 to November 7, 2017) databases using *a priori* determined search strategy. A senior librarian from the College of Physicians and Surgeons of B.C. Medical Library was consulted to assist with the literature searches.

Our objective was to determine if neckties worn by physicians colonize harmful pathogenic bacteria and whether neckties contribute to the spread of infection to patients in the inpatient or outpatient setting.

The literature search identified a main database of articles using the following search strategy (Appendix):

("infection"[MESH] OR "communicable diseases"{MESH] OR infect* OR communicable*) AND ("health personnel"[MESH] OR "physicians"[MESH] OR physician* OR doctors OR doctor) AND ("clothing"[MESH] OR "attire"[All Fields] OR necktie*)

We included papers that were primary studies that examined neckties; editorials and letters were excluded although their references, if any, would be reviewed. The search was limited to articles in humans and those published in English. Articles examining potential vectors such as identification badges, stethoscopes and bow ties were excluded unless the comparison was against neckties.

Study selection, quality assessment and data extraction:

Two authors (P.PA and S.K) independently conducted individual reviews of titles and abstracts identified in the literature search. Duplicates were removed using RefWorks. Discrepancies were resolved by discussion via review of the data and mutual consensus. Data was extracted by the same two individuals who conducted the study selection to ensure consistency of reporting. Discrepancies were handled in a similar manner as study identification. The information we extracted from the papers that met our inclusion criteria were: the type of study design, the number of patients, the number and specialty of the health care workers wearing the tie, the isolated bacteria, the comparison made, the

effect it had on the patient or the outcome, whether the study was conducted in an outpatient or inpatient setting, and the level of evidence the article presented.

The Oxford Center of Evidence Based Medicine recommendations (6) (Table 1) were used to assist in grading the level of evidence in the papers that fit our inclusion criteria. We assessed the full text articles for study quality and risk of bias using the Jadad Scale (7) as well as the Newcastle-Ottawa Scale (NOS) (8). The Jadad scale is the most widely used scale to assess the quality as well as the risk of bias of clinical trials. It is a 5-point system that assesses the methods used in the clinical trial based on random assignment, double blinding and the flow of patients. The NOS scale is used to assess the quality including potential bias of nonrandomized trials. The greater the number of stars (maximum 9), the better the quality of the article.

A meta-analysis was not possible given the heterogeneity of the study population, the small size of the studies, and the poor quality of the studies examined. Thus, given the paucity of the evidence, formal statistical analysis was not possible. Had the data been robust, a meta-analysis would have been performed.

Results:

The initial search identified 1675 abstracts in PubMed and Embase. After duplicates were removed (257), 1418 abstracts remained. On screening, 1374 titles were excluded as not

relevant based on our inclusion and exclusion criteria. Forty-four full text articles remained that were assessed for eligibility. Six articles were identified that satisfied our inclusion criteria (Figure 1). No study specifically assessed the likelihood that wearing a necktie would increase the risk of transmitting an infection to patients directly.

The highest quality paper (the only level 1B study, Jadad score was 3/5) (Table 2)was a multicenter randomized blinded trial comparing the difference in contamination between bowties versus neckties worn for three days by gynecologists and obstetricians. The physicians were randomized but the main weakness of the study was the lack of mention as to whether or not the investigators were blinded to the whether the bowtie or necktie was worn first by the physician; the affect, if any, this may have had on the study results in debateable. Overall, their results revealed no difference in contamination rates between bowties and neckties, nor were any of the bacteria found contaminating either tie thought to be "potentially highly pathogenic" (9).

Three of the studies that met our inclusion criteria were level 3B (Table 2). Lopez et al. in a prospective study found higher bacterial counts on neckties than on the front shirt pockets of 50 doctors (25 surgeons and 25 physicians) (10). *Staphylococcus aureus* was isolated from items of 16 doctors: 8 shirts (with counts ranging from 0 to 11) and 13 ties (with counts ranging from 0 to 86). Of the 50 participants, the majority of physicians had never cleaned their tie or could not remember when it was laundered last. Of those who could recall (14 of 50 doctors), the mean time was 73 days since cleaning their tie compared to less than two days for laundering their shirt (10). The NOS score assigned to

this study was 7/9, with a reasonable quality design. This paper fell short in reporting the adequacy of cohort follow up.

In a cross-sectional study (level 3B), Koh et al found that neckties worn by doctors were more likely to be contaminated compared with neckties worn by preclinical medical undergraduates who were not involved in patient care (11). Of the physician neckties, 26 of 50 were contaminated with *S.aureus* compared with 14 of 50 ties of preclinical medical students. Of those neckties positive for *S.aureus*, 16 physician neckties (62%) were identified as *MRSA* positive. None of the preclinical students' ties had *MRSA* and 10 of 14 *S. aureus* specimens on the medical student ties were presumably coagulase negative (reported 4 of 14 coagulase positive). The assigned NOS score was 7/9.

In a case control study (level 3B), Pisipati et al investigated the likelihood of contamination with important pathogenic bacteria (*MRSA*) of new neckties and pens given to four urological surgeons each week for five consecutive weeks (12). Similar to the previous papers discussed, only common environmental contaminants were found in their controlled study and no "important pathogenic bacteria" were cultured on the ties or pens. Similarly, the assigned NOS score was 7/9.

Weber et al found in their prospective experimental design (level 3B) that simulated patient encounters, wearing an unsecured tie was associated with more mannequins with bacterial contamination from physicians clothing compared with encounters where an unsecured tie was not worn (13). The assigned NOS score was 8/9.

In a cross sectional survey (level 4) with a study population of five neckties, growth of *coagulase negative staphylococcus* (CoNS) was reported from all five neckties of doctors in the ICU. Heavy growth was found in 2 of 5 neckties with CoNS, *S. citreus* on 3 of 5 ties with heavy growth on one and "*bacillus*" species on one tie (14). These organisms identified are not usually considered to be pathogenic in an immunocompetent patient.

Interpretation:

Healthcare-associated infections are associated with significant costs for patients and society. Any preventative measures to decrease their occurrence would result in significant decrease in patient morbidity and significant healthcare cost savings. Any identifiable factor that could be modified to lower the risk of HAI should be addressed. There is evidence that neckties worn by physicians are often contaminated with nonpathogenic bacteria commonly found on the skin and in the environment, as presumably is any worn article of clothing. There is very limited evidence that neckties may be contaminated more often with pathogenic (*MRSA*) bacteria, and very limited evidence that contaminated neckties may transmit bacteria in a controlled experimental setting (to a mannequin). Despite this, there is neither evidence that a healthcare professional who wears a necktie is responsible for increased rate of healthcare-associated infections nor that restricting healthcare professionals from wearing a necktie will decrease the rate of occurrence of such infections. One may infer from one study (Weber et al, level 3B study) that securing a necktie to avoid patient contact is advised,

but there is limited evidence that contact of a necktie with a patient will lead to infection. Future research is needed to look at whether neckties or other pendulous objects such as stethoscopes, lanyard and so forth transmit or lead to infection in patients. With the current evidence available, the likelihood that a necktie with any pathogen poses risk to a patient is neglible.

The UK bare below the elbow dress code policy has been openly questioned (15,16). The lack of evidence is apparent. For instance, studies have found no difference in bacterial colonization rates of hands between those observing the bare below the elbow policy and those who did not (17). Nonetheless, the policy was updated in 2010 with comparable recommendations (18). The updated policy similarly concluded it is considered poor practice to, "wear neckties/lanyards (other than bow-ties) during direct patient care activity. Ties have been shown to be contaminated by pathogens, and can accidentally come into contact with patients. They are rarely laundered and play no part in patient care." Evidence supporting the recommendation against wearing of a tie is once again not cited; instead it is referenced as 'common sense'.

Outbreak reports and observational studies looking at the dynamics of hand contamination have shown an association between patient care activities that involve direct patient contact and hand contamination (19). Regular hand washing has been shown to reduce hospital-acquired infections. Some studies have shown, removal of rings resulted in a decrease in frequency of hand carriage of pathogens before and after

performing hand hygiene (19, 20). However, in a prospective study of 93 physicians, Willis-Owen did not find a statistical difference in the number of colony forming units of bacteria or in the presence of clinically significant organisms found when comparing physicians who complied with the 'bare below the elbows' policy and those that did not (17). Other 'pendulous fomites' that are worn by physicians such as stethoscopes and identification badges have also been considered (22,23). Lanyards and identification badges can carry pathogenic bacteria such as MRSA, MSSA, Enterococcus species and gram-negative bacteria (23).

Although there is a lack of evidence confirming neckties are responsible for healthcare-associated infections, sensibility should prevail. The Society of Healthcare Epidemiology of America (SHEA) prudently recommends that rather than a ban on neckties, neckties should be secured by a lab coat or a tie-clip to prevent the tie from coming into contact with the patient (21). Similar logic should be applied to other 'pendulous fomites' that are worn by physicians such as stethoscopes and identification badges (22,23).

The symbolism behind health care apparel dates back to the early days of Florence Nightingale when she advocated for the use of nursing uniforms so nurses would appear more professional (21). Similarly, the necktie is an icon of male professionalism, and has been worn by male physicians for over 100 years. Other clothing such as the white coat has also been the most recognized symbol representing power and purity, dating back to the 19th century when Lister was developing his concept of aseptic surgery (24).

In essence, dress codes play an important role in nurturing the patient-physician relationship and instilling confidence in patients that they are receiving the highest quality care. Studies have shown patients (76.3%) prefer their physician be clothed in professional attire, i.e. shirt, necktie, and white coat for a male physician and tailored trouser or skirt with white coat for female physicians. Respondents' trust, confidence and willingness to share personal information were greater for a physician in professional attire (25). Hence, recommendations against wearing of a necktie are not without consequences.

One of the limitations of our study is that formal statistical analysis was not possible. The data available in the literature was heterogeneous and was evaluated qualitatively by validated methods versus quantitatively through meta-analysis. Secondly, our search set limits to literature published in English. However, none of the references cited in the 'bare below the elbow study' were in languages other than English and in general, exclusion of non-English articles has been found not to have a significant impact on the results of systematic reviews.

In summary, there is a lack of evidence to suggest that healthcare professionals wearing neckties contribute to a higher rate of healthcare-associated infections. The wearing of a necktie by a healthcare professional is a symbol evoking trust and confidence for a patient. Simple measures to avoid patient contact by the necktie seem prudent, but the available evidence does not support a nation-wide policy restricting their use. However, the data is sparse and a larger scale prospective study is required if concerns remain

regarding the wearing of neckties before implementing a nation-wide policy against their use in Canada.

Acknowledgement:
The authors acknowledge the contributions of Karen MacDonell from the College of Physicians and Surgeons of B.C. Medical Library.

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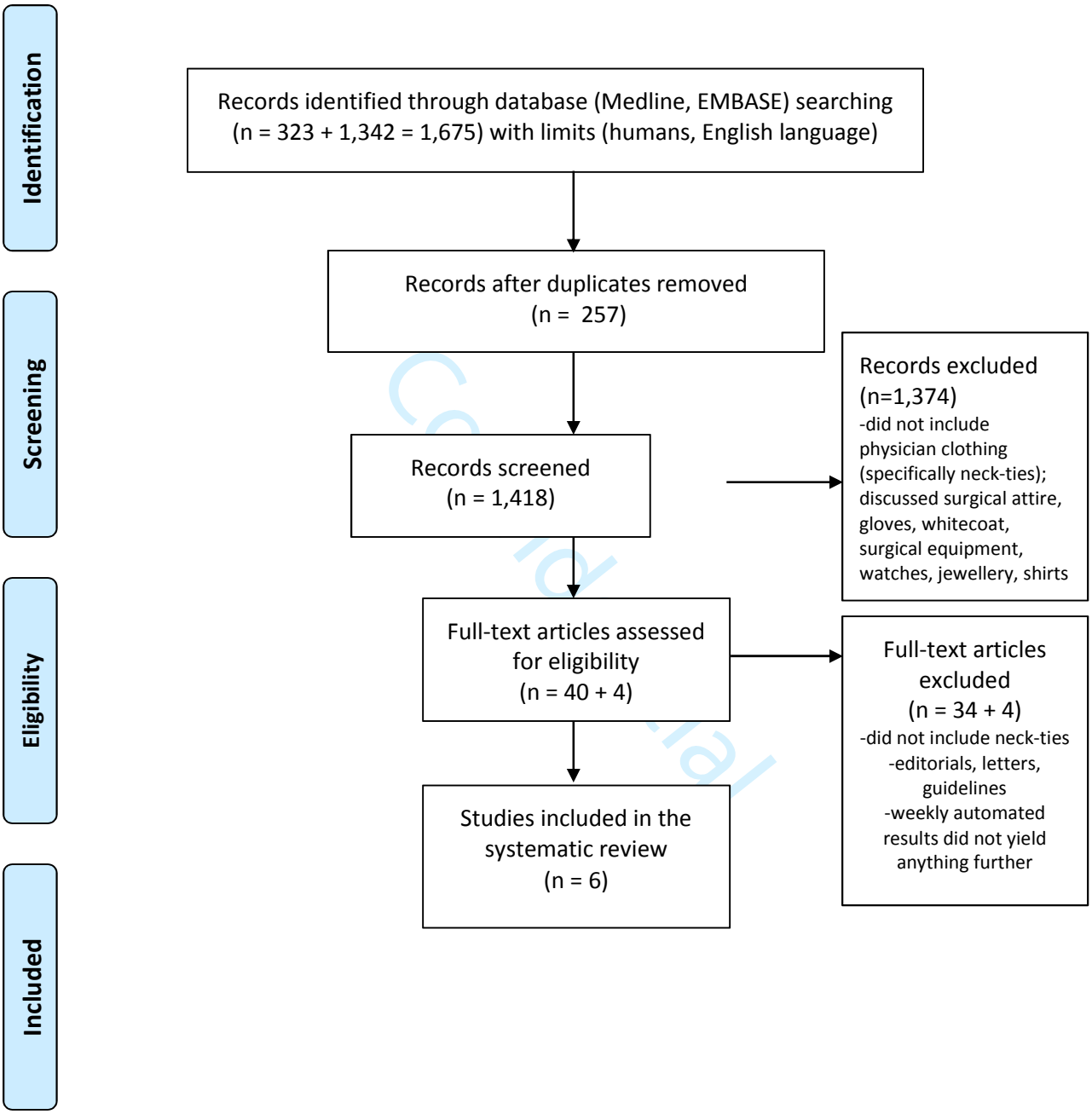
Appendix:

Search Strategy: (EMBASE 1974 to 2016 February 12)

#	Searches	Results
1	exp infection/	2830011
2	exp communicable disease/	18419
3	1 or 2	2830011
4	exp health care personnel/or exp physician/or (physician* or doctor or doctors).mp.	1445557
5	Exp clothing/ or (attire or necktie* or neck tie*).mp. (mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]	31434
6	(infect* or communicable*).mp. or 3 [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]	3356781
7	4 and 5 and 6	1817
8	Limit 7 to yr=”2014 – current”	259
9	Limit 8 to (human and English language)	254

Figure 1: Outcome of search strategy in Medline and EMBASE



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Table 1: The Oxford Center of Evidence Based Medicine – Levels of Evidence (italicized headings pertain to the current review).

Level of Evidence	**Study Design**
1 A	Systematic Review of RCT
1 B	*Randomized control trial*
1 C	*Case Series*
2 A	Systematic Review of cohort studies
2 B	*Individual cohort study (retrospective)*
2 C	Outcomes research/Ecological studies
3 A	Systematic Review of case control studies
3 B	*Individual case cohort study*
4	*Case Series and case control studies*
5	Expert Opinion

Table 2: Summary of the six papers included in the systematic review. The level of evidence is assessed using the Oxford Level of Evidence criteria. The Jadad scale and NOS scale are used to assess the quality of evidence.

Author	***Design***	***Level of Evidence***	***Comparison***	***Outcome***
Biljan et al., 1993 (9)	Multicenter randomized double blinded crossover trial, prospective design	1B Jadad = 3/5	Contamination of bowties vs. neckties in obs/gyne practice, N=15 Outpatient hospital	No difference in contamination by 3rd day onwards
Lopez et al., 2009 (10)	Cross sectional survey case control design	3B NOS = 7/9	Contamination of neckties vs. front shirt pocket in 25 surgeons and 25 physicians, N=50 Outpatient hospital	Higher bacterial counts on neckties than on shirts
Koh et al., 2009 (11)	Cross Sectional survey, case control design	3B NOS = 7/9	*MRSA* on neckties of medical staff vs preclinical medical students, N=100 Outpatient hospital	Higher rate on physicians neckties vs. medical students of *S.aureus* and *MRSA*
Pisipati et al., 2009 (12)	Case controlled study, prospective	3B NOS = 7/9	Compare bacterial growth on neckties and pens worn by surgeonss vs control, N=4 Outpatient hospital	Common environmental bacteria were found

Comment [JT1]: As requested, the references have been added adjacent to the authors.

Comment [JT2]: As per the editor's comment, #12 results, N for each study was included in the table.

Comment [JT3]: As requested by Dr.Schwandt comment #5 results, the setting of the research was listed according to what was described in the paper. It was divided into outpatient hospital setting type clinic versus inpatient setting which was the ICU in Dixon et al.

Weber et al., 2012 (13)	Case controlled study, prospective	3B NOS = 8/9	Compare the effect of sleeve length and wearing a necktie on the rate of transmission of bacteria from examiner to simulated patient (mannequin) Outpatient hospital	Wearing an unsecured tie results in greater transmission, but sleeve length did not affect transmission.
Dixon et al., 2000 (14)	Cross sectional survey Case series, no controls	4	Examine the type of bacteria on neckties of medical staff in the ICU, N=5 Inpatient hospital	5/5 CoNS 3/5 *S. citreus* 1/5 "*bacillus species*"

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	2, 5
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4,5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3,5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3,5-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3, 5-7, 17
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6,17
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6,7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6,7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6,7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6,7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6,7

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1,7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8,9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8,9, table 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	table 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8,9, table 2
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	10, 11
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	12
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	13
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	2,20

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097