Implementation Science

SYSTEMATIC REVIEW

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Effects of implementation strategies on nursing practice and patient outcomes: a comprehensive systematic review and meta-analysis

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Abstract

Background Implementation strategies targeting individual healthcare professionals and teams, such as audit and feedback, educational meetings, opinion leaders, and reminders, have demonstrated potential in promoting evidence-based nursing practice. This systematic review examined the effects of the 19 Cochrane Effective Practice and Organization Care (EPOC) healthcare professional-level implementation strategies on nursing practice and patient outcomes.

Methods A systematic review was conducted following the Cochrane Handbook, with six databases searched up to February 2023 for randomized studies and non-randomized controlled studies evaluating the effects of EPOC implementation strategies on nursing practice. Study selection and data extraction were performed in Covidence. Random-effects meta-analyses were conducted in RevMan, while studies not eligible for meta-analysis were synthesized narratively based on the direction of effects. The quality of evidence was assessed using GRADE.

Results Out of 21,571 unique records, 204 studies (152 randomized, 52 controlled, non-randomized) enrolling 36,544 nurses and 340,320 patients were included. Common strategies (> 10% of studies) were educational meetings, educational materials, guidelines, reminders, audit and feedback, tailored interventions, educational outreach, and opinion leaders. Implementation strategies as a whole improved clinical practice outcomes compared to no active intervention, despite high heterogeneity. Group and individual education, patient-mediated interventions, reminders, tailored interventions and opinion leaders had statistically significant effects on clinical practice outcomes. Individual education improved nurses' attitude, knowledge, perceived control, and skills, while group education also influenced perceived social norms. Although meta-analyses indicate a small, non-statistically significant effect of multifaceted versus single strategies on clinical practice, the narrative synthesis of non-meta-analyzed studies shows favorable

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outcomes in all studies comparing multifaceted versus single strategies. Group and individual education, as well as tailored interventions, had statistically significant effects on patient outcomes.

Conclusions Multiple types of implementation strategies may enhance evidence-based nursing practice, though effects vary due to strategy complexity, contextual factors, and variability in outcome measurement. Some evidence suggests that multifaceted strategies are more effective than single component strategies. Effects on patient outcomes are modest. Healthcare organizations and implementation practitioners may consider employing multifaceted, tailored strategies to address local barriers, expand the use of underutilized strategies, and assess the long-term impact of strategies on nursing practice and patient outcomes.

Trial registration PROSPERO CRD42019130446.

Keywords Implementation strategies, Quality improvement, Knowledge translation strategies, Nurses, Nursing practice, Professional practice, Clinical practice, Healthcare professional behavior, Patient outcomes

Contributions to the literature

- This is the first systematic review consolidating evidence on the effects of the 19 Cochrane Effective Practice and Organization of Care (EPOC) healthcare professional-level implementation strategies on nursing practice and patient outcomes.
- It identifies effective strategies such as educational meetings and materials, opinion leaders, strategies tailored to context-specific barriers and facilitators, and reminders.
- It illustrates the effects of strategies on determinants of nurses' behaviors, including attitude, perceived behavioral control, and social norms.
- It identifies the need for more high-quality studies evaluating underutilized strategies such as local consensus processes, patient-reported outcome measures, and continuous quality improvement, especially in low- and middle-income countries.

Background

Nurses, comprising 59% of the global healthcare workforce, play a pivotal role in delivering both autonomous and collaborative care across the spectrum of healthcare services [1, 2]. Their contributions are essential for achieving the United Nations' 2030 Sustainable Development Goals (SDGs), particularly in ensuring healthy lives and promoting well-being for people of all ages [3, 4]. Nurses are indispensable in providing comprehensive primary healthcare [5], ensuring quality care, and maintaining patient safety through clinical decision-making [6]. Given their central role in healthcare delivery, promoting the adoption of evidence-based practices among nurses is a global imperative to enhance patient outcomes and advance health equity [7, 8]. The range of nursing practices is vast and can include administering medication, assessing illnesses, conducting tests and screenings, documenting care, practicing hand hygiene and other infection prevention measures, offering vaccinations, and providing counseling and advice on health behaviors [9].

The successful adoption and sustained use of evidence-based practices by nurses is influenced by a multitude of factors spanning individual, sociocultural, and environmental levels [9–13], as documented in implementation science determinant frameworks such as the Theoretical Domains Framework (TDF) [14]. These factors can either hinder or facilitate implementation and encompass challenges such as lack of knowledge, unfavorable social norms, workflow or process issues, ineffective teamwork or leadership, and inadequate institutional support [9–13, 15]. Implementation science has generated a wealth of evidence on strategies that can overcome these multilevel barriers, fostering behavior change and promoting the adoption of best practices across various clinical contexts [16–18]. Implementation strategies—the specific methods/actions to promote the adoption of evidence-based practices—aim to produce change in nurses' behaviors or the clinical environments in which they operate, or both [19–21].

Implementation strategy taxonomies have been developed to characterize intervention components aimed at promoting evidence uptake, including the Cochrane Effective Practice and Organisation of Care (EPOC) Taxonomy [22]. The EPOC Taxonomy includes 19 professional implementation strategies, targeting individual healthcare professionals and team behaviors, including audit and feedback, clinical practice guidelines, communities of practice, educational materials, local opinion leaders, printed educational materials, and reminders [22]. Multifaceted strategies, or implementation interventions, combine several of these strategies to address multiple barriers to implementation simultaneously [23, 24]. Investigating the effectiveness of multifaceted versus single component strategies is crucial for identifying the most efficient methods to promote evidence-based

practices, optimizing resource use, and enhancing patient outcomes [23].

Studies examining the effects of implementation strategies show small to moderate impacts on changing health professionals' behaviors, with few providing evidence of a significant change in patient outcomes [25]. Systematic reviews have investigated the effects of audit and feedback [17], local opinion leaders [26], printed educational materials [27], strategies leveraging information and communication technologies [28–32], and reminders [33] on professional practice and patient outcomes. Specifically in nursing, two recent systematic reviews explored the effects of implementation strategies on the uptake of clinical practice guidelines by nurses and demonstrated positive effects on nursing practice and patient outcomes [34, 35]. However, to our knowledge, no systematic review and meta-analysis has been conducted to consolidate evidence on the effects of the full range of EPOC healthcare professional-level implementation strategies on nurses' practice and patient outcomes. Furthermore, no previous review has examined quantitatively the effects of implementation strategies on key determinants of nurses' behaviors, such as attitudes (including beliefs about consequences), knowledge, intentions, perceived behavioral control (including beliefs about capabilities), skills, and perceived social norms, as outlined in the TDF [14]. These determinants are particularly significant as they represent core elements of many established behavioral theories and frameworks [36], making them crucial for understanding and driving clinical practice change among nurses.

Objective and research questions

The objective of this systematic review and meta-analysis was to assess the effects of healthcare professional-level implementation strategies, as defined in the EPOC Taxonomy [22], on nurses' clinical practice and patient outcomes. We aimed to address the following questions:

1. What are the effects of implementation strategies on compliance with desired clinical practice in nurses (primary outcome) and patient outcomes (secondary outcome)?
2. What are the effects of implementation strategies on six key determinants of nurses' behavior in clinical practice, including attitudes, intentions, knowledge, perceived behavioral control, perceived social norms, and skills (secondary outcomes)?
3. What are the effects of multifaceted implementation strategies compared to single implementation strategies on compliance with desired clinical practice in nurses and patient outcomes?

Methods

This systematic review and meta-analysis was conducted based on the *Cochrane Handbook for Systematic Reviews of Interventions* [37] and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (see Additional file 1) [38].

Protocol and registration

The protocol was registered at the International Prospective Register of Systematic Reviews on 5/01/19 (PROSPERO CRD42019130446) and can be found online [39]. No changes have been made to the review methods since the protocol's registration.

Search strategy and eligibility criteria

A search strategy was developed in collaboration with a Research Librarian using controlled vocabulary (e.g., MeSH terms) and keywords relating to implementation strategies, nurses, and study designs. Searches were undertaken in CINAHL, EMBASE, ERIC, PsycINFO, PubMed and Web of Science for literature published between database inception until February 26, 2023 (see Additional file 2). Other sources searched to identify additional relevant citations included the reference lists of included studies and relevant systematic reviews found through the Cochrane Database of Systematic Reviews and Google Scholar.

We included studies conducted with all types of nurses (e.g., registered nurses, nurse practitioners, clinical nurse specialists, licensed practical nurses) across any clinical setting. Studies were excluded if more than 10% of the sample consisted of other healthcare professionals or if results specific to nurses were not reported. Studies focusing on nursing students were excluded. Implementation strategies were defined as methods or techniques to promote the initial adoption and sustained use of evidence-based interventions, practices and programs [22]. Eligible studies were required to include at least one of the 19 healthcare professional-level implementation strategies outlined in the EPOC Taxonomy (see Table 1) [22]. Studies of financial interventions, patient-oriented organizational interventions, structural organizational interventions, and regulatory interventions were considered out of scope. The review allowed for studies with all types of comparators or usual care. Studies had to report either an objective measure of nurses' practice, such as clinical interventions reported in patients' medical files or the number of tests ordered, or a subjective

Table 1 The 19 healthcare professional level implementation strategies in the Effective Practice and Organization of Care (EPOC) Taxonomy [22]

Implementation strategy group for the purpose of this review	EPOC implementation strategies ($N=19$)	Definition	Example
Group 1: Individual clinician education	*Clinical practice guidelines*	Dissemination of systematically developed guidelines intended to assist healthcare professionals and patients in making informed decisions about appropriate healthcare for specific clinical conditions	Providing nurses in geriatric care with updated guidelines on fall prevention strategies
	Educational materials	Development and distribution of manuals, toolkits, and other resources either in-person, in print, or online, designed to facilitate healthcare professionals' understanding and delivery of clinical innovations	Distributing a handbook to oncology nurses on the latest chemotherapy administration protocols
	Educational games	Utilization of interactive games either in-person, in print, or online as a method to enhance learning and improve standards of care among healthcare professionals	A mobile app game designed for nurses to practice emergency response scenarios, enhancing their decision-making skills in critical situations
	Educational outreach visits, or academic detailing	Personalized education sessions conducted by trained individuals who visit healthcare professionals in their practice settings to inform and influence practice patterns towards the adoption of clinical innovations	Academic detailers visiting community health centers to train nurses on the use of new digital tools for patient management
Group 2: Group clinician education	*Educational meetings*	Organization of events such as workshops, courses, or conferences specifically targeted at healthcare professionals to educate and train them about new clinical practices or innovations	A workshop for nurse practitioners on advanced wound care techniques, including the use of new biologic dressings
	Communities of practice	Formation of groups comprising individuals with shared interests who engage regularly to enhance their knowledge and expertise through collaborative learning	A virtual community of practice for pediatric nurses to discuss challenges and solutions in neonatal care
	Interprofessional education	Continuing education programs for healthcare professionals from various disciplines, aimed at fostering a collaborative environment to enhance the implementation of clinical innovations	An interprofessional training session for nurses, physicians, and pharmacists on multidisciplinary approaches to pain management
Group 3: Clinician reminders	*Reminders*	Manual or computerized prompts that direct healthcare professionals to perform specific actions during interactions with patients, such as those provided by computerized decision support systems	Computer alerts reminding nurses in the intensive care unit to assess patients for delirium at specific intervals
Group 4: Patient-mediated interventions	*Patient-mediated Interventions*	Strategies aimed at modifying healthcare professional behavior through direct engagement with patients, equipping patients to be proactive about their care and to question their healthcare guidelines and treatments	Educating patients in a diabetes clinic on how to communicate effectively with their nurses about their insulin usage and concerns
Group 5: Public release of performance data	*Public release of performance data*	Making performance data for healthcare professionals available to the public through written or electronic reports, intended to inform and influence consumer choice and provider accountability	Publishing annual nursing care quality metrics for a maternity ward on the hospital website to help expectant mothers choose their care providers
Group 6: Managerial supervision	*Managerial supervision*	Provision of continuous oversight and training for clinical supervisors who are tasked with overseeing the delivery of clinical innovations by healthcare providers	Implementing a mentoring program where experienced nurse supervisors provide guidance and feedback to newly graduated nurses during their first year of practice

Table 1 (continued)

Implementation strategy group for the purpose of this review	EPOC implementation strategies ($N=19$)	Definition	Example
Group 7: Audit and feedback	*Audit and feedback*	Regular summaries of healthcare professionals' performance, provided in written, electronic, or verbal format, often accompanied by recommendations for clinical improvements	Feedback sessions where nurse managers review monthly infection control practices with their team and suggest improvements
	Monitoring the performance of the delivery of healthcare	Ongoing assessment of healthcare services by individuals or organizations, comparing them against external standards to ensure quality and compliance	Regular audits of nursing documentation in the electronic health record to ensure accuracy and completeness of patient care information
	Routine patient-reported outcome measures	Systematic collection and analysis of data reported directly by patients about their health outcomes, used to inform healthcare delivery and patient care strategies	Nurses collecting and reviewing patient feedback on post-operative care in a surgical unit to improve nursing protocols
	Continuous quality improvement	An iterative method involving healthcare teams to continuously review and enhance the quality of care, incorporating systematic problem-solving methods and data analysis	A nurse-led initiative to reduce patient wait times in the emergency department by analyzing triage procedures and implementing efficiency improvements
	Clinical incident reporting	Systems designed to document and report critical incidents in healthcare settings, aimed at identifying and mitigating risks to patient safety	A system where nurses can report any medication errors or near misses, which is then reviewed for process improvement
Group 8: Tailored interventions	*Tailored interventions*	Customized strategies designed to address specific barriers or to leverage facilitators identified through assessments such as surveys or interviews, intended to enhance the adoption of clinical practices	Developing a tailored implementation strategy for nurses in a neonatal intensive care unit (NICU) based on a survey that identified specific barriers in adopting a new protocol for managing neonatal abstinence syndrome
	Local consensus processes	Engagement of local healthcare professionals and stakeholders in discussions to evaluate the relevance and appropriateness of a clinical innovation, through formal or informal consensus-building methods	Facilitating discussions among nursing teams to decide on the adoption of a new patient safety checklist
Group 9: Local opinion leaders	*Local opinion leaders*	Identification and informational engagement of key influencers within the healthcare community, recognized by their peers as leaders, to promote the adoption of clinical innovations among their colleagues	Engaging a highly respected nurse to promote best practices in patient-centered care across nursing teams

measure, such as self-reported performance of clinical interventions. Studies which focused solely on determinants of nurses' practice were excluded. In terms of study designs, the review included all types of randomized studies including randomized controlled trials (RCTs), cluster randomized trials (CRTs) and stepped wedge CRTs. We also included non-randomized controlled studies (NRCS). Cross-sectional studies, observational studies, and case reports were excluded. Only published peer-reviewed articles were included to allow for detailed review of intervention components; conference abstracts, dissertations and theses were excluded.

Selection of studies

Identified records were imported into EndNote X8 [40] and duplicates were removed. The remaining records were imported into the Covidence software [41] for screening where additional duplicates were removed automatically. Titles, abstracts, and full texts were screened in duplicate in Covidence for eligibility by two reviewers with conflicts resolved through discussion or moderation of a third reviewer.

Data extraction

All data were extracted in duplicate in Covidence by two reviewers with conflicts resolved through discussion or moderation of a third reviewer. Data were extracted for study, participant, and intervention characteristics (e.g., strategies in each study arm according to the EPOC Taxonomy), as well as our primary and secondary outcomes, into a pre-piloted and standardized data extraction form (Microsoft Excel for Office 365). All corresponding study authors were contacted by email to clarify study details and to obtain additional study characteristics and results data. Two reminder emails were sent to authors who did not respond to the initial request.

Assessment of risk of bias

For RCTs, risk of bias was assessed with the Cochrane Risk of Bias 2 (RoB 2) tool for randomized trials [42]. For CRTs, risk of bias was assessed with the Cochrane RoB 2 tool for CRTs [42]. For NRCS, risk of bias was assessed with the Risk Of Bias in Non-randomized Studies-of Interventions (ROBINS-I) tool [43]. If a single study reported multiple outcomes relevant to the review, risk of bias was assessed for each outcome. RCTs were ranked as having low risk, some concerns, or high risk of bias across five domains, and the overall risk of bias was derived. CRTs were ranked as having low risk, some concerns, or high risk of bias across six domains, and the overall risk of bias was derived. NRCS were ranked as having a low, moderate, serious, or critical risk of bias across seven domains, and the overall risk of bias was derived. Two reviewers assessed risk of bias independently, with conflicts resolved through discussion.

Measures of intervention effect

All continuous and dichotomous outcomes related to clinical practice were expressed in terms of compliance with the desired practice or process of care completed by a nurse. In cases where studies reported both dichotomous and continuous measures for the same targeted behavior, we extracted and conducted separate analyses for each type of measure. We prioritized the extraction of individual clinical practice measures over summary or composite measures whenever the former were available.

In situations where the intervention aimed to reduce a targeted behavior to align more closely with established guidelines, we inverted the outcome data for both continuous and dichotomous measures to ensure a consistent direction of effect and interpretation across studies. When a study measured multiple clinical practice outcomes, we selected the outcome identified as the primary outcome by the study authors. If the primary outcome was not specified, we extracted the first outcome listed in the results section.

Additional continuous and dichotomous outcomes extracted, where available, included nurses' attitudes (encompassing beliefs about consequences), defined broadly as emotional and evaluative responses to a clinical behavior; intention, defined as readiness to perform a clinical behavior; knowledge, defined as the awareness and understanding of specific facts, techniques, or processes that affect the clinical behavior; perceived behavioral control (encompassing beliefs about capabilities, self-efficacy), defined broadly as nurses' perception of their ability to perform a clinical behavior; perceived social norms (encompassing social influences), defined broadly as nurses' perception about the normative expectations of others regarding a clinical behavior; and skills, defined as the practical abilities to perform a clinical behavior. We also extracted continuous and dichotomous outcomes related to patient health, defined as patient health status, reduction in symptoms, and other health improvements reasonably attributable to the nursing care provided.

For outcomes assessed at multiple time points, we selected data from the longest follow-up period. In the case of cross-over studies, we used data from the first period only due to the risk of carryover effects.

Data analysis

Where data were available, we performed DerSimonian and Laird random-effects meta-analyses of the primary

(clinical practice) or secondary outcomes (patient outcomes; nurses' attitudes, intentions, knowledge, perceived control, perceived social norms, and skills) across various intervention categorizations outlined in Table 1. We synthesized the pooled estimate of studies in which the implementation strategy was present vs. not present (e.g., audit and feedback in the intervention arm [IA] vs. no active intervention or another implementation strategy in the control arm [CA]). We also synthesized the pooled estimate of studies comparing directly a multifaceted strategy to a single strategy.

For dichotomous outcomes, a pooled odds ratio (OR) with a 95% confidence interval (CI) was calculated in Review Manager Web (RevMan Web) Version 7.7.0 [44] using the proportion of people with each outcome of interest. A fixed continuity correction of 0.5 was applied where there was a 0 cell in calculating ORs. For continuous outcomes, we calculated the standardized mean difference (SMD) by using the difference between the post-test means, divided by the pooled standard deviation (SD) in RevMan Web since studies used a wide range of outcome measures for diverse constructs and targeted behaviors. Missing SDs were obtained, when possible, by using CIs or standard errors in calculations detailed in the Cochrane Handbook [37]. For the CRTs included, we conducted analyses adjusting for clustering with the design effect when possible. The design effect was calculated using the intracluster correlation coefficient (ICC), the number of clusters and the average sample size of each cluster [37]. Stepped-wedge CRTs were only included for descriptive purposes and were not used in the analysis due to the inability to adjust for time effects. For studies with multiple intervention groups, we included each pairwise comparison relevant to this review separately, but with shared control groups divided out approximately evenly among the comparisons [37]. Missing data regarding study and intervention characteristics, as well as results, were not imputed. Missing data regarding ICCs were imputed based on the median ICC observed in the extracted data. Two-sided p values of less than 0.05 were deemed to be statistically significant.

In addition to the quantitative analyses, we conducted a narrative synthesis to summarize and interpret the findings from studies that could not be included in the meta-analysis due to missing data, the nature of the outcome, or the nature of the comparison. As recommended in the Cochrane Handbook [37], we used the direct of the effects to synthesize findings narratively.

Tables were created to present the characteristics of included studies, the effects of implementation strategies on both primary and secondary outcomes, and the effects of implementation strategies on clinical practice outcomes across strata for the primary comparison.

Risk of bias judgments for each extracted outcome were summarized by domain using RoB 2 and ROBINS-I, and presented through risk of bias graphs and summaries with the risk of bias visualization tool (robvis) [45].

Subgroup analysis, investigation of heterogeneity and non-reporting bias

We assessed heterogeneity across studies using the I^2 statistic (I^2 of less than 25% = low heterogeneity; $I2$ 25–75% = moderate heterogeneity; $I2$ of more than 75% = high heterogeneity) and by visually examining forest plots to explore the range of effect sizes for comparisons of interest. We investigated heterogeneity by stratifying the meta-analysis for our first comparison (i.e., any implementation strategy versus no active intervention) based on the study design, the study setting, the targeted clinical behavior in nurses, and the intervention (i.e., implementation strategy group). We assessed non-reporting bias with funnel plots for our primary outcome.

Sensitivity analysis

We conducted a sensitivity analysis by excluding studies with unclear to high risk of bias to assess their potential impact on study outcomes.

Assessment of the certainty of the evidence and summary of findings

Two reviewers assessed the quality of evidence independently for each outcome using the five domains of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach [46] in the GRADEpro GDT software [47]: risk of bias, inconsistency, indirectness, imprecision, and publication bias. A third reviewer helped resolve any discrepancies in the assessments. Risk of bias was assessed by the percentage of studies evaluated as low risk of bias in a given comparison (not serious > 50% studies, serious 21–50%, very serious ≤ 20%). The certainty of evidence was rated for each outcome as "very low," "low," "moderate," or "high." A table was created to present an overview of effects and the certainty of evidence for clinical practice and patient outcomes, and summary of findings tables were created for all comparisons and outcomes.

Results

Results of the search and included studies

We identified 30,134 records from bibliographical databases and 39 from other sources, resulting in 21,602 unique records (see Fig. 1). Out of 837 records assessed for eligibility, 204 studies were included: 152 randomized studies and 52 controlled, non-randomized studies,

enrolling 36,544 nurses (reported in 161 studies) and 340,320 patients (reported in 88 studies). All corresponding authors were contacted, and a total of 78 authors (38%) responded to requests for additional data. Out of the 204 studies included in the review, 160 contributed data to the meta-analyses for our primary outcome (compliance with desired clinical practice) and 44 were synthesized narratively.

Characteristics of included studies

A summary of the characteristics of included studies is presented in Table 2. The majority were randomized studies (152 studies, 75%), including 96 CRTs (47%), 51 RCTs (25%), and 5 stepped-wedge CRTs (2%), involving a total of 30,473 nurses and 323,986 patients. Non-randomized studies accounted for 52 studies (25%), including 38 non-randomized controlled trials (19%), 13 non-randomized cluster-controlled trials (6%), and 1 controlled time series study (< 1%), involving 6,071 nurses and 16,334 patients. Most studies were conducted in hospital settings, particularly inpatient or emergency departments (139 studies; 68%). Primary care or general practice settings comprised 25 studies (12%), and nursing homes accounted for 21 studies (10%). Other settings included community health centers, homecare, hospital outpatient settings, public health units and skilled nursing facilities. In terms of country income status, most studies were conducted in high-income countries (160 studies, 78%), followed by upper-middle-income countries (37 studies, 18%), and a small number in lower-middle-income (7 studies, 3%) and low-income countries (1 study, < 1%). The studies targeted various clinical behaviors, with the most common focus on multiple behaviors (48 studies, 24%). Common behaviors included: providing counseling and advice (29 studies, 14%), infection prevention and control practices (26 studies, 13%), assessing and diagnosing illness (26 studies, 13%), administering medication (14 studies, 7%), documenting care (10 studies, 5%), and coordinating care (10 studies, 5%). Behaviors targeted in less than 5% of studies included testing and screening, managing physical restraints, managing symptoms, managing care equipment, prescribing, vaccinating, and reporting clinical incidents. Additional file 3 presents the characteristics of all included studies. Additional file 4 presents the excluded articles at full text assessment stage and reasons for exclusion.

Risk of bias across included studies

We summarized the decisions regarding individual domains within the Cochrane RoB 2 tool and ROBINS-I in the risk of bias summary (see Fig. 2). Overall, for CRTs, the risk of bias for all outcome assessments ($N=227$ from 96 CRTs and 5 stepped-wedge CRTs) was distributed as follows: 50% were assessed as low risk, 29% had some concerns, and 21% were considered high risk. For RCTs ($N=127$ outcome assessments across 51 RCTs), 50% of the assessments were categorized as having some concerns, 28% as high risk, and 22% as low risk. For NRCS ($N=85$ outcome assessments across 52 NRCS), 55% were considered to have a critical risk, 25% a serious risk, 18% a moderate risk and 2% a low risk. The full risk of bias assessment for each outcome, for RCTs, CRTs and NCRS is presented in Additional file 5.

Use of implementation strategies across included studies

As illustrated in the panel a of Fig. 3, among the implementation strategies employed in at least 10% of the studies, educational meetings were the most common (intervention arms [IAs] $N=155$; control arms [CAs] $N=29$), followed by educational materials (IAs $N=145$; CAs $N=22$), clinical practice guidelines (IAs $N=64$; CAs $N=13$), reminders (IAs $N=43$; CAs $N=3$), audit and feedback (IAs $N=38$; CAs $N=1$), educational outreach (IAs $N=32$; CAs $N=1$), tailored interventions (IAs $N=26$; CAs $N=2$), and local opinion leaders (IAs $N=24$; CAs $N=3$). Strategies employed in less than 10% of studies included patient-mediated interventions, local consensus processes, monitoring the performance of delivery of healthcare, clinical incident reporting, interprofessional education, communities of practice, managerial supervision, routine patient-reported outcome measures, educational games, and continuous quality improvement. No intervention used public release of performance data.

As illustrated in the panel b of Fig. 3, implementation strategies almost always included some form of individual clinician education (including educational materials, educational outreach, and clinical practice guidelines) and/or group clinician education (including communities of practice, educational meetings, and interprofessional education) combined with reminders, audit and feedback, local opinion leaders, and tailored interventions. Additional file 3 presents the implementation strategies used across study arms.

Effects of implementation strategies

Effects of implementation strategies as a whole compared to no active intervention

In comparison with no active intervention, implementation strategies as a whole had significant positive effects on continuous clinical practice outcomes (76 assessments; SMD 0.94, 95% CI 0.72–1.15; $I^2=95\%$; see Fig. 4), and dichotomous clinical practice outcomes (60 assessments; OR 2.11, 95% CI 1.70–2.62; $I^2=95\%$; see Fig. 5). Statistically significant positive effects were also observed on nurses' attitudes (30 assessments; SMD 0.59, 95% CI 0.23–0.95; $I^2=92\%$), knowledge (37 assessments; SMD

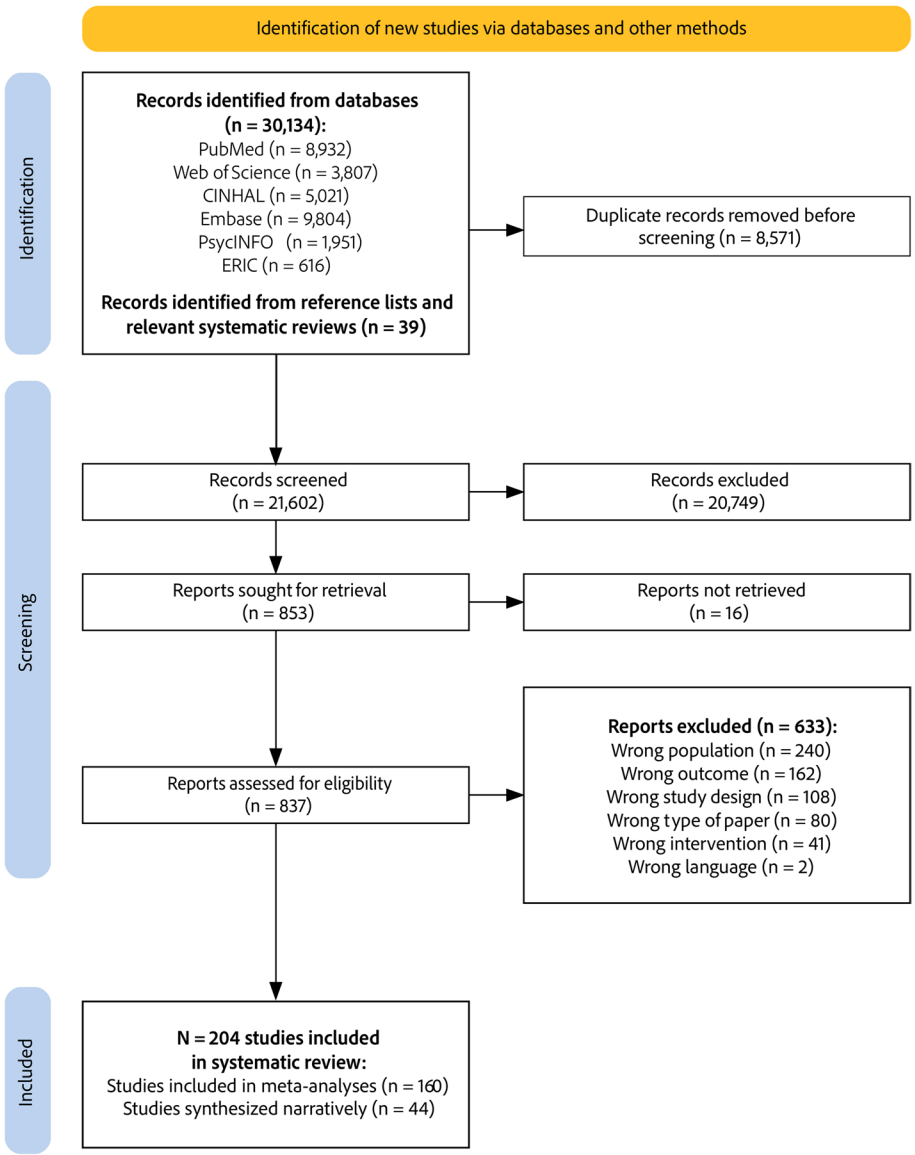

Fig. 1 PRISMA study flow diagram

1.16, 95% CI 0.82–1.49; I^2 = 91%), perceived behavioral control (19 assessments; SMD 0.74, 95% CI 0.35–1.13; I^2 = 91%), and skills (10 assessments; SMD 0.97, 95% CI 0.42–1.52; I^2 = 87%). No significant effects were observed on continuous patient outcomes (10 assessments; SMD 0.23, 95% CI -0.01–0.47; I^2 = 87%) and dichotomous patient outcomes (12 assessments; OR 1.46, 95% CI 0.96–2.22; I^2 = 84%). Statistical heterogeneity was high in all analyses. All forest plots are presented in Additional file 6. The clinical practice outcomes included in meta-analyses across all comparisons are presented in Additional file 7.

Table 3 presents subgroup analyses of the estimated SMDs for continuous outcomes and the estimated ORs for dichotomous outcomes to illuminate the variance in effects attributed to study design, study setting, and clinical behavior targeted for change. Minimal differences in effects were noted across these strata. Though, primary care/general practice for continuous clinical practice outcomes decreased and was no longer significant.

Effects of specific implementation strategies on primary and secondary outcomes

Table 4 displays effects of the implementation strategy subgroups by the primary outcome. Dichotomous clinical practice outcomes are positively affected (i.e., more likely to align with desired practice) by group

Table 2 Summary of characteristics of included studies ($N = 204$)[a]

	Number of studies (%)[b]	Number of nurses[c]	Number of patients[d]
Study design			
Cluster randomized trial	96 (47%)	22,356	310,101
Randomized controlled trial	51 (25%)	6499	5831
Non-randomized controlled trial	38 (19%)	5193	7954
Non-randomized cluster-controlled trial	13 (6%)	878	7645
Stepped-wedge cluster-randomized trial	5 (2%)	1618	8054
Controlled time series study	1 (1%)	NR	735
Study setting			
Hospital (inpatient or emergency department)	139 (68%)	25,884	82,237
Primary care or general practice	25 (12%)	1607	160,869
Nursing home	21 (10%)	2247	19,096
Community health center	7 (3%)	507	2896
Homecare	6 (3%)	1260	1599
Hospital (outpatient)	3 (1%)	465	3502
Public health unit	2 (1%)	95	62,168
Skilled nursing facility	2 (1%)	4479	7953
Country income status			
High income	159 (78%)	33,047	323,382
Upper-middle income	37 (18%)	2894	16,938
Lower-middle income	7 (3%)	498	NR
Low income	1 (1%)	105	NR
Target clinical behavior			
Multiple	47 (23%)	7744	100,810
Providing counseling and advice	29 (14%)	2892	4372
Practicing infection prevention and control measures (e.g., hand hygiene)	26 (13%)	4824	5551
Assessing and diagnosing illness	26 (13%)	9133	11,865
Administering medication	14 (7%)	2236	15,496
Documenting	10 (5%)	541	1266
Coordinating care	10 (5%)	1226	1016
Testing and screening	8 (4%)	482	57,683
Managing physical restraints	8 (4%)	2011	12,415
Managing symptoms	8 (4%)	338	2721
Managing care equipment	8 (4%)	504	19,362
Prescribing	3 (1%)	38	96,741
Vaccinating	3 (1%)	4479	9617
Reporting incidents	2 (1%)	NR	1405
Other	2 (1%)	96	NR

[a] *NR* Not reported

[b] For study setting, one study was conducted both in hospital and nursing home settings – giving a total of 205 studies instead of 204

[c] Number of nurses enrolled reported in 160 studies

[d] Number of patients enrolled reported in 89 studies

clinician education, individual clinician education, reminders, patient-mediated interventions, tailored interventions, and opinion leaders. Continuous clinical practice outcomes are positively affected by group clinician education, individual clinician education, and tailored interventions. Across all implementation strategy subgroups, group clinician education, individual clinician education and tailored interventions had statistically significant effects on patient outcomes. These results may be influenced by heterogeneity and the lack

Fig. 2 **a** Summary of risk of bias for cluster randomized trials. **b** Summary of risk of bias for randomized controlled trials. **c** Summary of risk of bias for non-randomized controlled studies

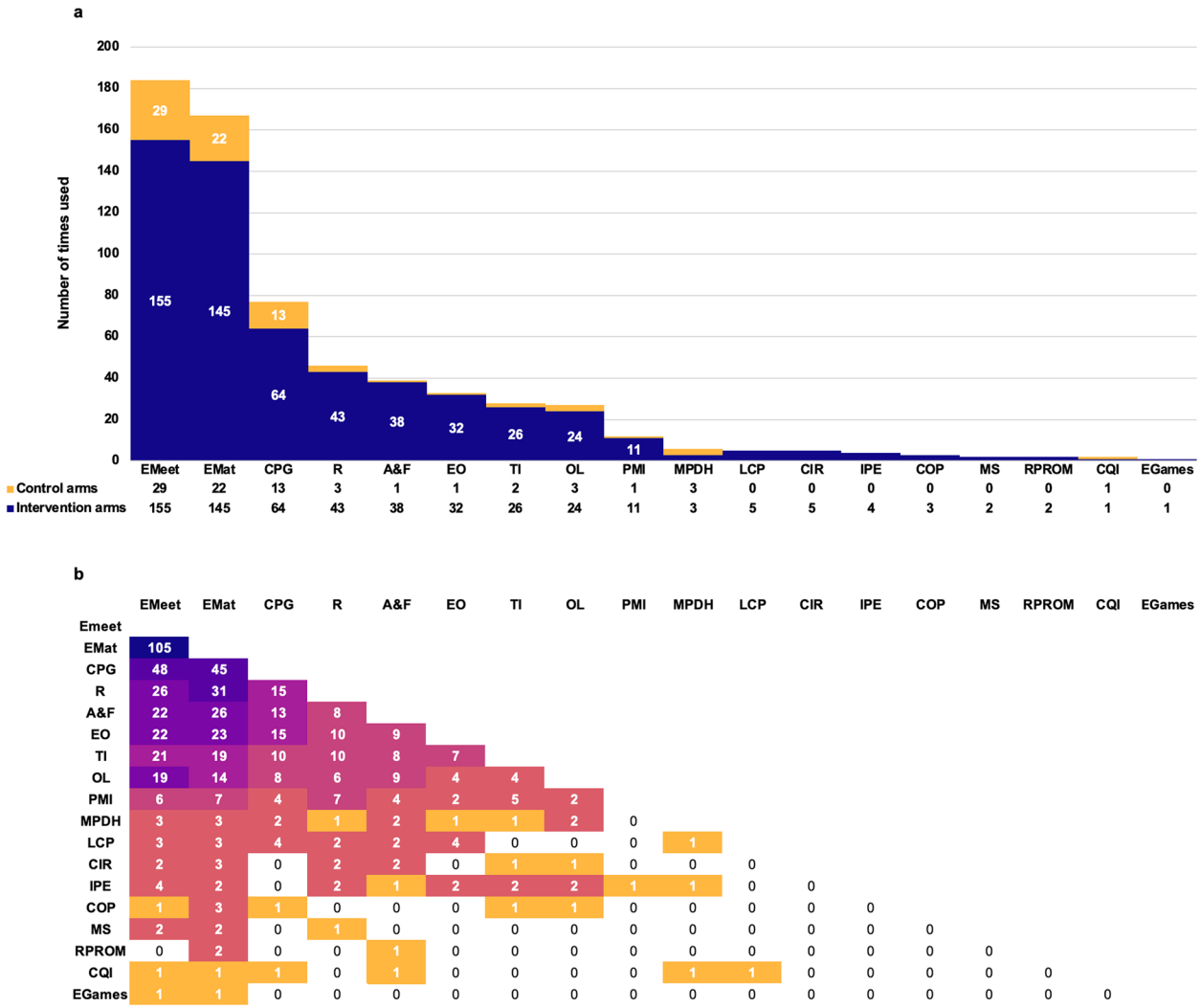

Fig. 3 **a** Frequency of use of each implementation strategy across intervention and control arms. **b** Frequency of combinations of implementation strategies in interventions assessed in included studies. EMeet = educational meetings, EMat = educational materials, CPG = clinical practice guidelines, *R* = reminders, A&F = audit and feedback, EO = educational outreach, TI = tailored interventions, OL = local opinion leaders, PMI = patient-mediated interventions, MPDH = monitoring the performance of delivery of healthcare, LCP = local consensus processes, CIR = clinical incident reporting, IPE = interprofessional education, COP = communities of practice, MS = managerial supervision, RPROM = routine patient-reported outcome measures, CQI = continuous quality improvement, EGames = educational games

of control over co-existing strategies within these subgroup analyses, likely leading to an inflation of the effects of individual strategies.

Table 5 displays effects of the implementation strategy subgroups by secondary outcomes. Attitude (continuous) was positively influenced by group clinician education, individual clinician education, audit and feedback, and tailored interventions. Attitude (dichotomous) was positively influenced by group clinician education and individual clinician education. Knowledge was positively influenced by group clinician education, individual clinician education, and tailored interventions. Perceived behavioral control was positively influenced by group clinician education, individual clinician education, and reminders. Skills were positively influenced by group clinician education and individual clinician education. Perceived social norms were positively influenced by group clinician education.

Effects of multifaceted implementation strategies compared to single implementation strategy

In studies comparing a multifaceted implementation strategy (combining two or more implementation strategies) with a single type of implementation strategy,

multifaceted strategies had small, non statistically significant effects on continuous clinical practice outcomes (12 assessments; SMD 0.23, 95% CI -0.01–0.46; I^2=77%; see panel a of Fig. 6), dichotomous clinical practice outcomes (20 assessments; OR 1.35, 95% CI 0.76–2.40; I^2=91%; panel b of Fig. 6), and dichotomous patient outcomes (5 assessments; OR 1.30, 95% CI 0.89–1.90; I^2=0%) (see Additional file 6).

Effects of implementation strategies in included studies not ineligible for meta-analysis

After contacting all study authors, 44 studies were not included in meta-analyses for our primary outcome due to missing data (n=27) [48–74], comparisons that were not relevant to our analyses (e.g., comparing two groups receiving the same type of implementation strategy with design variations) (n=14) [75–88], or expressing their outcomes as rates rather than in a compatible format (n=3) [89–91].

Of these studies, 25 focused solely on educational strategies, with 22 showing more favorable outcomes in the experimental groups. Kaner et al. [78] demonstrated that educational outreach increased brief alcohol interventions compared to clinical practice guidelines. Educational meetings (EMeet), often supplemented with educational materials (EMat) and/or clinical practice guidelines (CPG), led to improvements across various areas: blood glucose monitoring (O'Neill et al.: EMeet), [63] communication (Antonini et al.: EMeet), [48] diabetes management (Lim et al.: EMeet + EMat), [59] endotracheal suctioning practices (Day et al.: CPG + EMeet), [52] nursing documentation and care planning (Müller-Staub et al.: EMeet; Brady et al.: EMeet), [49, 81] use of physical restraints (Chang et al.: EMeet), [51] counseling (Tsai et al.: EMeet; Woodcock et al.: EMeet), [72, 86] and symptom management (Hessig et al.: EMat + EMeet; Michaels et al.: CPG + EMat + EMeet). [55, 61] Magnan et al. [80] used educational materials alone to improve physical examination. Nine studies evaluated technology-enhanced educational strategies. Carrico et al. [87] reported that biosimulated visual demonstration of particulate transmission resulted in increased personal protective equipment use. Jansson et al. [84, 92], through two studies, demonstrated adding feedback and debriefing to simulation-focused educational meetings, improved nurses' adherence to evidence-based guidelines for mechanical ventilation. Rutherford-Hemming et al. [82] found higher levels of evidence-based performance of neurological examinations in simulation-based education compared to a self-study module. Wang et al. [83] found improved application of counseling following the additional of simulation to educational meetings and materials. Wang et al. reported the effects of game-based learning on hand hygiene practices. [85] Kinsman et al. [88], Lau et al. [79], and Van de Steeg et al. [70] found e-learning programs improved physical examination, medication administration, and delirium care. Hammersley et al. [53], Seeley et al. [68], and Segal et al. [69] found no benefits from educational strategies.

Four out of five studies using audit and feedback alone were inconclusive. Charrier et al. [76] found that audit and feedback and the presence of facilitators, compared with self-monitoring, improved compliance to protocols for pressure lesions and the management of catheters. Bittner et al. [75], Hutchinson et al. [91], Noordman et al. [62], and Rothschild et al. [66] found no effects of audit and feedback on hand hygiene, history-taking, the reporting of medication errors, and medication errors.

Studies using multifaceted implementation strategies including other strategies than education compared to no active intervention were often successful, with 9 out of 10 showing positive results. Brennan et al. [50] evaluated a tailored intervention using the CAM-ICU guideline, which increased delirium screenings and led to a decrease in delirium rates. Chambers et al. [89] and Fabre et al. [90] found that a multifaceted implementation strategy reduced nurse-led urine culturing. Hödl et al. [56] improved urinary incontinence equipment management using educational outreach, materials, guidelines, and reminders. Documentation improved by 43% in the multi-faceted group, while the control group saw a 15% decrease after 2 weeks. Lin et al. [60] found that a multifaceted strategy (audit and feedback, tailored intervention, educational meetings, and materials) improved the use of relaxation techniques in surgical nurses in Taipei. Morita et al. [73] found improved palliative care practices following a multifaceted strategy involving tailoring and education. Reynolds et al. [65] assessed a multifaceted strategy (educational outreach, educational materials, audit and feedback) to improve compliance with chlorhexidine gluconate bathing documentation and reduce central line-associated bloodstream infections. While CHG bathing compliance increased significantly by 6.97%, the 27.4% decrease in CLABSI rates was not significant. Schondelmeyer et al. [67] reported that education (meetings, clinical practice guidelines, outreach) with audit and feedback reduced guideline-discordant continuous pulse oximetry use by 30% in pediatric nurses in the USA. Wald et al. [74] also found effects of audit and feedback on the uptake of catheter-associated urinary tract infection prevention measures. One study of a multifaceted implementation strategy had inconclusive results. Happ et al. [93] evaluated a web-based training with local opinion leaders to reduce ICU adverse events, finding no significant changes in physical restraint use.

Four studies specifically compared the effects of multifaceted versus single-component strategies, with all

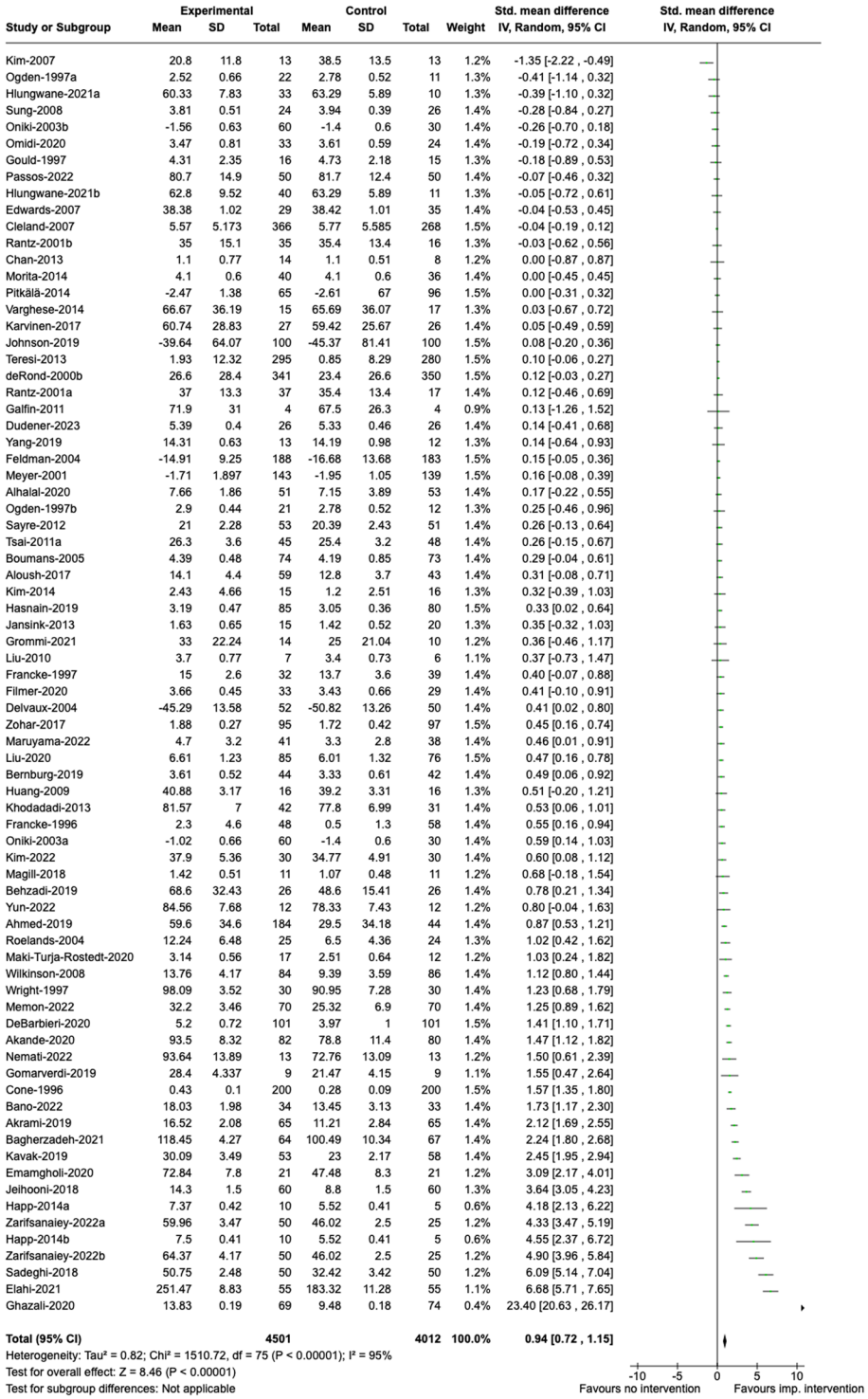

Fig. 4 Effects of implementation strategies on continuous clinical practice outcomes, compared with no active intervention

favoring multifaceted strategies. Hong et al. [57] found higher urinary catheter care practice implementation using local opinion leaders with educational meetings, than either component alone. Johnston et al. [58] used audit and feedback, local opinion leaders, and educational materials compared to only monitoring healthcare delivery on the documentation of pain assessment in Canadian patients. Pagaiya et al. [64] compared a multifaceted

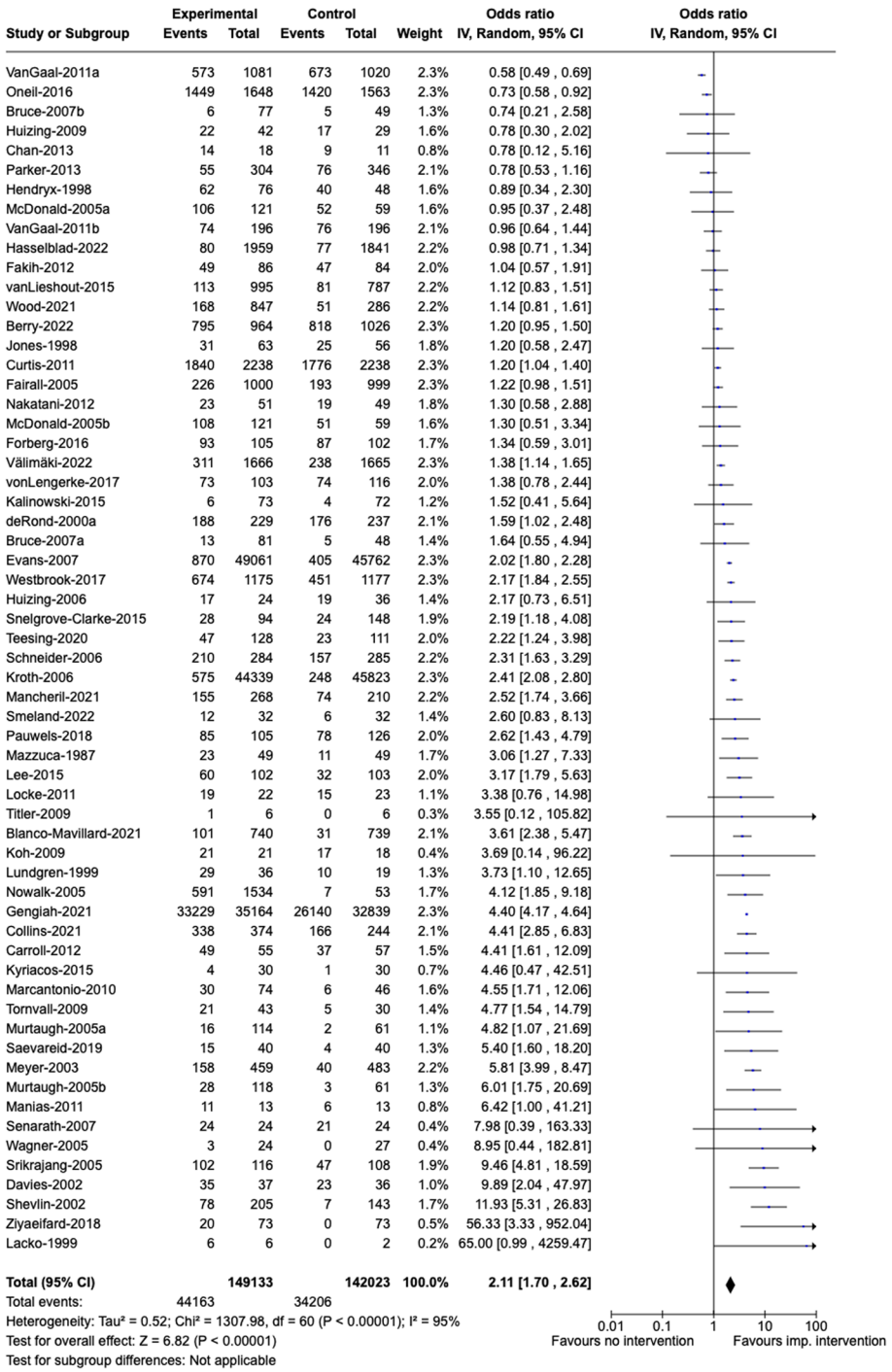

Fig. 5 Effects of implementation strategies on dichotomous clinical practice outcomes, compared with no active intervention

strategy to guidelines alone for reducing antibiotic prescriptions in Thailand. Walsh et al. [71] found that web-based education with process feedback significantly reduced oversedation in ICU patients in the UK, more than other education methods.

Sensitivity analyses

We conducted sensitivity analyses to exclude studies assessed as being at overall unclear or high risk of bias, as presented in Additional file 8. Effect measures tended to decrease with the removal of high risk of bias

Table 3 Effects on clinical practice outcomes across strata for the primary comparison (any implementation strategy vs no active intervention)[a]

Strata	Clinical practice outcomes (Continuous)			Clinical practice outcomes (Dichotomous)		
	N studies	SMD (95% CI)	I^2	N studies	OR (95% CI)	I^2
Study design						
Cluster randomized trials	26	**0.70**[a] (0.45, 0.96)	90%	39	**1.86**[a] (1.42, 2.43)	97%
Randomized controlled trials	23	**1.37**[a] (0.87, 1.87)	97%	8	**2.90**[a] (1.77, 4.76)	77%
Non-randomized studies	21	**0.86**[a] (0.46, 1.25)	95%	10	**2.54**[a] (1.50, 4.32)	89%
Study setting						
Hospital (inpatient or emergency department)	51	**1.10**[a] (0.81, 1.39)	95%	33	**2.14**[a] (1.70, 2.69)	91%
Primary care or general practice	7	0.21 (-0.07, 0.49)	75%	8	**2.00**[a] (1.05, 3.80)	98%
Nursing home	6	**0.15**[a] (0.02, 0.29)	3%	9	2.15 (0.96, 4.84)	95%
Clinical behavior targeted for change						
Counseling and advice	25	**0.71**[a] (0.40, 1.02)	92%	9	**1.54**[a] (1.09, 2.17)	81%
Infection control and prevention measures	12	**1.32**[a] (0.54, 2.09)	96%	8	1.12 (0.81, 1.54)	85%
Assessing and diagnosing illness	13	**1.85**[a] (1.11, 2.59)	97%	20	**1.91**[a] (1.56, 2.34)	75%
Coordinating care	9	**1.05**[a] (0.28, 1.82)	95%	11	**1.71**[a] (1.38, 2.12)	89%

[a] Denotes a statistically significant result (i.e., two-sided p value of less than 0.05)

studies, though most remained statistically significant. In rare instances, the effect sizes increased, such as with continuous clinical practice outcomes for multifaceted interventions compared to single strategy interventions. Heterogeneity remained high in most analyses.

Non-reporting bias

Funnel plots indicated some evidence for non-reporting bias in dichotomous clinical practice outcomes (any vs no implementation strategies comparison), continuous clinical practice outcomes (individual clinician education comparison), and continuous clinical practice outcomes (group clinician education comparison) (Additional file 9). These studies tend to be heavily concentrated to the upper left of the triangle suggesting that the effect measure could be underestimated for the intervention. We did not find clear evidence for non-reporting bias for other outcomes.

Certainty of the evidence

Table 6 provides an overview of the impact of various implementation strategies compared with different or no active interventions for improving compliance with desired clinical practice and patient outcomes. The table presents both quantitative findings from meta-analyses and narrative findings from studies not included in the meta-analyses. It also includes the certainty of evidence (GRADE) for each type of intervention and outcome, offering a comprehensive view of how different strategies influence clinical practice and patient care. Detailed summary of findings tables are presented in Additional file 10.

Discussion

This systematic review examined the effects of healthcare professional-level implementation strategies on nursing practice and patient outcomes across 204 studies. Overwhelmingly, the implementation strategies described were multi-component, primarily involving individual and group education (e.g., educational meetings, educational materials, clinical practice guidelines, communities of practice, interprofessional education) combined with reminders, audit and feedback, local opinion leaders, and tailored interventions. In a quarter of the included

Table 4 Effects of implementation strategies on clinical practice and patient outcomes by subgroup

Subgroup	Clinical practice outcomes (Dichotomous)			Clinical practice outcomes (Continuous)			Patient outcomes (Dichotomous)			Patient outcomes (Continuous)		
	N	OR (95% CI)	I^2	N	SMD (95% CI)	I^2	N	OR (95% CI)	I^2	N	SMD (95% CI)	I^2
Strategy including **group clinician education (GCE)** vs a strategy that does not include GCE or no active intervention	63	**1.81**[a] (1.50, 2.19)	94%	72	**0.96**[a] (0.73, 1.19)	95%	13	**1.37**[a] (1.07, 1.77)	84%	8	0.14 (-0.11, 0.38)	86%
GCE only vs a strategy that does not include GCE or no active intervention	6	**1.81**[a] (1.05, 3.12)	68%	13	**0.34**[a] (0.03, 0.65)	87%	..	..	..	..	..	..
GCE only vs no active intervention	5	**2.14**[a] (1.09, 4.21)	74%	10	**0.41**[a] (0.05, 0.77)	89%	..	..	..	2	0.67 (-0.24, 1.58)	74%
Strategy including **individual clinician education (ICE)** vs a strategy that does not include ICE or no active intervention	61	**2.04**[a] (1.62, 2.56)	96%	67	**0.82**[a] (0.60, 1.03)	94%	11	1.26 (0.81, 1.94)	81%	9	0.17 (-0.02, 0.35)	79%
ICE only vs a strategy that does not include ICE or no active intervention	5	**2.87**[a] (1.47, 5.58)	68%	10	**0.36**[a] (0.06, 0.65)	81%	..	..	..	..	..	..
ICE only vs no active intervention	3	2.79 (0.95, 8.23)	76%	7	**0.44**[a] (0.09, 0.80)	84%				2	**0.62**[a] (0.03, 1.22)	80%
Strategy including **reminders** vs a strategy that does not include reminders or no active intervention	25	**2.44**[a] (1.89, 3.17)	90%	12	0.61 (-0.11, 1.33)	95%	8	1.00 (0.76, 1.31)	48%	..	..	..
Reminders only vs a strategy that does not include reminders or no active intervention	4	**2.24**[a] (1.00, 5.06)	82%	..	..	..	..	..	..	..	..	..
Reminders only vs no active intervention	3	**2.49**[a] (1.08, 5.75)	86%	2	0.17 (-0.66, 0.99)	86%	..	..	..	..	..	..
Strategy including a **patient-mediated intervention (PMI)** vs a strategy that does not include PMI or no active intervention	9	**1.78**[a] (1.13, 2.79)	95%	..	..	..	2	0.97 (0.79, 1.19)	0%	..	..	..
Strategy including **audit and feedback (A&F)** vs a strategy that does not include A&F or no active intervention	22	1.42 (0.94, 2.13)	98%	8	-0.18 (-0.60, 0.24)	86%	11	1.11 (0.74, 1.65)	72%	3	-0.21 (-0.66, 0.25)	62%
Strategy including a **tailored intervention (TI)** versus a strategy that does not include TI or no active intervention	15	**1.90**[a] (1.23, 2.93)	99%	10	**1.41**[a] (0.65, 2.17)	97%	6	1.34 (0.96, 1.86)	79%	4	**0.23**[a] (0.09, 0.37)	86%
Strategy including **opinion leaders (OLs)** vs a strategy that does not include TI or no active intervention	15	**1.96**[a] (1.22, 3.14)	98%	5	0.35 (-0.04, 0.74)	81%	5	0.92 (0.86, 1.00)	0%	..	..	..

[a] Denotes a statistically significant result (i.e., two-sided p value of less than 0.05)

Table 5 Effects of implementation strategies on the determinants of nurses' behavior in clinical practice by subgroup

Subgroup	Intention			Attitude (Dichot.)			Attitude (Cont.)			Knowledge			Perceived behavioral control			Skills			Perceived social norms		
	N	SMD (95% CI)	I^2	N	OR (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2
Strategy including **group clinician education (GCE)** vs a strategy that does not include GCE or no active intervention	4	0.43 (-0.12, 0.99)	69%	2	2.59 (0.48, 13.87)	27%	32	**0.54**[a] (0.19, 0.89)	93%	38	**1.07**[a] (0.73, 1.40)	93%	17	**0.75**[a] (0.33, 1.17)	93%	9	**0.64**[a] (0.33, 0.95)	53%	3	**0.23**[a] (0.01, 0.45)	0%
GCE only vs a strategy that does not include GCE or no active intervention	..	..	..	..	..	..	5	0.18 (-0.12, 0.48)	40%	..	..	..	..	..	..	..	..	..	..	..	..
GCE only vs no active intervention	..	..	..	..	..	..	4	0.13 (-0.23, 0.50)	51%	2	1.37 (-1.15, 3.89)	98%	5	**0.27**[a] (0.03, 0.50)	0%		..	..	..	..	..
Strategy including **individual clinician education (ICE)** vs a strategy that does not include ICE or no active intervention	2	0.16 (-0.31, 0.63)	24%	2	1.65 (0.71, 3.83)	0%	30	**0.68**[a] (0.31, 1.05)	93%	42	**1.03**[a] (0.73,1.33)	91%	14	**0.89**[a] (0.39, 1.38)	93%	8	**0.49**[a] (0.22, 0.77)	24%	..	..	..
ICE only vs a strategy that does not include ICE or no active intervention	..	..	..	..	..	..	5	0.08 (-0.47, 0.63)	79%	.	..	..	..	..	.	..	..	..	..	..	..

Table 5 (continued)

Subgroup	Intention			Attitude (Dichot.)			Attitude (Cont.)			Knowledge			Perceived behavioral control			Skills			Perceived social norms		
	N	SMD (95% CI)	I^2	N	OR (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2
ICE only vs no active intervention	..	..	..	..	..	..	3	-0.08 (-0.43, 0.26)	0%	3	0.33 (-0.67, 1.33)	85%	3	0.31 (-0.45, 1.08)					..	..	..
Strategy including **reminders** vs a strategy that does not include reminders or no active intervention	..	..	..	..	..	..	5	1.10 (-0.41, 2.60)	97%	10	**1.07**[a] (0.41, 1.74)	92%	3	**7.48**[a] (6.74, 8.21)	84%	..	..	..	..	..	..
Strategy including a **patient-mediated intervention (PMI)** vs a strategy that does not include PMI or no active intervention	..	..	..	..	..	..	..	..	..	…	.	..	..	..	..	..	..	..	..	..	..
Strategy including **audit and feedback (A&F)** vs a strategy that does not include A&F or no active intervention	..	..	..	..	..	..	3	**0.20**[a] (0.01, 0.38)	0%	4	-0.17 (-0.97, 0.64)	87%	..	..	..	..	..	..	..	..	..

Table 5 (continued)

Subgroup	Intention			Attitude (Dichot.)			Attitude (Cont.)			Knowledge			Perceived behavioral control			Skills			Perceived social norms		
	N	SMD (95% CI)	I^2	N	OR (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2	N	SMD (95% CI)	I^2
Strategy including a **tailored intervention (TI)** vs a strategy that does not include TI or no active intervention	..	..	..	..	..	..	4	0.28 (-0.01, 0.57)	65%	5	0.53 (-0.04, 1.09)	91%	..	..	..	..	..	..	..	..	..
Strategy including **opinion leaders (OLs)** vs a strategy that does not include OLs or no active intervention	..	..	..	..	..	..	..	..	..	3	0.03 (-0.20, 0.27)	0%	..	..	..	..	..	..	..	..	..

[a] Denotes a statistically significant result (i.e., two-sided p value of less than 0.05)

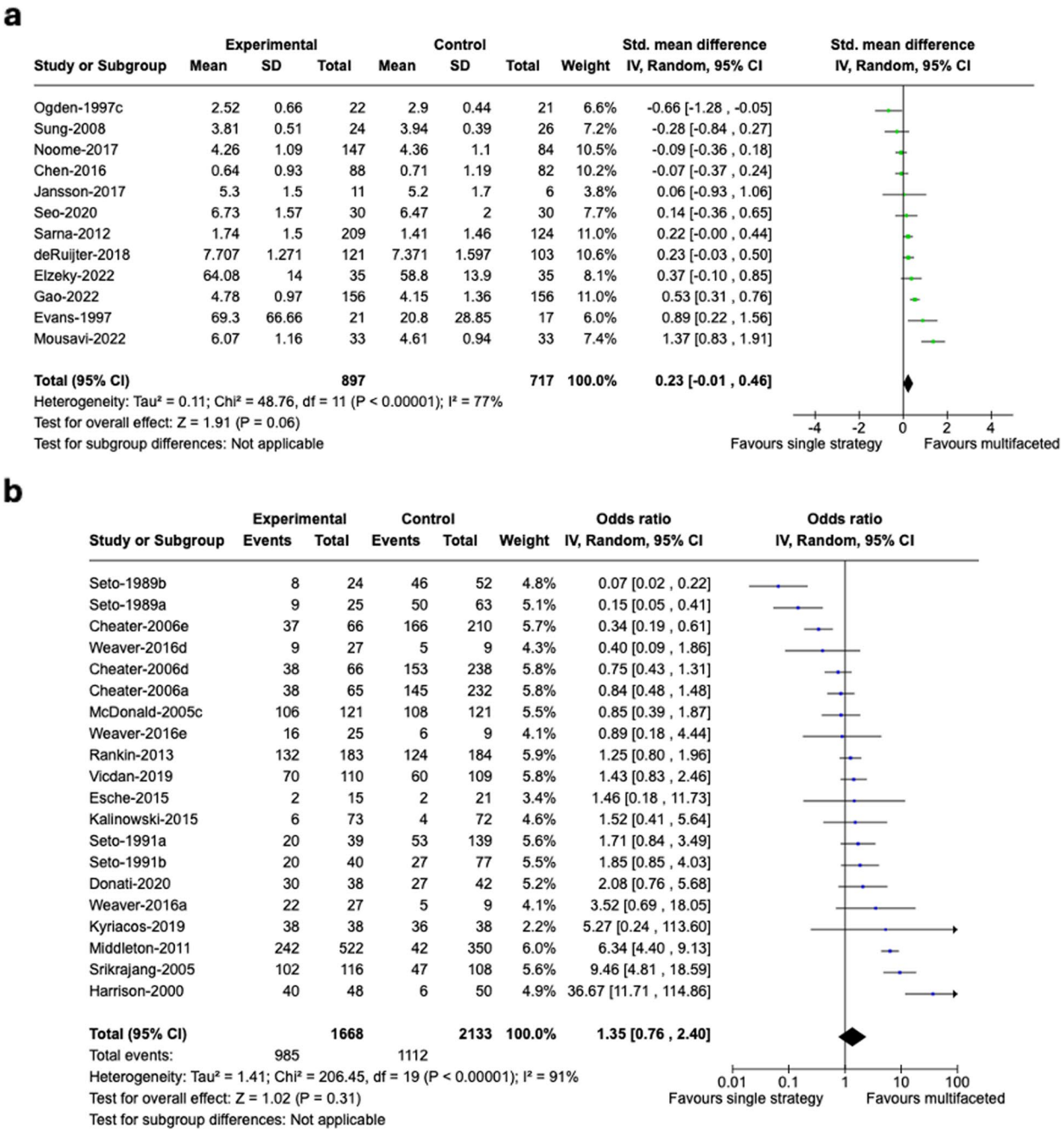

Fig. 6 Effects of multifaceted vs. single strategies on continuous (**a**) and dichotomous (**b**) clinical practice outcomes

studies, implementation strategies targeted multiple clinical behaviors for change, such as providing counseling and advice, practicing hand hygiene, assessing and diagnosing illness, administrating medication and documenting care. Meta-analyses of 160 studies and narrative synthesis of 44 studies not eligible for meta-analysis revealed that both single and multifaceted implementation strategies have positive effects on clinical practice outcomes, with important variability across strategies. Statistically significant and practically meaningful positive effects were also observed for secondary outcomes including nurses' attitudes, knowledge, perceived behavioral control and skills for strategies consisting of individual or group education, reminders, and tailored interventions. Effects on patient outcomes were observed

for group and individual education, as well as tailored interventions.

Our findings are consistent with previous reviews of implementation strategies, demonstrating the positive effects of group and individual education, reminders, patient-mediated interventions, and the involvement of opinion leaders on clinical practice outcomes. A systematic review by Spoon et al. [35] similarly identified a broad spectrum of implementation strategies that positively influenced guideline adherence among nurses and improved patient-reported nursing outcomes. Likewise, Cassidy et al. [34] found that combining educational meetings with other strategies, such as educational materials and opinion leaders, effectively supported guideline-concordant nursing care. Forsetlund et al. [16] associated educational meetings with likely improvements in professional practice and patient outcomes, while Giguère et al [27] observed that printed educational materials, when used alone and compared to no intervention, might improve slightly healthcare professionals' practices and patient health outcomes. Additionally, Flodgren et al. [26] reported that opinion leaders, whether alone or in combination with other interventions, can promote evidence-based practice, though their effectiveness varies across studies. However, despite its widespread use, audit and feedback have shown mixed results. A systematic review by Ivers et al. [94] indicated small improvements in professional practice among physicians but provided limited evidence of effectiveness among nurses. In our meta-analyses, strategies including audit and feedback did not achieve statistically significant impacts on clinical practice outcomes (a sensitivity analysis excluding high-risk-of-bias studies showed a statistically significant effect, but only in two studies). This may be due to limited statistical power, heterogeneity, or limitations of this strategy in inducing practice change among nurses. Notably, while 9 out of 14 studies of strategies including audit and feedback synthesized narratively favored the experimental group in terms of clinical practice outcomes, 8 of these studies involved multifaceted strategies.

Additionally, our review highlights the underuse of many implementation strategies. Ten out of 19 EPOC strategies examined were used in less than 5% of included studies. This suggests a need for further exploration and integration of the full range of EPOC strategies to potentially enhance nursing practice and patient outcomes. Furthermore, there is a need to consider additional taxonomies of implementation strategies, such as the Expert Recommendations for Implementing Change (ERIC) Taxonomy, which outlines 73 unique strategies across 9 clusters [20]. Designing and evaluating multifaceted strategies using a broader range of implementation strategies could help address the gaps in current implementation research and practice. While our exploration of the effects of implementation strategies on determinants of nurses' behavior is novel and provides insights on the effectiveness of educational strategies on attitudes, intentions, knowledge, perceived behavioral control, perceived social norms, and skills, further research could benefit from examining outcomes through the lens of the TDF [14] and the Capability, Opportunity, Motivation and Behavior (COM-B) Model [95], as these frameworks allow for a deeper understanding of the determinants of behavior change.

Our findings contribute to the ongoing discussion about the effectiveness of multifaceted versus single component implementation strategies. An overview of reviews by Squires et al. [96] found no strong evidence that multifaceted strategies significantly improve outcomes compared to single interventions. A more recent overview of reviews by Boaz et al. [25], without quantitative analyses, concluded that the effectiveness of multifaceted strategies compared to single strategies is nuanced and context-dependent. The authors discussed that while multifaceted strategies appear to be more likely to generate positive results than single strategies, the evidence varies, and the impact on patient outcomes is often limited. In our review, while quantitative findings suggest a small, non-statistically significant effect of multifaceted versus single strategies on clinical practice, the narrative synthesis of studies with outcomes ineligible for meta-analysis shows favorable outcomes in all four studies using multifaceted strategies compared to single strategies. These multifaceted strategies typically combined elements such as educational outreach, audit and feedback, tailored interventions, and the use of local opinion leaders. This might indicate that multifaceted strategies can enhance the uptake of evidence-based practice among nurses more effectively than single strategies. However, the translation of these improvements to better patient outcomes is uncertain. Tailoring strategies and ensuring organizational capacity to support research utilization, as emphasized by Boaz et al. [25], are crucial. Our analyses showed that tailored strategies based on contextual assessments of implementation barriers and enablers had significant effects on professional outcomes and patient outcomes. This suggests that strategies customized to address specific barriers and facilitators within a particular context, echoing a previous systematic review by Baker et al., [97] may be more effective in driving improvements in patient care.

The analysis reveals that while implementation strategies can improve clinical practice outcomes among nurses, their impact on patient outcomes is modest. This

Table 6 Overview of quantitative findings, narrative findings and certainty of evidence: implementation strategies compared with different or no active interventions for improving compliance with desired clinical practice and patient outcomes[a,b,c]

Types of interventions and comparisons	Impact		Outcomes and certainty of the evidence (GRADE) for meta-analytic results			
	Quantitative findings (meta-analyses)	Narrative findings	Continuous clinical practice outcomes	Dichotomous clinical practice outcomes	Continuous patient outcomes	Dichotomous patient outcomes
Any implementation strategy vs None	Implementation strategies as a whole, compared to no active intervention, probably improve compliance with desired clinical practice among nurses (moderate certainty of evidence). Implementation strategies may slightly improve patient outcomes (low certainty of evidence)	Among the 21 studies not included in the meta-analysis comparing any implementation strategy to no active intervention, 18 favored the experimental group for clinical practice outcomes	⊕⊕⊕⊖ **Moderate** (26 CRTs, 23 RCTs, 21 NCRS)	⊕⊕⊕⊖ **Moderate** (38 CRTs, 9 RCTs, 11 NCRS)	⊕⊕⊖⊖ **Low** (6 CRTs, 2 RCTs, 2 NCRS)	⊕⊕⊖⊖ **Low** (7 CRTs, 2 RCTs, 3 NCRS)
Multifaceted strategies vs Single	Multifaceted implementation strategies, compared to single component strategies, may slightly improve compliance with desired clinical practice among nurses (low certainty of evidence) and patient outcomes (low to very low certainty of evidence)	Among the 4 studies not included in the meta-analysis comparing multifaceted implementation strategies to single strategies, all favored the experimental group for clinical practice outcomes	⊕⊕⊖⊖ **Low** (3 CRTs, 6 RCTs, 3 NCRS)	⊕⊕⊖⊖ **Low** (9 CRTs, 4 RCTs, 1 NCRS)	⊕⊖⊖⊖ **Very low** (1 CRT, 1 RCT)	⊕⊕⊖⊖ **Low** (3 CRTs)
Group clinician education (GCE) vs No GCE	Implementation strategies including GCE, compared to strategies not including GCE or no active intervention, probably improve compliance with desired clinical practice among nurses (moderate certainty of evidence), and may slightly improve patient outcomes (moderate to low certainty of evidence)	Among the 18 studies not included in the meta-analysis comparing strategies with GCE to those without, 14 favored the experimental group for clinical practice outcomes	⊕⊕⊕⊖ **Moderate** (25 CRTs, 24 RCTs, 19 NCRS)	⊕⊕⊕⊖ **Moderate** (39 CRTs, 6 RCTs, 10 NCRS)	⊕⊕⊕⊖ **Moderate** (6 CRTs, 2 RCTs)	⊕⊕⊖⊖ **Low** (8 CRTs, 2 RCTs, 2 NRCS)
Individual clinician education (ICE) vs No ICE	Implementation strategies including ICE, compared to strategies not including ICE or no active intervention, probably improve compliance with desired clinical practice in nurses (moderate to low certainty of evidence) and slightly improve patient outcomes (moderate certainty of evidence)	Among the 17 studies not included in the meta-analysis comparing strategies with ICE to those without, 15 favored the experimental group for clinical practice outcomes	⊕⊕⊖⊖ **Low** (23 CRTs, 22 RCTs, 17 NCRS)	⊕⊕⊕⊖ **Moderate** (34 CRTs, 7 RCTs, 12 NCRS)	⊕⊕⊕⊖ **Moderate** (7 CRTs, 1 RCT, 2 NRCS)	⊕⊕⊕⊖ **Moderate** (7 CRTs, 1 RCT, 3 NRCS)

Table 6 (continued)

Types of interventions and comparisons	Impact		Outcomes and certainty of the evidence (GRADE) for meta-analytic results			
	Quantitative findings (meta-analyses)	Narrative findings	Continuous clinical practice outcomes	Dichotomous clinical practice outcomes	Continuous patient outcomes	Dichotomous patient outcomes
Reminders vs No Reminders	Implementation strategies including reminders, compared to no reminders or no active intervention, probably improve compliance with desired clinical practice in nurses (high to low certainty of evidence), but probably makes little to no difference in patient outcomes (moderate certainty of evidence)	Among the 4 studies not included in the meta-analysis comparing strategies with reminders to those without or no active intervention, 3 favored the experimental group for clinical practice outcomes	⊕⊕⊖⊖ **Low** (4 CRTs, 2 RCTs, 5 NCRS)	⊕⊕⊕⊕ **High** (16 CRTs, 5 RCTs, 2 NRCS)	..	⊕⊕⊕⊖ **Moderate** (6 CRTs, 2 NRCS)
Patient-mediated intervention (PMI) vs No PMI	Implementation strategies including a PMI, compared to no PMI or no active intervention, may improve compliance with desired clinical practice among nurses (low certainty of evidence), but we are uncertain about their effects on patient outcomes (low certainty of evidence)	..	..	⊕⊕⊖⊖ **Low** (7 CRTs, 1 NRCS)	..	⊕⊕⊖⊖ **Low** (2 CRTs)
Audit and Feedback (A&F) vs No A&F	Implementation strategies including A&F, compared to no A&F or no active intervention, probably slightly improve compliance with desired clinical practice in nurses (moderate certainty of evidence), but may make little to no difference in patient outcomes (low to very low certainty of evidence)	Among the 14 studies not included in the meta-analysis comparing strategies with A&F to those without or no active intervention, 9 favored the experimental group for clinical practice outcomes, though 8 of these were multifaceted strategies	⊕⊕⊕⊖ **Moderate** (5 CRTs, 2 NRCS)	⊕⊕⊕⊖ **Moderate** (13 CRTs, 4 NRCS)	⊕⊖⊖⊖ **Very low** (2 CRTs)	⊕⊕⊖⊖ **Low** (6 CRTs, 2 NRCS)
Tailored Intervention (TI) vs No TI	Tailored implementation strategies, compared to non-tailored strategies or no active intervention, improve compliance with desired clinical practice in nurses (high to moderate certainty of evidence) and probably improve slightly patient outcomes (moderate certainty of evidence)	Among the 5 studies not included in the meta-analysis comparing strategies with TI to those without or no active intervention, all favored the experimental group for clinical practice outcomes	⊕⊕⊕⊖ **Moderate** (3 CRTs, 3 RCTs, 3 NRCS)	⊕⊕⊕⊕ **High** (13 CRTs, 1 NRCS)	⊕⊕⊕⊖ **Moderate** (2 CRTs, 1 RCT)	⊕⊕⊕⊖ **Moderate** (5 CRTs, 1 NRCS)

Table 6 (continued)

Types of interventions and comparisons	Impact		Outcomes and certainty of the evidence (GRADE) for meta-analytic results			
	Quantitative findings (meta-analyses)	Narrative findings	Continuous clinical practice outcomes	Dichotomous clinical practice outcomes	Continuous patient outcomes	Dichotomous patient outcomes
Opinion Leaders (OLs) vs No OLs	Implementation strategies including OLs, compared to no OLs or no active intervention, may improve compliance with desired clinical practice in nurses (low certainty of evidence), but probably make little to no difference in patient outcomes (moderate certainty of evidence)	Among the 5 studies not included in the meta-analysis comparing strategies with OLs to those without or no active intervention, 4 favored the experimental group for clinical practice outcomes	⊕⊕⊖⊖ **Low** (1 CRT, 3 NRCS)	⊕⊕⊖⊖ **Low** (12 CRTs, 1 NRCS)	..	⊕⊕⊕⊖ **Moderate** (4 CRTs)

High certainty: Further research is very unlikely to change our confidence in the estimate of effect

Moderate certainty: Further research is likely to have an important impact on our confidence in the estimate of effect and maychange the estimate

Low certainty: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate

Very low certainty: We are very uncertain about the estimate

[a] See individual 'Summary of findings' tables (by intervention type) for specific impact and rationale for downgrading evidence

[b] *GCE* Group Clinician Education, *ICE* Individual Clinician Education, *PMI* Patient-Mediated Intervention, *A&F* Audit and Feedback, *TI* Tailored Intervention, *OLs* Opinion Leaders, *CRT* Cluster Randomized Trial, *RCT* Randomized Controlled Trial, *NRCS* Non-Randomized Controlled Study

[c] GRADE Working Group grades of evidence

observation aligns with broader research, which suggests that while nurses play a crucial role in healthcare delivery, the direct translation of their practice improvements into measurable patient benefits is influenced by a multitude of factors. The pathway from practice changes to patient outcomes is complex, shaped by organizational culture, patient engagement, and broader systemic issues within healthcare settings [16, 17, 25]. Considering the role of these factors and the influence of other healthcare professionals, nurses can have a nuanced and often indirect influence on patient outcomes within the larger healthcare system [6]. However, several outcomes directly affected by nursing practice were not extracted in the context of this review, such as length of stay, readmissions and patient satisfaction [98]. Additionally, we extracted the longest follow-up measurements for all outcomes, which may have diminished the observed effects. Consequently, it is important to interpret these overall averages and findings with caution, given the effects of strategies may vary significantly depending on the context, target behaviors, actors, outcomes and specific populations involved.

The predominance of studies (190 studies) from high-income countries highlights a critical gap in the literature regarding the effectiveness of implementation strategies on nursing practice in low- and middle-income countries (LMIC). A recent review using the ERIC Taxonomy suggests that many implementation strategies can be applied to LMIC contexts [99]. However, out of 60 studies in this review, a minority of studies employed randomized trials or high-quality quasi-experimental designs with controls, and just one study evaluated implementation strategy effectiveness [99]. Future research should focus on exploring the adaptation and evaluation of professional implementation strategies in diverse contexts to ensure global relevance and equity in healthcare improvements.

A key strength of this systematic review is its focus on nursing practice, improving comparability across studies. The inclusion of studies conducted with multiple types of healthcare providers in previous systematic reviews of implementation strategies constitutes an important source of heterogeneity. Additional strengths include the extraction of continuous and dichotomous clinical practice and patient outcomes, as well as a comprehensive range of determinants preceding clinical practice in nurses (e.g., social norms, attitudes, intentions), providing additional insights on the effects of implementation strategies. Other methodological strengths of the review include contacting all study authors systematically to obtain additional data, the use of the EPOC Taxonomy to guide data extraction and analysis of findings and the use of GRADE to assess the certainty of evidence and enhance the reliability of the review's conclusions.

This review also has limitations. The presence of multiple co-interventions and varying study designs could confound the results, making it challenging to isolate the effect of specific implementation strategies. Some studies were judged to have a high risk of bias, potentially affecting the reliability of the findings, though sensitivity analyses were conducted to exclude these studies. Additionally, we could not abstract some important factors, such as organizational and contextual characteristics, and the effects of implementation strategies depend on engagement with the intervention, which was not measured or reported in many studies. We synthesized and described a very large, heterogeneous dataset, which we believed could not be meaningfully summarized effectively through a narrative approach alone. The meta-analyses demonstrated substantial heterogeneity for most analyses (I^2 often above 75%), indicating significant variability in the effect sizes across studies. This high heterogeneity can reduce the reliability of the pooled estimates and suggests that the effects of implementation strategies may differ substantially depending on the context and specific characteristics of each study. There was considerable variation in the measurement and reporting of clinical practice and patient outcomes across studies. This variation complicates the comparison and synthesis of results and may contribute to the observed heterogeneity. For these reasons, the findings from our quantitative analyses should be interpreted with caution given that they rely on heterogenous and moderate quality data, and as a quantitative aid to the narrative synthesis.

This comprehensive review offers several actionable recommendations and implications for healthcare systems. Implementation practitioners and healthcare organizations may consider adopting and investing in multifaceted, tailored, context-specific strategies that address local barriers and leverage facilitators for the successful implementation of evidence-based interventions in nursing practice. Furthermore, practitioners and organizations should also consider expanding the repertoire of strategies they employ, incorporating underutilized strategies listed in the EPOC Taxonomy such as local consensus processes, patient-mediated interventions, and continuous quality improvement, while exploring additional strategies outlined in the ERIC Taxonomy. Finally, there is need for ongoing monitoring and evaluation mechanisms to assess the long-term impact of implementation strategies on both clinical practice and patient outcomes.

Conclusions

Implementation strategies play a crucial role in enhancing evidence-based nursing practice and potentially improving patient outcomes. Future research should

focus on exploring how different healthcare settings and contexts influence the effectiveness of implementation strategies; investigating the sustainability and long-term impact of strategies on both clinical practice and patient outcomes; evaluating the effectiveness of novel and underutilized implementation strategies; evaluating the effectiveness of implementation strategies in diverse healthcare systems (particularly in LMICs); and designing trials that more rigorously measure the direct impact of implementation strategies on patient outcomes.

Abbreviations

A&F	Audit and feedback
CHG	Chlorhexidine gluconate
CLABSI	Central line-associated bloodstream infections
CI	Confidence interval
CIR	Clinical incident reporting
CPG	Clinical practice guidelines
COP	Communities of practice
CQI	Continuous quality improvement
CRT	Cluster randomized trial
EGames	Educational games
EMat	Educational materials
EMeet	Educational meetings
EO	Educational outreach
EPOC	Effective Practice and Organisation of Care Group
ERIC	Expert Recommendations for Implementing Change
ICU	Intensive care unit
IPE	Inter-professional education
LCP	Local consensus processes
LMIC	Low and middle-income countries
MPDH	Monitoring the performance of delivery of healthcare
MS	Managerial supervision
OL	Local opinion leaders
OR	Odds ratio
PMI	Patient-mediated interventions
R	Reminders
RCT	Randomized control trial
RevMan Web	Review Manager Web
RoB 2	Risk of Bias 2
ROBINS-I	Risk Of Bias in Non-randomized Studies-of Interventions
RPROM	Routine patient-reported outcome measures
SD	Standard deviation
SDG	Sustainable Development Goals
SMD	Standardized mean difference
TI	Tailored interventions

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Supplementary Material 5.

Supplementary Material 6.

Supplementary Material 7.

Supplementary Material 8.

Supplementary Material 9.

Supplementary Material 10.

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Authors' contributions

GF conceptualized the study, developed the research questions, and defined the scope of the review. GF, in collaboration with a Research Librarian, designed and ran the search strategies. Title and abstract screening were performed by GF, BV, MAMC, ALav, MFD, ALap, GC, GR and CP. The full text review was carried out by GF, BV, MAMC, ALav, MFD, ALap, GC, GR, CEC and CP. Data extraction and risk of bias assessment were conducted by GF, BV, CW, MAMC, ALav, MFD, ALap, SAC, GC, GR, NA, MM, CEC, CP, TM and PL. GF, BV, CW, and NA managed the data cleaning and performed the meta-analyses, which were reviewed by KK. GF, BV and CW prepared the tables and figures, while GF and CW led the narrative synthesis and drafted the manuscript. KK, SC, MPG, SS, NS and SM provided critical input into the organization, analysis, and interpretation of the results. All authors read and approved the final manuscript.

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Availability of data and materials

All data are included in this published article and its supplementary information files.

Declarations

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Competing interests

The authors declare that they have no competing interests.

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