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Systematic review protocol assessing the potentiality of algorithms and artificial intelligence adoption to disrupt patient care with a safer and faster medication management.

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[°]Antonio Oliva and Gerardo Altamura, contributed equally to this work and thus should be considered co-first Authors.

[§]Gianfranco Damiani and Simone Grassi are co-senior Authors.

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ABSTRACT

Introduction

In primary care, almost 75% of outpatient visits by family doctors and general practitioners involve continuation or initiation of drug therapy. Due to the enormous amount of drugs used by outpatients in unmonitored situations, the potential risk of adverse events due to an error in the use or prescription of drugs is much higher than in a hospital setting. Artificial Intelligence application can help healthcare professionals to take charge of patient safety by improving error detection, patient stratification and drug management. The aim is to investigate the impact of AI algorithms on drug management in primary care settings and to compare Artificial Intelligence or algorithms with standard clinical practice to define the medication fields where a technological support could lead to better results.

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A systematic review and meta-analysis of literature will be conducted querying PubMed, Cochrane and ISI Web of Science. The primary outcome will be the reduction of medication errors obtained by AI application. The search strategy and the study selection will be conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the Population, Intervention, Comparator, Outcome (PICO) framework. Quality of included studies will be appraised adopting the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies for non-randomized controlled trials (NRCTs) as well as the Quality Assessment of Controlled Intervention Studies of National Institute of Health for randomized controlled trials (RCTs).

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Formal ethical approval is not required since no human beings are involved. The results will be disseminated widely through peer-reviewed publications.

KEYWORDS Artificial intelligence; Primary Care; Public Health; Legal Medicine; Risk Management

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- There could be an eventual lack of homogeneity of patient safety indicators
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INTRODUCTION

Patient safety is a global public health issue. Adverse drug events (ADEs) and medication errors are frequent preventable causes of increased morbidity, mortality, hospitalization rates and healthcare costs¹. According to Williams, medical errors can be sub-grouped into three classes: prescribing, dispensing and administration errors². The preventability of these events is a critical factor that must be carefully interpreted. Indeed, the evaluation of causal inference is often critical because adverse events can be associated both to adverse drug reactions (usually unpreventable) and to medication errors (preventable since related to human decisions)³. According to the Institute of Medicine, 1 of 131 outpatient and 1 of 854 inpatient deaths are caused by medication errors⁴. However, there is little evidence on the real incidence of errors, especially in primary care setting⁵. Primary care is a complex system composed by healthcare professionals - working within socio-sanitary structures - that provide first medical care for acute diseases and guarantee continuity of assistance in chronic pathologies. Three-fourths of the visits of family doctors concerns the indication or the follow-up of a pharmacological treatment⁶. Outpatients are significantly more exposed to a risk of drug misuse (and thus of adverse events) than inpatients because of the lack of a strict medical monitoring⁷. Since primary care is a heterogeneous and complex setting and – as said – drug-related errors are extremely frequent, artificial intelligence (and, in particular, e-health) could have a significant impact on the safety and the quality of care in this field. In particular, the clinical decision-making can be supported and empowered by algorithms⁸. In particular, electronic health records and electronic support systems based on algorithms could enhance the compliance with standards, avoid preventable errors and tailor the treatment on the basis of the specific characteristics and needs of the patients^{9,10}. The aim of the study is to investigate the impact of AI algorithms on drug management in primary care settings. Furthermore, we aim to compare Artificial Intelligence or algorithms with standard clinical practice to define the medication fields where a technological support could lead to better results.

METHODS AND ANALYSIS

The synopsis for this systematic review is prospectively submitted in the International Prospective Register of Systematic Reviews (PROSPERO).

Important amendments and updates made to the protocol will be documented and published alongside the results of the systematic review.

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A comprehensive search strategy will be created and implemented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) checklist¹¹. The Population, Intervention, Comparison, Outcome (PICO) framework¹² was adopted to formulate the following research question: “Do Artificial Intelligence and Algorithms in primary care have the potentiality to disrupt patient care with a safer and faster medication management?”. MEDLINE (via PubMed), Cochrane and ISI Web of Science databases will be queried to retrieve relevant peer-reviewed articles. Initially, controlled descriptors and the relative keywords were identified and verified in each scientific database. Afterwards, a Boolean search string, combining Medical Subject Headings terms (MeSH) and free-text words, such as “primary care”, “ambulatory care”, “outpatient care”, “general practitioner”, “general paediatrics”, “artificial intelligence”, “algorithms”, “machine learning”, “deep learning”, “neural networks”, “medication error”, “adverse event”, “prescribing error”, “dispensing error”, “administration error”, “monitoring error”, “medication errors reporting”, “medication reconciliation”, will be used. In addition, the reference lists of all relevant articles and the references for additional data sources missed during the database search will be scanned (i.e., snowball search) and their full texts will be retrieved.

Study Selection Criteria

All the articles that will meet the inclusion criteria will be included in the systematic review. Table 1 provides a brief summary of the main elements considered in the PICO model.

Table 1. Inclusion and Exclusion Criteria

PICO	Inclusion Criteria	Exclusion Criteria
Population	General population in primary care	Patients in secondary, tertiary and quaternary care
Intervention	Analysis of the application of AI/Algorithms in primary care for reducing medications errors	–
Comparator	General practice	–
Outcomes	Reduction of preventable medication errors that results in a decrease in hospital admissions, emergency department visits, and mortality.	Studies not reporting any outcomes

Additionally, the inclusion will be restricted to articles written in English describing RCT, clinical trials or controlled trials. The search strategy will be also restricted by availability of full texts published in peer-reviewed journals.

The primary outcome measures will be the reduction of preventable medication errors that resulted in a decrease in hospital admissions, emergency department visits, and mortality through the application of artificial intelligence or algorithms to primary care settings.

The secondary outcome will be the identification of the medication fields where technological support could lead to better results.

Screening and Data Extraction

After the removal of duplicate articles, and according to the inclusion and exclusion criteria, four independent researchers (FC, GA, MTR and MZ) will conduct the initial screening by evaluating the titles and abstracts. Then, the same researchers will screen the full text of each study to determine the potential eligibility. In both of the two screening phases, any disagreements or ambiguous situations will be resolved by a fifth author by discussing the inclusion and exclusion criteria of the article.

Data extraction will be completed by three independent investigators (MCN, SG and MS). A data extraction spreadsheet will be designed including the following: (1) study characteristics (i.e. first author, publication year, country of the study, journal title, article title); (2) setting characteristics (i.e. home setting, ambulatory, nursery home); (3) methodological characteristics (i.e. study type, duration of intervention, sample size, target population, type of medication error, type of intervention and comparator); and (4) the main findings (i.e., outcomes, quadruple aim, severity of avoided reaction).

Quality Assessment

Methodological quality of the Randomized Controlled Trials (RCTs) and Non-Randomized Controlled Trials (NRTCs) will be assessed using the Quality Assessment of Controlled Intervention Studies of National Institute of Health (NIH). This tool analyses several aspects of the included studies: population and participation rate, inclusion criteria, sample size justification, association between exposure and outcome, outcome description, drop-out rate, exposure measures and assessment, confounding variables. The tool assesses 14 parameters for evaluating the internal validity of a study. For each item, the investigator could select “yes,” “no,” or “cannot determine/not reported/not applicable”.

The scale assesses the following study-level aspects: randomization; allocation concealment; blinding; completeness of outcome data and selective outcome reporting, drop-out rate, adherence to the intervention, dimension of sample size.

A potential risk of bias was considered if the item was rated as “no” or “cannot determine/not reported/not applicable” were selected for the items by the reviewer. If the “yes” answers were $\geq 75\%$ of the total, an article was considered of “good” quality; if they were $< 75\%$ but $\geq 50\%$, an article was scored as “fair”; if they were

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3 < 50%, the article was scored as “poor”. So, a score of ten or greater was indicative of good methodological
4 quality, nine to seven was fair and studies scoring below seven were deemed to be of poor quality.
5 Three reviewers (GA, MCN and GA) will assess independently the quality of included studies and
6 disagreements will be resolved by a fourth reviewer (GS).
7

8 ***Descriptive analysis and meta-analysis***

9 A narrative synthesis, including tables and figures, will be carried out for all the included manuscripts. If
10 applicable, the pooled mean difference (MD) and 95% (CI) will be calculated to abridge continuous data¹³,
11 while a proportion meta-analysis will be carried out for proportion outcomes. To deal with potential
12 heterogeneity, a random-effects meta-analysis will be conducted¹⁴.

13 The I² statistic, which quantifies the degree of variability among studies due to heterogeneity rather than sample
14 error¹⁵, as well as forest plot will be used to assess the heterogeneity.

15 A leave-one-out sensitivity analysis will be performed by iteratively removing one study at a time to point out
16 if one study may influence the overall estimate of the rest of the studies.

17 Publication bias for each outcome will be assessed, if at least 10 studies will be included in the meta-analysis,
18 through funnel plots, and the asymmetry of funnel plots will be tested using Egger’s test.

19 All statistical analyses will be conducted using statistical software STATA¹⁶ v.16 and two-sided P values <0.05
20 will be considered statistically significant.
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22 ***Patient and Public Involvement***

23 No patient involved.
24

25 **ETHICS AND DISSEMINATION**

26 Formal ethical approval is not required since the systematic review and meta-analysis will not foresee the
27 involvement of human beings. The results will be disseminated widely through peer-reviewed publications.
28

29 **Author Contributions** The study concept was developed by AO, GD, GDM, MC. The manuscript of the
30 protocol was drafted by GA, MCN, SG, MZ, GS, FC, GA, MS, MTR and critically revised by AO, GD, GDM,
31 MC. AO, GD, GDM, MC developed and provided feedback for all sections of the review protocol and
32 approved the final manuscript. The search strategy was developed by GA, MCN, SG, MZ, GS, FC, GA, MS,
33 MTR. Study selection will be performed by FC, GA, MTR, MZ. Data extraction and quality assessment will
34 be performed by GA, MCN, and GA, with GS as a fourth party in case of disagreements. All authors have
35 approved the final version of the manuscript.
36

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41 **Competing interests** None declared.
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43 **Patient consent for publication** Not required.
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ABSTRACT

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Study Selection Criteria

All the articles that will meet the inclusion criteria will be included in the systematic review. Table 1 provides a brief summary of the main elements considered in the PICO model.

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Comparator	General practice	–
Outcomes	Reduction of preventable medication errors that results in a decrease in hospital admissions, emergency department visits, and mortality.	Studies not reporting any outcomes

Additionally, the inclusion will be restricted to original primary analyses written in English describing RCT, clinical trials or controlled trials. Thus, systematic reviews and meta-analyses will be excluded. The search strategy will be also restricted by availability of full texts published in peer-reviewed journals. Articles focusing on not digital technologies-based AI interventions will be excluded.

The primary outcome measures will be the reduction of preventable medication errors that resulted in a decrease in hospital admissions, emergency department visits, and mortality through the application of artificial intelligence or algorithms to primary care settings.

The secondary outcome will be the identification of the medication fields where technological support could lead to better results.

Screening and Data Extraction

After the removal of duplicate articles, and according to the inclusion and exclusion criteria, four independent researchers (FC, GA, MTR and MZ) will conduct the initial screening by evaluating the titles and abstracts. Then, the same researchers will screen the full text of each study to determine the potential eligibility. In both of the two screening phases, any disagreements or ambiguous situations will be resolved by a fifth author by discussing the inclusion and exclusion criteria of the article.

Data extraction will be completed by three independent investigators (MCN, SG and MS). A data extraction spreadsheet will be designed including the following: (1) study characteristics (i.e. first author, publication year, country of the study, journal title, article title); (2) setting characteristics (i.e. home setting, ambulatory, nursery home); (3) methodological characteristics (i.e. study type, duration of intervention, sample size, target population, type of medication error, type of intervention and comparator); and (4) the main findings (i.e., outcomes, quadruple aim, severity of avoided reaction).

Quality Assessment

Methodological quality of the Randomized Controlled Trials (RCTs) and Non-Randomized Controlled Trials (NRTCs) will be assessed using the Quality Assessment of Controlled Intervention Studies of National

Institute of Health (NIH). This tool analyses several aspects of the included studies: population and participation rate, inclusion criteria, sample size justification, association between exposure and outcome, outcome description, drop-out rate, exposure measures and assessment, confounding variables. The tool assesses 14 parameters for evaluating the internal validity of a study. For each item, the investigator could select “yes,” “no,” or “cannot determine/not reported/not applicable”.

The scale assesses the following study-level aspects: randomization; allocation concealment; blinding; completeness of outcome data and selective outcome reporting, drop-out rate, adherence to the intervention, dimension of sample size.

A potential risk of bias was considered if the item was rated as “no” or “cannot determine/not reported/not applicable” were selected for the items by the reviewer. If the “yes” answers were $\geq 75\%$ of the total, an article was considered of “good” quality; if they were $< 75\%$ but $\geq 50\%$, an article was scored as “fair”; if they were $< 50\%$, the article was scored as “poor”. So, a score of ten or greater was indicative of good methodological quality, nine to seven was fair and studies scoring below seven were deemed to be of poor quality.

Three reviewers (GA, MCN and GA) will assess independently the quality of included studies and disagreements will be resolved by a fourth reviewer (GS).

Descriptive analysis and meta-analysis

A narrative synthesis, including tables and figures, will be carried out for all the included manuscripts. If applicable, the pooled mean difference (MD) and 95% (CI) will be calculated to abridge continuous data¹⁷, while a proportion meta-analysis will be carried out for proportion outcomes. Separate pooled analyses will be performed for each group of studies (i.e., RCTs and NRCTs) as well as for each included outcome. Furthermore, in case of small numbers of studies will be found, the estimates for percent reduction in medication errors will be pooled. To deal with potential heterogeneity, a random-effects meta-analysis will be conducted¹⁸.

The I^2 statistic, which quantifies the degree of variability among studies due to heterogeneity rather than sample error¹⁹, as well as forest plot will be used to assess the heterogeneity.

In addition, there could be many decision nodes, such as the search of studies, eligibility criteria, type of data to be extracted, and the type of analyses, within the systematic review process, that may require sensitivity analyses. A leave-one-out sensitivity analysis will be performed by iteratively removing one study at a time to point out if one study may influence the overall estimate of the rest of the studies. If results will be consistent across the different analyses, the findings will be treated as robust while, on the contrary, they need to be assessed with caution.

Publication bias for each outcome will be assessed, if at least 10 studies will be included in the meta-analysis, through funnel plots, and the asymmetry of funnel plots will be tested using Egger’s test.

The main limitations related to the meta-analysis are the biases affecting primary studies, publication, reporting and selection bias, and the heterogeneity²⁰. Nonetheless, quality assessment and sensitivity analyses will be conducted, by two independent authors, to overcome these caveats.

All statistical analyses will be conducted using statistical software STATA²¹ v.16 and two-sided P values < 0.05 will be considered statistically significant.

Patient and Public Involvement

No patient involved.

DISCUSSION

We believe that the main implication of this systematic review could be the prioritization of the medical areas in which a better result, intended as medication error reduction, has been found, creating guidelines that could make the process more efficient. In addition, given the impending PNRR Allocation of fundings for technological infrastructures, consolidating the already existing evidences addressing the efficacy of AI could help political decision-makers in allocating the resources. Finally, this systematic review might result an important tool for giving answers to some of the still existing questions relatively to safety and usability of AI machines in the health sector.

ETHICS AND DISSEMINATION

Formal ethical approval is not required since the systematic review and meta-analysis will not foresee the involvement of human beings. The results will be disseminated widely through peer-reviewed publications.

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3 **Author Contributions** The study concept was developed by AO, GD, GDM, MC. The manuscript of the
4 protocol was drafted by GA, MCN, SG, MZ, GS, FC, GA, MS, MTR and critically revised by AO, GD, GDM,
5 MC. AO, GD, GDM, MC developed and provided feedback for all sections of the review protocol and
6 approved the final manuscript. The search strategy was developed by GA, MCN, SG, MZ, GS, FC, GA, MS,
7 MTR. Study selection will be performed by FC, GA, MTR, MZ. Data extraction and quality assessment will
8 be performed by GA, MCN, and GA, with GS as a fourth party in case of disagreements. All authors have
9 approved the final version of the manuscript.
10

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12 privato. Profili interdisciplinari sulla governance senza governo della società algoritmica", Università Cattolica
13 del Sacro Cuore, grant number R1024500180.
14

15 **Competing interests** None declared.
16

17 **Patient consent for publication** Not required.
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Supplementary File 1

Search string

Pubmed

("primary care" OR "ambulatory care" OR "outpatient care" OR "basic health care" OR "basic health-care" OR "basic healthcare" OR "day-to-day health care" OR "first aid" OR "initial medical care" OR "local doctors" OR "local doctor" OR "primary medical care" OR "primary health-care" OR "primary healthcare" OR "general practitioner" OR "general practitioners" OR "GP" OR "GPs" OR "family medicine" OR "general internal medicine" OR "general paediatrics" OR "primary care physician" OR "continuity of care" OR "first aid station" OR "first-aid station" OR "medical station" OR "home care" OR "home assistance" OR "home help")

AND ("artificial intelligence"[MeSH] OR "algorithms" OR "electronic prescribing" OR "Telehealth" OR "machine learning" OR "deep learning" OR "neural networks" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "telemedicine"[MeSH] OR "m-health" OR "mhealth" OR "mobile health" OR "ehealth" OR "e-health" OR "digital health")

AND ("Medication use" OR "adverse drug events" OR "drug prescription" OR "medication errors"[MeSH] OR "prescription errors" OR "medication error" OR "medication adverse event" OR "drug error" OR "medication administration" OR "medication prescription" OR "medication use" OR "prescribing error" OR "dispensing error" OR "omission error" OR "wrong time error" OR "monitoring error" OR "compliance error")

Cochrane

ID	Search Hits
#1	primary care 104889
#2	ambulatory care 9348
#3	outpatient care 15467
#4	basic health care 3678
#5	basic health-care 1677
#6	basic healthcare 1432
#7	day-to-day health care 462
#8	first aid 4818
#9	initial medical care 9351
#10	local doctors 912
#11	local doctor 1043

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3	#12	primary medical care	38283
4			
5	#13	primary health-care	29122
6			
7	#14	primary healthcare	14360
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9	#15	general practitioner	6570
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11	#16	general practitioners	5850
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13	#17	GP	10821
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15	#18	GPs	3516
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17	#19	family medicine	11532
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19	#20	general internal medicine	10061
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21	#21	general paediatrics	2610
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23	#22	primary care physician	9669
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25	#23	continuity of care	1867
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27	#24	medical station	548
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29	#25	home care	25285
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31	#26	home assistance	1977
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33	#27	home help	4992
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35	#28	m-health	1541
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37	#29	mhealth	1683
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39	#30	mobile health	6529
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41	#31	ehealth	1492
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43	#32	e-health	1507
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45	#33	digital health	4314
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47	#34	artificial intelligence	832
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49	#35	algorithms	6345
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51	#36	electronic prescribing	1197
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53	#37	Telehealth	2191
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57	#39	deep learning	914
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3 #40 neural networks 1133
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5 #41 Machine Intelligence 216
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11 #44 adverse drug events 84274
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(“primary care” OR “ambulatory care” OR “outpatient care” OR “basic health care” OR “basic health-care” OR “basic healthcare” OR “day-to-day health care” OR “first aid” OR “initial medical care” OR “ local doctors” OR “local doctor” OR “primary medical care” OR “primary health-care” OR “primary healthcare” OR “general practitioner” OR “general practitioners” OR “GP” OR “GPs” OR “family medicine” OR “general internal medicine” OR “general paediatrics” OR “primary care physician” OR “continuity of care” OR “first aid station” OR “first-aid station” OR “medical station” OR “home care” OR “home assistance” OR “home help”)

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AND (“Medication use” OR “adverse drug events” OR “drug prescription” OR “medication errors” OR “prescription errors” OR “medication error” OR “medication adverse event” OR “drug error” OR “medication administration” OR “medication prescription” OR “medication use” OR “prescribing error” OR “dispensing error” OR “omission error” OR “wrong time error” OR “monitoring error” OR “compliance error”)

Reporting checklist for protocol of a systematic review and meta analysis.

Based on the PRISMA-P guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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In your methods section, say that you used the PRISMA-Preorting guidelines, and cite them as:

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		Reporting Item	Page Number
Title			
Identification	#1a	Identify the report as a protocol of a systematic review	1
Update	#1b	If the protocol is for an update of a previous systematic review, identify as such	n/a
Registration			
	#2	If registered, provide the name of the registry (such as PROSPERO) and registration number	2
Authors			
Contact	#3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contribution	#3b	Describe contributions of protocol authors and identify the guarantor of the review	4

1	Amendments			
2				
3		#4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	n/a
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8	Support			
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10	Sources	#5a	Indicate sources of financial or other support for the review	4
11				
12	Sponsor	#5b	Provide name for the review funder and / or sponsor	4
13				
14	Role of sponsor or funder	#5c	Describe roles of funder(s), sponsor(s), and / or institution(s), if any, in developing the protocol	n/a
15				
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18	Introduction			
19				
20	Rationale	#6	Describe the rationale for the review in the context of what is already known	2
21				
22	Objectives	#7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	2
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30	Methods			
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32	Eligibility criteria	#8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	3
33				
34	Information sources	#9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	2
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40	Search strategy	#10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	2
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45	Study records - data management	#11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	3
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47	Study records - selection process	#11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	3
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50	Study records - data management	#11c	Describe planned method of extracting data from reports (such as	3
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1	collection process		piloting forms, done independently, in duplicate), any processes for	
2			obtaining and confirming data from investigators	
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4	Data items	#12	List and define all variables for which data will be sought (such as	2
5			PICO items, funding sources), any pre-planned data assumptions and	
6			simplifications	
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9	Outcomes and	#13	List and define all outcomes for which data will be sought, including	2
10	prioritization		prioritization of main and additional outcomes, with rationale	
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13	Risk of bias in	#14	Describe anticipated methods for assessing risk of bias of individual	3
14	individual studies		studies, including whether this will be done at the outcome or study	
15			level, or both; state how this information will be used in data synthesis	
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18	Data synthesis	#15a	Describe criteria under which study data will be quantitatively	4
19			synthesised	
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22	Data synthesis	#15b	If data are appropriate for quantitative synthesis, describe planned	4
23			summary measures, methods of handling data and methods of	
24			combining data from studies, including any planned exploration of	
25			consistency (such as I ² , Kendall's τ)	
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29	Data synthesis	#15c	Describe any proposed additional analyses (such as sensitivity or	n/a
30			subgroup analyses, meta-regression)	
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33	Data synthesis	#15d	If quantitative synthesis is not appropriate, describe the type of	4
34			summary planned	
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37	Meta-bias(es)	#16	Specify any planned assessment of meta-bias(es) (such as publication	4
38			bias across studies, selective reporting within studies)	
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41	Confidence in	#17	Describe how the strength of the body of evidence will be assessed	n/a
42	cumulative		(such as GRADE)	
43	evidence			
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 47 Attribution License CC-BY. This checklist was completed on 09. September 2021 using
 48 <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
 49