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Faculty of Electronics, Telecommunications and Informatics

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SYSTEMATIC LITERATURE REVIEW – METHODS AND HINTS

Aleksadra Karpus, Agnieszka Landowska, Jakub Miler, Małgorzata Pykała

ABSTRACT

Report concerns performing Systematic Literature Reviews in technical domains of knowledge. There are multiple issues to address while starting to perform the review and meta-analysis, starting from formulating a research question and resulting keywords to the reporting activity. The report gathers selected lessons learned and might be a source of practical hints for performing the review.

Scope of the report:

- steps in systematic literature reviews;
- search engines and inclusion/exclusion criteria;
- PRISMA method for reporting SLR;
- a case study of systematic literature review in EMBOA project and lessons learned.

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1. Introduction

A systematic review is a way of gathering and summing up state-of-the-art in some domain of knowledge. The main goal is to identify and review the key available studies relevant to a particular topic of interest. Systematic review aims to perform the literature search and evaluation in a transparent, rigorous, and replicable way. There are three phases of a systematic review: planning the review, conducting the review and reporting the review.

Evaluation of the state-of-the-art in a particular topic is usually the first step in conducting a research study. In 2019 a project EMBOA on Affective loop in Socially Assistive Robotics as an intervention tool for children with autism was started. The project is executed by an interdisciplinary and international consortium of partners: Gdansk University of Technology, Poland; University of Hertfordshire, UK; Istanbul Teknik Universitesi, Turkey; Yeditepe University, Turkey; Macedonian Association for Applied Psychology, North Macedonia, and University of Augsburg, Germany.

The EMBOA project aims at the development of guidelines and practical evaluation of applying emotion recognition technologies in robot-supported intervention in children with autism. The EMBOA project goal is to confirm the possibility of the application (feasibility study), and in particular, we aim at the identification of the best practices and obstacles in using the combination of the technologies. What we hope to obtain is a novel approach for creating an affective loop in child-robot interaction that would enhance interventions regarding emotional intelligence building in children with autism. The lessons learned, summarized in the form of guidelines, might be used in higher education in all involved countries in robotics, computer science, and special pedagogy fields of study.

The EMBOA project combines three domains: autism therapy, social robots and automatic emotion recognition. As the project consortium is interdisciplinary and partners bring diverse backgrounds, the first step of the study was to perform a literature review. This report provides our lessons learned and might be of interest for other researchers.

The report is organized as follows: section 2 provides a general description to systematic literature review phases and steps. Section 3 provides notes on diverse search engines, that might be of use in decision making while choosing search engine, search keywords and fields. Section 4 provides a short introduction to PRISMA as a method of reporting systematic literature reviews. Section 5 provides a case study description. The case study is a systematic literature review performed under EMBOA project. Section with summary of findings follows.

2. Systematic Literature Review process steps

Systematic literature review is a methodological approach for capturing state-of-the-art in a specific domain of interest. The method is called systematic as the goal is not to find and browse through a couple of papers, but rather to find key studies and perform the review with a transparency and rigour, that would allow to replicate the literature study [1].

Systematic literature review might be defined as a sequence of the following steps.

1. Setting up a research question
2. Defining keywords and search string
3. Decisions on search engines, inclusion and exclusion criteria
4. Data extraction
5. Multiple-phase selection based on quality criteria and research question
6. Final selection of papers and snowballing technique

7. Extraction of the key findings
8. Reporting systematic review.

The steps are usually performed in sequence, however are sometimes performed iteratively, with back and forth loops, depending on the results of the step. For example, after performing data extraction, one frequently goes back to refining keywords in order to get more correct resulting list of papers. Refining search strings based on the extraction results is a frequent practice, especially when a large set of papers is extracted to narrow it down to a reasonable number.

A short description of the steps follows.

(1) Setting up a research question

This is the most important step of the process. The literature review might be performed for a couple of reasons. Among frequently expressed ones is" getting familiar with the discipline". If so, you don't need to perform a systematic review. General familiarisation with the discipline is better done by reading books, portals and review papers.

After getting familiar with the topic, one might find more specific questions regarding list of techniques used, list of variables under investigation, usage of specific solutions etc. One might also wonder whether some challenge was already solved in any way previously. For that purposes systematic literature review is a good tool to apply.

(2) Defining keywords and search string

After setting up the question, you should derive keywords from it. It should include the topic of interest (solution, technique, or challenge), but also words that help to narrow down the results to a certain domain. For example in a study that deals with electrodermal activity in humans, a shortcut EDA is frequently used, however while searching with EDA expression only, we get results from every field, that uses the same shortcut for something – for example, in this, case we get results from economy and physics.

The keywords are then translated into search strings, which are a combination of words and AND/OR operators. While doing so, think about the synonyms and alternative versions of the word, including not only nouns, but also adjectives or adverbs used in the domain.

For example, while studying autism, one might consider using search string:

autism OR autistic OR ASD OR ASC

where ASD stands for autism spectrum disorder and ASC stands for autism spectrum condition.

In search strings you might include expressions, instead of single words, but they need to go in parenthesis eg. "product owner".

(3) Decisions on search engines, inclusion and exclusion criteria

There are multiple databases that index papers and might be used for the purpose of systematic reviews. Among those used in computer science one might find: Elsevier Science Direct, SpringerLink, Web Of Science, Scopus, IEEEXplore, and ACM Digital Library. The databases usually store metadata describing each paper, including title, authors, publisher, date of publication, and sometimes even abstract and the keywords. The databases are usually combined with a search engine, that allows to perform search of the papers according to the keywords defined. Only few of the databases store and allow to search within the full text of the paper.

In order to perform a systematic review you must decide, which database (or databases) to use. According to the triangulation rule in research, it's advisable to use three of them, that cover a broad scope and do not overlap heavily. More information on the search engines is provided in Section 3 of this report. The section might help you with choosing the right database for your search.

One should also define inclusion and exclusion criteria – the rules that would allow you to choose among thousands of papers you might find. First of all you shall decide, whether you are interested in scientific papers only, or you also consider books, webpages, conferences or standards. If you focus on scientific sources only (so called "white literature"), you have the guarantee that the paper was at least reviewed by somebody before publication. Books and webpages, as well as unpublished technical reports and thesis (do called "grey literature") are the ones that have less credibility, and you will have to figure out yourself the value of specific source. However, there are some findings that appear in grey literature only or are described in detail there. Out of scientific papers you might choose between the search within journal papers only or include conference papers as well as between search in original papers only or review papers as well.

Another inclusion/exclusion criteria are years of publication. If the domain is relatively young, one might consider search in the last 5 or 10 years. While performing a second literature review on a certain topic, having one dated for example 7 years ago, you might consider only papers from the last 7 years, etc.

(4) Data extraction

After decisions are made, perform a technical part – simply retrieve the papers from the engines, combine and remove duplicates and then evaluate the outcome. If the outcome is too vast (thousands of papers) or too limited (only a few papers) consider refining search strings and inclusion/exclusion criteria.

(5) Multiple-phase selection based on quality criteria and research question

Once a list of papers is ready, you might start reviewing the papers. Usually at this stage you have a hundred or a few hundreds of papers and it's still hard to read them all. Selection of relevant papers out of the vast list might be based on screening by titles, screening by abstract, screening the whole paper. While screening by title and abstract you usually tag for relevance to your research question. You might consider creating additional quality criteria, such as paper length (e.g. exclude one-page and two-page communications), context of study (e.g. just studies in-the-wild), level of detail given (e.g. algorithms described), number of participants (e.g. experiments with 20+ participants), etc.

Tagging might be by a single person or by multiple taggers. A sample table with tagging is shown in Figure 1. The sample was taken from EMBOA project. After duplicates elimination we still had 700+ papers. First the papers were tagged for relevance by title only. We used the scale: 2(surely relevant) -1(maybe)-0(not relevant). Then sum of scores for 4 taggers was calculated and the papers scored 8 were taken to the next stage automatically, the papers scored less than 4 were excluded automatically, while papers scored 4-7 went under screening by abstract procedure. You might consider diverse scales for tagging, but this scale worked for us. Taggers should work independently, and 3 taggers are considered fair (triangulation rule). If tagged by 1 person only, some bias should be encountered. Therefore for a master thesis tagging by 1 person is OK, however for more valid result, consider multiple taggers. In order to evaluate if your number of taggers is enough, you might consider to calculate inter-rater consistency.

			By Title					By abstract Please annotate by abstract only those with no color in S column					
Document	Title	Abstract	Sum by title	Tagger 1	Tagger 2	Tagger 3	Tagger 4	Sum (abstract)	Tagger 1	Tagger 2	Tagger 3	Tagger 4	Comment
Article	Deep interaction: Wearable robot-assisted emotion communication for enhancing perception and expression ability of children with Autism Spectrum Disorders	Recent changes in both	8	2	2	2	2						
Article	Non-sequential Learning in a Robotics Class: Insights from the Engagement of a Child with Autism Spectrum Disorder	This case study focused	4	1	1	1	1	0	0	0	0	0	
Article	Robot Enhanced Therapy for Autistic Children: An Ethical Analysis	The use of social robots	5	1	2	1	1	3	1	1	0	1	
Article	Personalized Robot Interventions for Autistic Children: An Automated Methodology for Attention Assessment	We propose a robot-me	4	1	1	1	1	4	1	1	1	1	
Article	Influence of Reaction Time in the Emotional Response of a Companion Robot to a Child's Aggressive Interaction	The quality of a compar	7	1	2	2	2	2	1	1	0	0	
Review	Humanoid Robots as Teachers and a Proposed Code of Practice	This article will discrimir	4	1	1	1	1	0	0	0	0	0	
Article	Robot-Assisted Autism Spectrum Disorder Diagnostic Based on Artificial Reasoning	Autism spectrum disord	5	1	1	1	2	3	1	1	1	0	
Article	Socio-emotional development in high functioning children with Autism Spectrum Disorders using a humanoid robot	The use of robots had a	6	2	1	1	2	8	2	2	2	2	
Conference	Modules of Interaction for ASD Children Using Rero Robot (Humanoid)	Autism Spectrum Disorc	2	1	0	0	1	0					
Conference	Design of a Robotic Crib Mobile to Support Studies in the Early Detection of Cerebral Palsy: A Pilot Study	According to data from	0	0	0	0	0	0					
Article	Are preconceptional stressful experiences crucial elements for the aetiology of autism spectrum disorder? Insights from an animal model	Autism spectrum disord	3	0	1	1	1	0					
Article	Shell and body of cat character robot for early intervention to treat children with autism spectrum disorders	Despite consistent incre	2	0	1	1	0	0					
Conference	Head design and optimization of an emotionally interactive robot for the treatment of autism	Emotionally interactive	4	1	1	1	1	4	1	1	1	1	
Review	Leveraging Robotics Research for Children with Autism: A Review	Robotics research in hel	4	1	1	1	1	3	1	1	0	1	
Letter	Teaching Robotics Coding to a Student with ASD and Severe Problem Behavior	Research on teaching ST	1	0	0	0	1	0					
Article	A proposal to act on theory of mind by applying robotics and virtual worlds with children with ASD	The article proposes an	2	1	0	0	1	0					
Article	Concordance between physiological arousal and emotion expression during fear in young children with autism spectrum disorders	This study aimed to mea	5	0	2	1	2	8	2	2	2	2	
Conference	Facial expression detection employing a brain computer interface	Facial tracking has been	2	1	0	0	1	0					
Article	Living and Robotic Dogs as Elicitors of Social Communication Behavior and Regulated Emotional Responding in Individuals with Autism and Severe Language Delay: A Preliminary Comparative Study	The inclusion of animals	6	0	2	2	2	8	2	2	2	2	ok if we consider

Figure 1. Sample tagging by title and by abstract in systematic literature review

In our study we have used Google spreadsheet, however reference management tools might be considered an alternative tool for this process.

(6) Final selection of papers and snowballing technique

After tagging, you get a list of papers to read, usually of a size of tens. While reading papers, you might exclude them as well, if they are not relevant. It happens, that when you read papers, one article cites another one, that also seems to be relevant, although is not on your list. Include them. This is called a "snowballing" technique, as if you continue the process with other papers, you might end up with a quite extensive list.

(7) Extraction of the key findings

Once your papers coming both from tagging process and snowballing are ready and read, it's time to sum up the results and identify the key findings. Refer to your research questions to know, what to describe. Consider adding numbers e.g. term "a" is used in 45% of papers, 70% of the studies involve less than 10 participants, etc.

(8) Reporting systematic review

There is a standard-de-facto for reporting a systematic review called PRISMA [2] and as the approach it proposes is systematic, we recommend using this one. PRISMA is described in more detail in section 4.

3. Databases and search engines

Systematic literature review is usually performed with well-known scientific databases. In technical sciences, the most common ones are: ACM Digital Library, Elsevier Science Direct, IEEE Explore, Scopus, Springer Link and Web of Science. Each database has its own search engine which leads to some problems and difficulties while performing SLR.

First of all, each database has its own set of search fields. Since the SLR should consist of the same query performed on different databases, one has to decide which search fields should be used. All considered databases allow to search based on title of scientific paper and all defined fields. The problem starts when we want to search papers based on keywords or abstract. Some of the databases, e.g. IEEE Explore or Scopus, support such search fields. Other (like Elsevier Science Direct or Web of Science) define new field „topic" which is a combination of three fields, i.e. title, keywords and abstract. Table 1 summarizes considered databases and search fields that they support. Of course, there are other search fields like „author" or „grant institution" and many more. However, we found them irrelevant while performing SLR.

Table 1. Search fields supported by search engines for scientific databases.

Database	All fields	Title	Topic	Keywords	Abstract
ACM Digital Library	x	x		x	x
Elsevier Science Direct	x	x	x		
IEEE Explore	x	x		x	x
Scopus	x	x	x	x	x
Springer Link	x	x			
Web of Science	x	x	x		

It is very important to execute the same query on all considered databases while performing SLR. However, the query format depends on a search engine. The common thing is that all search engines use logical operators for building queries. In most databases three basic operators are available, i.e. AND, OR and NOT. An exception is Scopus database which uses AND NOT instead of NOT. Some of them implement other operators. Only two of six considered databases (i.e. ACM Digital Library and Elsevier Science Direct) do not allow to use wildcard characters to simplify a query. And only two search engines, i.e. Scopus and Springer Link, support automatic inflection, so we do not have to use OR operator or wildcard characters for plurals etc. This information is summarized in Table 2.

There are also other inconsistencies in a query format between different scientific databases. For example, in IEEE Explore there is a need for repeating the name of a search field before each search term, e.g.

```
„("Document Title":emotion OR "Document Title":mood OR "Document
Title":affect OR "Document Title":expression) AND ("Document
Title":children OR "Document Title":child OR "Document Title":young) AND
("Document Title":autism OR "Document Title":ASD OR "Document Title":ASC
OR "Document Title":autistic)"
```

Very strict restriction exists in Elsevier Science Direct. This database allows usage of only 8 logical operators in one query.

Table 2. Query formats in different search engines.

Database	Wildcard characters support	Logical operators	Automatic inflection
ACM Digital Library		AND, OR, NOT	
Elsevier Science Direct		AND, OR, NOT *	
IEEE Explore	x	AND, OR, NOT	
Scopus	x	AND, OR, AND NOT, PRE/, W/	x
Springer Link	x	AND, OR, NOT, NEAR, ONEAR	x
Web of Science	x	AND, OR, NOT, SAME, NEAR	

* maximum number of 8 operators per query is allowed

Another difficulty during the SLR is that search engines use different filters or implement them in a different way. The first example is „year" filter. It is present in each considered scientific database. However, in ACM Digital Library it is defined as all years since selected, while in other databases it is a specific range of years (or even one year if needed). Another important for SLR example is „publication type". In most of the databases it takes values like „article" or „proceedings/conference paper". However, in Elsevier Science Direct it takes values like „research paper" or „review paper" and in ACM Digital Library there is no publication type filter at all. Moreover, in Springer Link and Elsevier Science Direct it can be used after results of query are returned while in other three databases it has to be defined during the definition of a query.

Scientific databases support many different options for export of the query results, such as Bibtex, EndNote, or Mendeley. However, for SLR purposes the best option is export to *csv* format to be able to perform integration and further analysis on the data. From all considered databases only Elsevier Science Direct does not support export to such file format. Still, one can obtain csv file by exporting results to plain text format and performing tricky *find and replace* in good text editor. But this task is very time-consuming.

Other five databases allow export to *csv*. Nonetheless, we cannot expect that the resulting file will have the same form. As a matter of fact, they differ significantly in a number and name of columns. For example, ACM Digital Library does not attach abstract into results file and Web of Science defines different naming convention for columns (some more important ones are explained in Table 3). Web of Science has additional constraint which is not present in other databases, i.e. it allows to export only 500 records at one time. The problem with exporting records is also present in IEEE Explore. For an unknown reason, an export option sometimes omits some records. Repeating export could help to fix the issue.

Table 3. Most important columns from Web of Science database (WoS) and their common names.

WoS name	Common name	WoS name	Common name
AU	Author	PI	Publisher City
TI	Title	SN	ISSN
SO	Publication Name	BN	ISBN
SE	Series	JI	Journal Name
DT	Document Type	PY	Publication Year
DE	Keywords	VL	Volume
AB	Abstract	IS	Issue
PU	Publisher	DI	DOI

4. Reporting SLR - PRISMA

The aim of this chapter is to provide the reader with all the most needed information for the creators of Systematic Literature Reviews who want to use PRISMA. The content of the fourth chapter is a collection of fragments from the sources on PRISMA [2]. As a result the chapter has a condensed form, so that the reader can easily and quickly find the information he needs without having to use several sources and analyze them. However, he can always use the sources indicated for more information if he considers it necessary.

What is PRISMA?

PRISMA is an evidence-based minimum set of **P**referred **R**eporting **I**tems for reporting in **S**ystematic Reviews and **M**eta-**A**nalyses. PRISMA focuses on the reporting of reviews evaluating randomized trials, but can also be used as a basis for reporting systematic reviews of other types of research. The aim of **the PRISMA statement** is to help authors improve the reporting of systematic reviews and meta-analyses. It may also be useful for critical appraisal of published systematic reviews [2].

The PRISMA Statement

The PRISMA Statement consists of a **checklist** and a **flow diagram**. Each can be found at the end of this chapter and on the PRISMA website.

The checklist

The checklist consists of 27 items, which are contained in seven sections, such as: title, abstract, introduction, methods, results, discussion and funding. Summary of checklist items is included in the Table 4. Table with examples and explanations, the meaning and rationale for each checklist item is provided as Appendix to this report.

PRISMA authors strongly recommend that the checklist be used in conjunction with the PRISMA Explanation and Elaboration Document [2]. More information might be found in PRISMA documentation [4], [5], [6].

The flow diagram

The flow diagram depicts the flow of information through the four phases of a systematic review, such as: identification, screening, eligibility and included. It maps out the number of records identified, included and excluded, and the reasons for exclusions [2]. Scheme for PRISMA flow diagram is provided in Figure 2.

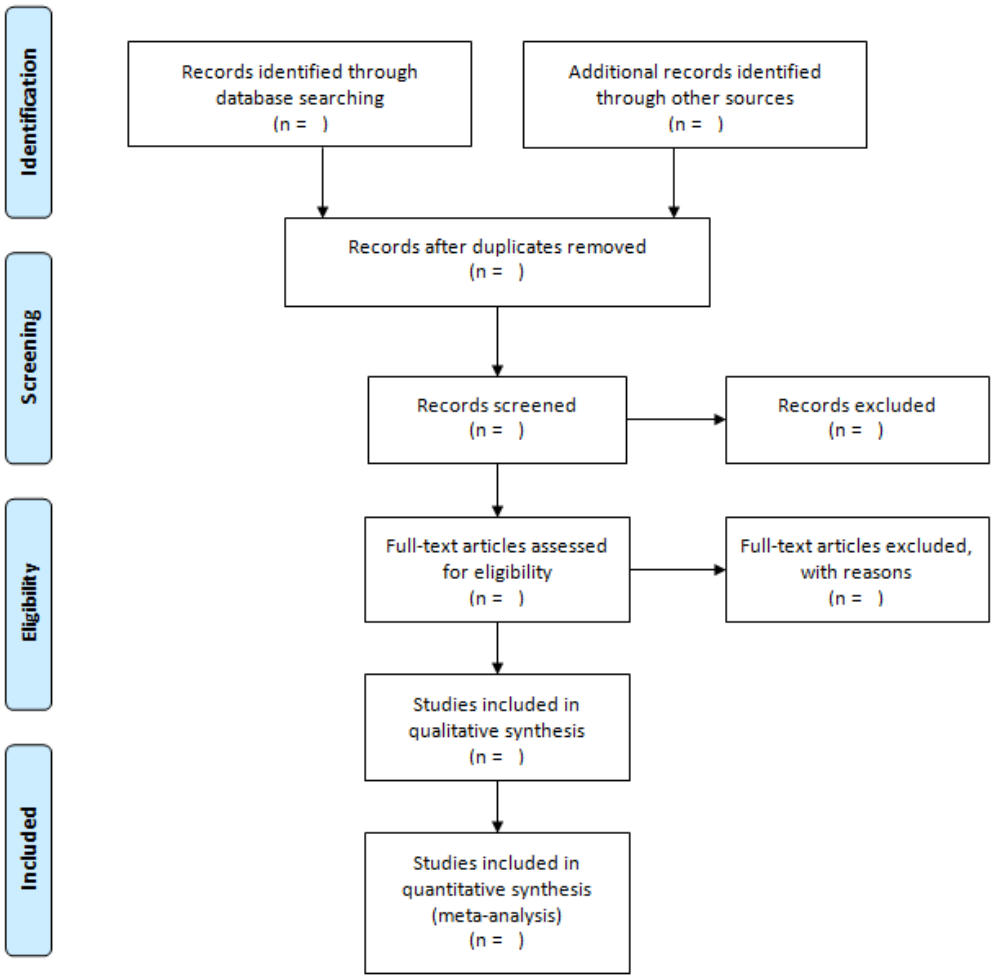


Figure 2. Template for PRISMA flow diagram [4]

Extensions

Several extensions of the PRISMA Statement have been developed to facilitate the reporting of different types or aspects of systematic reviews:

PRISMA for Abstracts - the 12-item checklist,

PRISMA Equity – the guidance for reporting equity-focused systematic reviews in order to help reviewers identify, extract, and synthesize evidence on equity in systematic reviews,

PRISMA Harms - the checklist containing four extension items that must be used in any systematic review addressing harms, irrespective of whether harms are analysed alone or in association with benefits,

PRISMA Individual Patient Data – the guidelines for reporting systematic reviews and meta-analyses of IPD,

PRISMA for Network Meta-Analyses – the guidance for reporting systematic reviews comparing multiple treatments using direct and indirect evidence in network meta-analyses,

PRISMA for Protocols – the checklist to facilitate the development and reporting of systematic review protocols.

PRISMA for Diagnostic Test Accuracy - the 27-item PRISMA diagnostic test accuracy checklist provides specific guidance for reporting of systematic reviews.

PRISMA for Scoping Reviews - the checklist contains 20 essential reporting items and 2 optional items to include when completing a scoping review.

PRISMA for Acupuncture - the checklist including five new sub-items (including sub items) and six modified items to be used when conducting systematic reviews of acupuncture interventions [2].

All of the extensions are available on the PRISMA website [2].

Citing and Using PRISMA

When referring to the PRISMA, it is recommended using journal article citations rather than referring to the PRISMA website.

Table 4. PRISMA checklist items

Section	Item	Description
TITLE	**Title**	1. Identify the report as a systematic review, meta-analysis, or both.
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.
INTRODUCTION	**Rationale**	3. Describe the rationale for the review in the context of what is already known.
	Objectives	4. Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).
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.
	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.

	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.
	Search	8. Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.
	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).
	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.
	Data items	11. List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.
	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.
	Summary measures	13. State the principal summary measures (e.g., risk ratio, difference in means).
	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.
	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).
	Additional analyses	16. Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.
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.
	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.
	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).
	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.
	Synthesis of results	21. Present the main results of the review. If meta-analyses are done, include for each, confidence intervals and measures of consistency
	Risk of bias across studies	22. Present results of any assessment of risk of bias across studies (see Item 15).
	Additional analysis	23. Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).

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).
	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).
	Conclusions	26. Provide a general interpretation of the results in the context of other evidence, and implications for future research.
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.

To see explanations of the checklist items, take a look at the appendix.

5. Case study

We performed SLR on emotion recognition in children with autism. According to guidelines proposed by Kitchenham et al. [1], we started with defining research questions. We tried to be as much general as possible and consider all aspects, technical as well as psychological, related to emotion recognition in children with autism. We finished up with four research questions, and summary of the SLR scheme is provided in Table 5, followed by a more detailed explanation.

Table 5. Summary of SLR step-by-step

Step	Results
1. Setting up a research question	RQ1: What emotions are recognizable in children with autism? RQ2: Which techniques are used in emotion recognition in children with autism? RQ3: Which channels are used in emotion recognition in children with autism? RQ4: What techniques (synchronisation, late/early fusion) are used for multimodal recognition?
2. Defining keywords and search string	emotion; affective; emotional; mood; affect; expression; children; child; young; autism; ASD; autism spectrum disorder; autism spectrum; ASC; autism spectrum condition; autistic; pervasive disorder
3. Decisions on search engines, inclusion and exclusion criteria	ACM Digital Library, Elsevier Sciecne direct, IEEE Explore, Scopus, SpringerLink, Web of Science, PubMed Inclusion criteria: all years, conference papers and reviewed journal papers, papers that focus on automatic emotion recognition, papers that report trials with at least 1 child Exclusion citeria: short communications (1- or 2-page long), theoretical papers
4. Data extraction	All seven databases, by title only, resulted in 1565 papers (637 after removal of duplicates)
5. Multiple-phase selection based on quality criteria and	Manual tagging by 4 independent taggers. Scale: 2 (relevant) -1(not sure) -0(not relevant)

	research question	Papers with total score 8: 29 Papers with total score 7: 39 Papers with total score 6: 36 Papers with total score 5: 89 Papers with total score 4: 135 Papers with total score 3: 60 Papers with total score 2: 43 Papers with total score 1: 47 Papers with total score 0: 158 Qualified to reading after title/abstract tagging: 69.
6.	Final selection of papers and snowballing technique	11 additional papers came from snowballing technique 69+11=80 papers to read 36 qualified for detailed analysis and reporting
7.	Extraction of the key findings	For each paper we tag: - number of children in the study (with ASD or typically developing), - wording about children (using expression "child with autism" vs "autistic child"), - emotion recognized, - modalities used for emotion recognition, - techniques used for emotion recognition. We also note challenges/recommendations or other relevant observations.
8.	Reporting systematic review	Apart from this technical report a publication following PRISMA statement is planned.

The final search query looks as follows:

```
(emotion OR affective OR emotional OR mood OR affect OR expression)
AND (children OR child OR young)AND (autism OR ASD OR ASC OR autistic OR
"pervasive disorder")
```

We decided to use seven scientific databases: ACM Digital Library, Elsevier Sciecne direct, IEEE Explore, Scopus, SpringerLink, Web of Science, PubMed.
First six ones are the most popular scientific databases in technical sciences and they were describe in Section 3. The last one is important for scientists in medical and psychological domains and we decided to include it.

In Section 3 we described constraints which different scientific databases have for a query format. Thus, we had to slightly modify our search query to fit these requirements. For IEEE Explore we had to add the field name to each keyword. The query for a title of a scientific paper is shown below.

```
("Document Title":emotion OR "Document Title":affective OR "Document
Title":emotional OR "Document Title":mood OR "Document Title":affect OR
"Document Title":expression)

AND ("Document Title":children OR "Document Title":child OR "Document
Title":young)
```

```
AND ("Document Title":autism OR "Document Title":ASD OR "Document
Title":ASC OR "Document Title":autistic OR ("Document Title":pervasive
AND "Document Title":disorder))
```

Elsevier Science Direct allows usage of only eight logical operators at one time. Our search query contains fourteen ones. Therefore, we decided to split our query to six queries based on the first parenthesis and merge their results at the end of the searching process.

According to Kitchenham, we sholud define inclusion and exlusion criteria. Thus, we limited our search only to original research and review papers written in English and published in journals or conference proceedings. For those databeses where no language filter was available, papers written in other languages will be excluded in the further phase of SLR.

Because we receive thousands of records while considering *all fields* in the databases, we decided to test also *title* and *topic/keywords*. Number of obtained results for each database and search field is presented in Table 6. For Elsevier Science Direct we present two numbers for the title field. The one in parenthesis is the sum of number of results for all six queries which arise after splitting the original one. The other one is the number of records after removing duplicates.

Table 6. Number of obtained results for each database and search field.

		Search field			
		All fields	Keywords	Topic	Title
Database	ACM Digital Library	126	8	na	21
	Elsevier Science Direct	71860	1278	-	96 (106)
	IEEE Explore	272	5	na	44
	Scopus	92484	3960	-	561
	Springer Link	46086	na	Na	0
	Web of Science	10615	na	8395	509
	PubMed	6999	na	3349	324
	Total	228442	16995		1555 (1565)

Finally, we decided to use the title field, because 1555 records are feasible to analyze in contradiction to ten times more results or even more.

After collecting results from different databases, we unified the file format and merge all records to remove duplicates and perform initial analysis. Papers were evaluated for their title (and keywords, in case of doubts) relevance to research questions by four persons. The relevance was measured on the three-points scale: 0 – irrelevant, 1 – somehow relevant, 2 – strongly relevant. Papers with total rank equal or greater than 7 were classified to the next phase of SLR. Results from this phase of SLR are presented in Table 7 and depicted in Figure 3.

Table 7. Results of initial paper retrieval

Number of all received records	1565
Number of papers without duplicates	637
Number of records without DOI	45
Number of records without abstract	27

There was a significant amount of duplicates (59% of papers found). We had some discussion whether to include papers without DOI, which is a minimal standard for journals and conference proceedings nowadays. We decided not to exclude them before tagging. After tagging only one paper without DOI went to the next stage. However, this was the one which we could not find access to. It was not the problem of paid access, we also tried to find it vie ResearchGate, but no available version was found, paid or not. In future studies we recommend removal of papers without DOI.

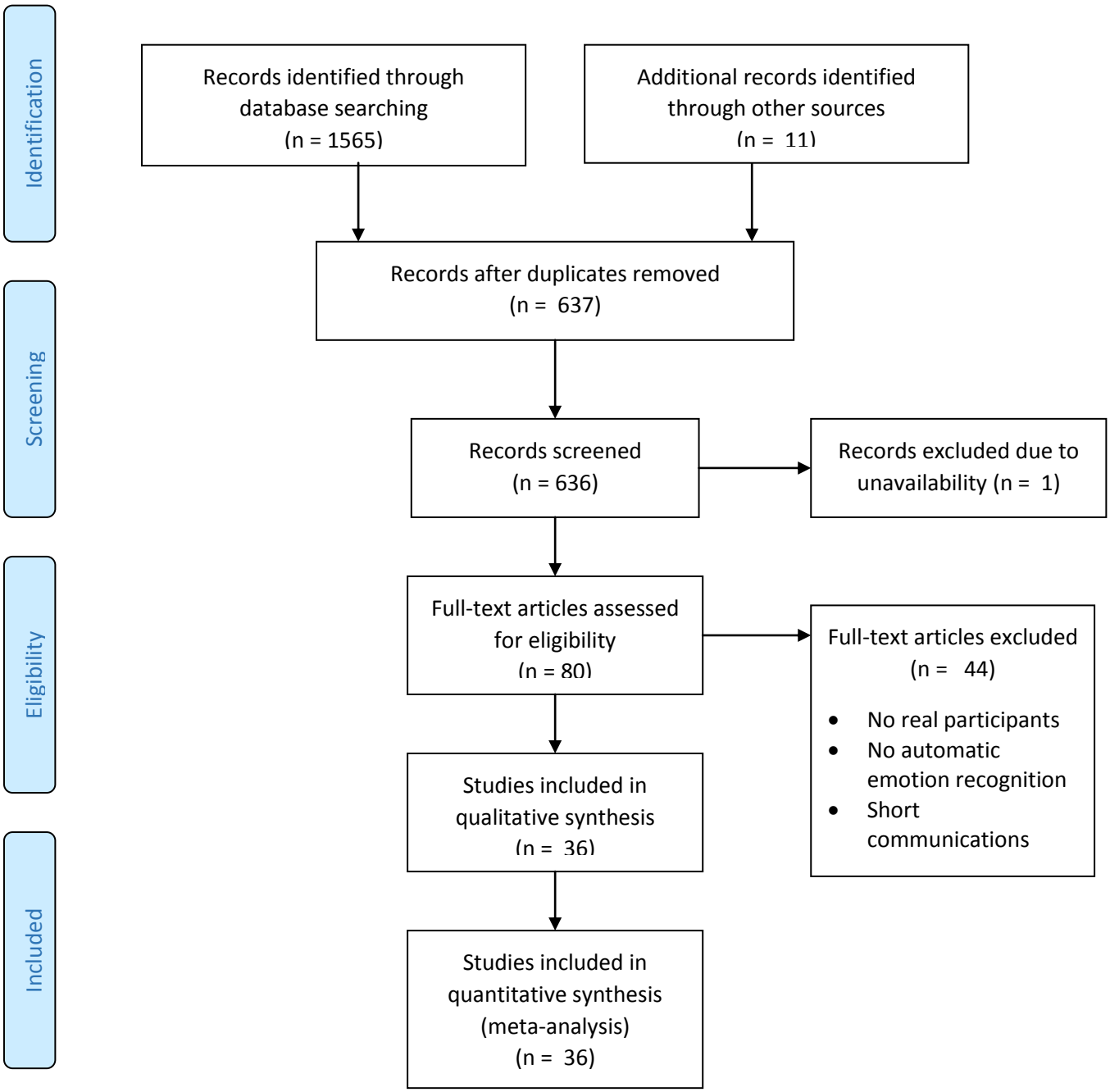
Using 7 databases for literature search allowed us also to compare the number of papers duplicated between pairs of them. The results are shown in table 8.

Table 8. Number of duplicates between databases/search engines

		Database						
		ACM	Elsevier	IEEE	Scopus	Springer	Web of Science	PubMed
Database	ACM	**21**	0	2	14	0	4	0
	Elsevier	0	**96**	0	91	0	91	38
	IEEE	2	0	**44**	41	0	33	2
	Scopus	14	91	41	**536**	0	439	277
	Springer	0	0	0	0	**0**	0	0
	Web of Science	4	91	33	439	0	**507**	271
	PubMed	0	38	2	277	0	271	**307**
Unique in that database only		**7**	**4**	**3**	**60**	**0**	**53**	**18**

Please note, that we haven't found papers by title in Springer. Searching with all fields provided an extensive number of 46086 papers. After duplicates removal we have found that the list includes 133 papers from the Springer provider, although they were not directly found in Springer Link search engine.

Figure 3. PRISMA flow diagram for the systematic review (case study)



6. Conclusions

This report summarizes the lessons learned regarding performing systematic literature reviews. It is intended to be an introduction to performing systematic reviews. Our toolkit and recommendations are made according to our best knowledge, but please keep in mind, that there might be other tools and recommendations which might suit you better.

Having said this, please feel free to use our recommendation in you work, as the aim is always the same - transparency and reproducibility of research. You have succeeded in your systematic review, not only of you have found (some) answers to your research questions. Another criteria is that your study was comprehensive and free of possible bias. In order to evaluate this, a reviewer or a reader must find a transparent and easy to follow pattern in procedure and reporting of results.

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Appendix. PRISMA checklist with excerpt of explanations

Section	Item	Description
TITLE	**Title**	**1. Identify the report as a systematic review, meta-analysis, or both.** Explanation: Authors should identify their report as a systematic review or meta-analysis. Terms such as "review" or "overview" do not describe for readers whether the review was systematic or whether a meta-analysis was performed [4].
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.** Explanation: The abstract should present a balanced and realistic assessment of the review's findings that mirrors, albeit briefly, the main text of the report. Structured abstracts give readers more complete information and facilitate finding information more easily than unstructured abstracts. Proposal of abstract structure: *Background* - context for readers and explanation the importance of the review question; *Objectives* - primary objective of the review; *Data Sources* - searched sources, any language or publication type restrictions, and the start and end dates of searches; *Study Selection* - inclusion criteria; *Data Extraction Methods* - how many people did extraction of articles, what appraisal methods used during data abstraction and what methods used to integrate or summarize the data; *Data Synthesis* - the main results of the review are reported. If the review includes meta-analyses, authors should provide numerical results with confidence intervals for the most important outcomes. Ideally, they should specify the amount of evidence in these analyses (numbers of studies and numbers of participants). *Limitations* - the most important weaknesses of included studies as well as limitations of the review process. *Conclusions* - clear and balanced Conclusions that are closely linked to the objective and findings of the review [4].
INTRODUCTION	**Rationale**	**3. Describe the rationale for the review in the context of what is already known.** Explanation: Readers need to understand the rationale behind the study and what the systematic review may add to what is already known. Authors should tell readers whether their report is a new systematic review or an update of an existing one. If the review is an update, authors should state reasons for the update, including what has been added to the evidence base since the previous version of the review [4].
	Objectives	**4. Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).** Explanation: The questions should be stated precisely and explicitly so that readers can understand quickly the review's scope and the potential applicability of the review to their interests. Framing questions so that they include the following five "PICOS" components may improve the explicitness of review questions: P - the patient population or disease being addressed, I - the interventions or exposure of interest, C - the comparators, O - the main outcome or endpoint of interest, S - the study designs chosen [4].

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.** Explanation: A protocol is important because it pre-specifies the objectives and methods of the systematic review. Having a protocol can help restrict the likelihood of biased post hoc decisions in review methods, such as selective outcome reporting. Authors may modify protocols during the research. Legitimate modifications may extend the period of searches to include older or newer studies, broaden eligibility criteria that proved too narrow, or add analyses if the primary analyses suggest that additional ones are warranted. Authors should, however, describe the modifications and explain their rationale. Although worthwhile protocol amendments are common, one must consider the effects that protocol modifications may have on the results of a systematic review, especially if the primary outcome is changed [4].
	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.** Explanation: Carefully defined eligibility criteria inform various steps of the review methodology. They influence the development of the search strategy and serve to ensure that studies are selected in a systematic and unbiased manner. The eligibility criteria are divided into two components: study characteristics and report characteristics. Study eligibility criteria are likely to include the populations, interventions, comparators, outcomes, and study designs of interest as well as other study-specific elements, such as specifying a minimum length of follow-up. Report eligibility criteria are likely to include language of publication, publication status (e.g., inclusion of unpublished material and abstracts), and year of publication. Inclusion or not of non-English language literature, unpublished data, or older data can influence the effect estimates in meta-analyses [4].
	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.** Explanation: At a minimum, for each database searched, authors should report the database, platform, or provider and the start and end dates for the search of each database. Authors should also report who developed and conducted the search. In addition to searching databases, authors should report the use of supplementary approaches to identify studies, such as hand searching of journals, checking reference lists, searching trials registries or regulatory agency Web sites, contacting manufacturers, or contacting authors. Authors should also report if they attempted to acquire any missing information (e.g., on study methods or results) from investigators or sponsors; it is useful to describe briefly who was contacted and what unpublished information was obtained [4].
	Search	**8. Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.** Explanation: You should report full electronic search strategy for at least one major database. As an alternative to presenting search strategies for all databases, authors could indicate how the search took into account other databases searched, as index terms vary across databases. Authors should be straightforward in describing their search constraints. Apart from the keywords used to identify or exclude records, they should report any additional limitations relevant to the search, such as language and date restrictions [4].

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).** Explanation: Authors should report how they screened the retrieved records (typically a title and abstract), how often it was necessary to review the full text publication, and if any types of record (e.g., letters to the editor) were excluded. Efforts to enhance objectivity and avoid mistakes in study selection are important. Thus authors should report whether each stage was carried out by one or several people, who these people were, and, whenever multiple independent investigators performed the selection, what the process was for resolving disagreements. The use of at least two investigators may reduce the possibility of rejecting relevant reports. The benefit may be greatest for topics where selection or rejection of an article requires difficult judgments. For these topics, authors should ideally tell readers the level of inter-rater agreement, how commonly arbitration about selection was required, and what efforts were made to resolve disagreements (e.g., by contact with the authors of the original studies) [4].
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.** Explanation: Reviewers extract information from each included study so that they can critique, present, and summarize evidence in a systematic review. They might also contact authors of included studies for information that has not been, or is unclearly, reported. Some systematic reviewers use a data extraction form that could be reported as an appendix or "Web extra" to their report. These forms could show the reader what information reviewers sought and how they extracted it. Authors could tell readers if the form was piloted. Regardless, authors should tell readers who extracted what data, whether any extractions were completed in duplicate, and, if so, whether duplicate abstraction was done independently and how disagreements were resolved. Published reports of the included studies may not provide all the information required for the review. Reviewers should describe any actions they took to seek additional information from the original researchers. The description might include how they attempted to contact researchers, what they asked for, and their success in obtaining the necessary information. Authors should also tell readers when individual patient data were sought from the original researchers and indicate the studies for which such data were used in the analyses. The reviewers ideally should also state whether they confirmed the accuracy of the information included in their review with the original researchers, for example, by sending them a copy of the draft review. Some studies are published more than once. Duplicate publications may be difficult to ascertain, and their inclusion may introduce bias. We advise authors to describe any steps they used to avoid double counting and piece together data from multiple reports of the same study (e.g., juxtaposing author names, treatment comparisons, sample sizes, or outcomes). Authors ideally should present any algorithm that they used to select data from overlapping reports and any efforts they used to solve logical inconsistencies across reports [4].
Data items	**11. List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.** Explanation: It is important for readers to know what information review authors sought, even if some of this information was not available. If the review is limited to reporting only those variables that were obtained, rather than those that were deemed important but could not be obtained, authors should refer readers to the protocol, and archive their extraction forms, including definitions of variables. The published systematic review should include a description of the processes used with, if relevant, specification of how readers can get access to additional

	materials. Authors should report whether some variables were added after the review started. Authors should report any assumptions they made about missing or unclear information and to explain those processes. For example, in studies of women aged 50 or older it is reasonable to assume that none were pregnant, even if this is not reported [4].
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.** Explanation: It is important for authors to describe any methods that they used to gauge the risk of bias in the included studies and how that information was used. Additionally, authors should provide a rationale if no assessment of risk of bias was undertaken. Authors should specify the methodological components that they assessed. The ultimate decision regarding which methodological features to evaluate requires consideration of the strength of the empiric data, theoretical rationale, and the unique circumstances of the included studies. Authors should report how they assessed risk of bias; whether it was in a blind manner; and if assessments were completed by more than one person, and if so, whether they were completed independently. Finally, authors need to report how their assessments of risk of bias are used subsequently in the data synthesis. If authors exclude studies from the review or any subsequent analyses on the basis of the risk of bias, they should tell readers which studies they excluded and explain the reasons for those exclusions. Authors should also describe any planned sensitivity or subgroup analyses related to bias assessments [4].
Summary measures	**13. State the principal summary measures (e.g., risk ratio, difference in means).** Explanation: When planning a systematic review, it is generally desirable that authors pre-specify the outcomes of primary interest as well as the intended summary effect measure for each outcome. If possible the choice of effect measures should be explained. For binary outcomes, the most common summary measures are the risk ratio, odds ratio, and risk difference. For continuous outcomes, the natural effect measure is the difference in means. For time-to-event outcomes, the hazard ratio is the most common summary measure. Reviewers need the log hazard ratio and its standard error for a study to be included in a meta-analysis [4].
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.** Explanation: The data extracted from the studies in the review may need some transformation (processing) before they are suitable for analysis or for presentation in an evidence table. When meta-analysis is done, authors should specify the effect measure (e.g., relative risk or mean difference), the statistical method (e.g., inverse variance), and whether a fixed- or random-effects approach, or some other method (e.g., Bayesian) was used. If possible, authors should explain the reasons for those choices [4].
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).** Explanation: Reviewers should explore the possibility that the available data are biased. They may examine results from the available studies for clues that suggest there may be missing studies (publication bias) or missing data from the included studies (selective reporting bias) [4].

	Additional analyses	**16. Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.** Explanation: Authors may perform additional analyses to help understand whether the results of their review are robust, all of which should be reported. Such analyses include sensitivity analysis, subgroup analysis, and meta-regression. It is important to inform readers whether these analyses were performed, their rationale, and which were pre-specified [4].
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.** Explanation: Authors should report, ideally with a flow diagram, the total number of records identified from electronic bibliographic sources (including specialized database or registry searches), hand searches of various sources, reference lists, citation indices, and experts. The flow diagram and text should describe clearly the process of report selection throughout the review. Authors should report: unique records identified in searches; records excluded after preliminary screening (e.g., screening of titles and abstracts); reports retrieved for detailed evaluation; potentially eligible reports that were not retrievable; retrieved reports that did not meet inclusion criteria and the primary reasons for exclusion; and the studies included in the review. Indeed, the most appropriate layout may vary for different reviews. Authors should also note the presence of duplicate or supplementary reports [4].
	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.** Explanation: For each included study, authors should provide a citation for the source of their information regardless of whether or not the study is published. This information makes it easier for interested readers to retrieve the relevant publications or documents. Authors should avoid, whenever possible, assuming information when it is missing from a study report (e.g., sample size, method of randomization). Reviewers may contact the original investigators to try to obtain missing information or confirm the data extracted for the systematic review. If this information is not obtained, this should be noted in the report. If information is imputed, the reader should be told how this was done and for which items. Following the presentation and description of each included study, as discussed above, reviewers usually provide a narrative summary of the studies [4].
	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).** Explanation: Reviewers should assess the risk of bias in the included studies using a standard approach with defined criteria. They should report the results of any such assessments [4].
	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.** Explanation: The required summary data for continuous outcomes are the mean, standard deviation, and sample size for each group. In reviews that examine time-to-event data, the authors should report the log hazard ratio and its standard error (or confidence interval) for each included study. For all included studies it is important to present the estimated effect with a confidence interval. In principle, all the above information should be provided for every outcome considered in the review, including both benefits and harms. When there are too many outcomes for full information to be included, results for the most important outcomes should be included in the main report with other information provided as a Web appendix. The choice of the

		information to present should be justified in light of what was originally stated in the protocol [4].
	Synthesis of results	**21. Present the main results of the review. If meta-analyses are done, include for each, confidence intervals and measures of consistency** Explanation: Results of systematic reviews should be presented in an orderly manner. If authors have conducted one or more meta-analyses, they should present the results as an estimated effect across studies with a confidence interval. Authors should also provide, for each meta-analysis, a measure of the consistency of the results from the included studies such as I^2; a confidence interval may also be given for this measure. If no meta-analysis was performed, the qualitative inferences should be presented as systematically as possible with an explanation of why meta-analysis was not done [4].
	Risk of bias across studies	**22. Present results of any assessment of risk of bias across studies (see Item 15).** Explanation: Authors should present the results of any assessments of risk of bias across studies. If a funnel plot is reported, authors should specify the effect estimate and measure of precision used, presented typically on the x-axis and y-axis, respectively. Authors should describe if and how they have tested the statistical significance of any possible asymmetry. Results of any investigations of selective reporting of outcomes within studies should also be reported. Authors should tell readers if any pre-specified analyses for assessing risk of bias across studies were not completed and the reasons (e.g., too few included studies) [4].
	Additional analysis	**23. Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).** Explanation: Authors should report any subgroup or sensitivity analyses and whether or not they were pre-specified. For analyses comparing subgroups of studies, the authors should report any tests for interactions, as well as estimates and confidence intervals from meta-analyses within each subgroup. Similarly, meta-regression results should not be limited to p-values, but should include effect sizes and confidence intervals.The amount of data included in each additional analysis should be specified if different from that considered in the main analyses. Importantly, all additional analyses conducted should be reported, not just those that were statistically significant [4].
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).** Explanation: Authors should give a brief and balanced summary of the nature and findings of the review. Sometimes, outcomes for which little or no data were found should be noted due to potential relevance for policy decisions and future research [4].
	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).** Explanation: A discussion of limitations should address the validity (i.e., risk of bias) and reporting (informativeness) of the included studies, limitations of the review process, and generalizability (applicability) of the review. Limitations of the review process might include limitations of the search (e.g., restricting to English-language publications), and any difficulties in the study selection, appraisal, and meta-analysis processes [4].
	Conclusions	**26. Provide a general interpretation of the results in the context of other evidence, and implications for future research.** Explanation: Authors should try to relate the results of the review to other evidence, as this helps readers to better interpret the results. Authors should make explicit recommendations

		for future research [4].
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.** Explanation: Authors of systematic reviews, like those of any other research study, should disclose any funding they received to carry out the review, or state if the review was not funded. Authors should also report whether the funder had any role in the conduct or report of the review. Beyond funding issues, authors should report any real or perceived conflicts of interest related to their role or the role of the funder in the reporting of the systematic review [4].