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Review

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Oral hygiene and periodontal treatment interventions for reducing blood pressure in hypertensive adults from low and middle-income countries: a systematic review

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Abstract

Introduction: *while previous systematic reviews have established a link between periodontal diseases and hypertension in high-income countries, evidence from Low and Middle-Income Countries (LMICs) remains scarce. This systematic review aimed to fill this gap by evaluating the impact of oral hygiene education and periodontal therapy on reducing high blood pressure in hypertensive patients.* ***Methods:*** *we conducted a comprehensive search of clinical trials and cohort studies published between 2000-2022 across PubMed, SCOPUS, Medline, CINAHL, and Google Scholar. Secondary outcomes included changes in blood levels in pro-inflammatory C-reactive protein (CRP) and interleukin-6 (IL-6), and anti-inflammatory interleukin-10 (IL-10). Quality and risk of bias were evaluated using the Joanna Brings Institute Appraisal Checklists.* ***Results:*** *out of 519 records, we included four articles that met the eligibility criteria. Three studies from Brazil and one from Syria assessed the primary outcomes of systolic and diastolic blood pressure (SBP/DBP) among hypertensive patients (SBP/DBP≥140/90mmHg) undergoing periodontal treatment and oral hygiene education. Three out of four studies demonstrated important reductions in SBP and DBP with average reductions of 12.5 mmHg and 10.0 mmHg, respectively, in response to oral hygiene and periodontal therapy. Furthermore, three studies reported decreases in systemic inflammatory markers, including CRP, cytokines, triglycerides, and erythrocyte sedimentation rate (ESR).* ***Conclusion:*** *this systematic review underscores the potential of periodontal therapy and oral hygiene education in managing hypertension, especially in resource-constrained LMICs. Further research is essential to validate these findings and address the specific needs of diverse populations in these regions.*

Introduction

Hypertension is globally defined as a systolic arterial blood pressure (SBP) ≥ 140mmHg and a diastolic blood pressure (DBP) ≥90mmHg [1], affecting over 30% of the adult population worldwide. It stands as a leading causative factor for cardiovascular diseases [2], resulting in high mortality rates due to fatal heart attacks and strokes [3]. Confirmed risk factors for hypertension, include poor oral hygiene, diabetes, and tobacco smoking [4].

Periodontitis is a major global health burden, with an estimated 50% of the population affected globally and severe periodontitis represents the 6th most prevalent disease worldwide (11.2%) [5,6]. Despite variations in periodontal disease classifications globally, severe periodontitis remains a significant concern [7,8]. In the USA, the National Health and Nutrition Examination Survey (NHANES) between 2009-2012 revealed that 8.9% of the population presented with severe periodontitis [9]. In Low and Middle-Income Countries (LMICs), as defined as countries with low, lower-middle, or upper-middle-income economy according to the World Economic Situation and Prospect (WESP) and World Bank [10,11], the prevalence of severe periodontitis tends to be much higher, such as 42.2% in Ethiopia [12] and 43.4% in the Ivory Coast [13]. Prevalence of periodontitis was also high in East African countries, with Rwanda reporting 39.6% of their adult population as having periodontitis among people attending the Rwanda Military Hospital [14]. In Uganda, 28.6% of young adults [15], and in Kenya varies between 12-24% in adults [16]. These disparities highlight the need for intervention studies on oral and systemic health in specific LMICs populations.

Recent studies have also shown that oral disease including periodontitis (gum disease), may also be associated with hypertension. However, data on

these associated risks are mainly derived from high income countries, emphasizing the need for more mechanistic and interventional studies in low and middle-income countries [5,17,18]. Elevated cardiovascular markers such as CRP, IL-6, fibrinogen, and systemic inflammation are predictors of increased blood pressure [19,20], making them potential secondary outcomes, to assess systemic responses to both hypertension and periodontitis, aspects not fully evaluated in previous systematic reviews.

Individuals with moderate to severe periodontitis appear to have greater (20%) odds of developing hypertension [21], with the likelihood increasing with hypertension (49%) [9]. In addition, Desvarieux *et al.* demonstrated in the USA that people with periodontitis had a higher risk of developing hypertension, associated with an increasing bacterial load due to subgingival plaque [22]. Systematic reviews from developed countries including Poland, Japan, Sweden, and USA, consistently demonstrate two to three times higher odds for hypertension in individuals with periodontitis [23,24]. Studies from Tanzania, India, and Cameroun have reported an association between periodontitis and hypertension [25,26]. Therefore, there is need to study both hypertension and periodontitis considering the scarcity of evidence in Africa (LMICs) [27].

Another pertinent piece of evidence is the observation that successful treatment of periodontal disease by non-surgical therapy (sometimes called root planning, root surface debridement depending on the country) may lower blood pressure, namely decrease hypertension [24,28]. Hence, this systematic review aims to evaluate oral hygiene education and periodontal therapy's effectiveness in reducing high blood pressure among hypertensive patients in LMICs.

Methods

Protocol and registration

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [29]. The systematic review protocol was registered in PROSPERO with registration ID: CRD42022375002.

Search strategy

We searched the following electronic databases: PubMed, Medline, CINAHL EBSCO HOST Scopus, with a supplement of Google Scholar for relevant published articles in English from January 2000 to December 2022. We used the search terms to identify relevant articles: periodontal diseases, periodontitis, periodontic, periodontal attachment loss, hypertension, high blood pressure, arterial blood pressure, oral hygiene, oral hygiene instruction, periodontal treatment, dental scaling, dental prophylaxis, periodontal therapy, sub gingival scaling, root planning. We used Boolean operators such as "AND" and "OR" to find out the related articles. For additional articles, we conducted a manual search and examined reference lists to retrieve relevant citations.

Study eligibility

We followed PICO outline for this review. We included studies on hypertensive and pre-hypertensive individuals (female and males) with periodontitis who were aged from 18 to 65 years old. We also included studies that evaluated the efficacy of Oral Hygiene Education and periodontal therapy (supra and subgingival scaling) by comparing them with the usual care. The outcomes were reduction of diastolic and Systolic Blood Pressure (SBP) following periodontal therapy and oral hygiene education. Furthermore, primary outcomes were changes in blood pressure (SBP and DBP) among patients undergoing periodontal treatment and oral hygiene instructions, whereas the secondary outcomes were changes in systemic levels of CRP and pro-

inflammatory (IL-6,) and anti-inflammatory (IL-10) cytokines, endothelial function, oral bacteria and periodontal clinical parameters of hypertensive patients such as clinical attachment loss, pocket depths and bleeding on probing.

Inclusion and exclusion criteria

This study considered only articles published in peer-reviewed journals with the following inclusion criteria: randomized clinical trials, cohort studies, and case-control studies. Additionally, reported articles in English focusing on periodontitis (all stages), oral hygiene and periodontal treatment (non-surgical therapy), and reducing high blood pressure defined as hypertension according to the appropriate classification system were included. Articles on case reports, case series, cross-sectional studies, and those reporting on pregnant and lactating women with hypertension were excluded, as well as articles on other systemic diseases other than hypertension. Furthermore, articles reporting on countries other than Low and Middle-Income Countries (LMICs) as defined by the World Economic Situation and Prospect (WESP) and World Bank [10,11] were excluded.

Screening and selection of papers

This process involved two steps. Firstly, the retrieved titles and abstracts detected by the search were exported to Covidence [30], duplicates were removed. Secondly, two independent reviewers independently screened the titles and abstracts and conducted full-text assessments of potential eligible studies. Any disagreements were resolved by consensus through discussion if not, a third reviewer was consulted. A list of excluded studies is provided in Annex 1. Two reviewers who retrieved the potential eligible studies included in our study performed independent full-text reading. Four included studies (two cohorts and two clinical trials) that met the inclusion were captured. The results of the search are presented in a PRISMA flow diagram (Figure 1).

Data extraction

Two authors and an assistant researcher independently performed data extraction. The included studies were presented in an evidence table describing study characteristics, population, type of interventions, and effect of intervention on periodontal diseases and high blood pressure (hypertension). Any disagreements that arose between the reviewers were resolved through discussion. Characteristics of included studies are presented in Table 1.

Synthesis of the results

Due to the high degree of heterogeneity in the included studies (study designs, intervention details, outcome measures), meta-analysis was not conducted. We presented our results in tables and synthesized our results narratively.

Results

A flow diagram illustrating the studies selection process is presented in Figure 1. The electronic searches across five databases yielded 519 records, which were then reduced to 492 records after removing duplicates. A total of 492 records were screened for titles and abstracts. Subsequently, 27 articles underwent full-text screening, resulting in the exclusion of 23 articles that did not meet the eligible criteria outlined in our inclusion criteria. The excluded studies are detailed in Annex 1. Finally, four articles were included in this review.

Study characteristics

All included studies are summarized in Table 1. Among the four included studies, two were randomized clinical trials, and two were cohort studies. The sample sizes ranged from 22 to 64 participants [31,32].

Risk of bias assessment

The methodological quality utilized the Joanna Briggs Institute appraisal checklist for the critical

appraisal of the included studies [33]. All included studies were appraised for quality by two independent reviewers, with contentious issues resolved through discussion. Randomized controlled trials (RCTs) generally reported most items compared to cohort studies. The Figure 2 and Figure 3 presents the methodological quality assessment of cohort studies and RCTs, respectively. The PRISMA guidelines were followed, and any discrepancies were resolved through discussions.

Confirmation of an effective intervention

Confirmation of successful interventions (oral hygiene and periodontal therapy) is crucial for the validity of this review, considering the known variability in managing periodontal disease among clinicians. The interventions varied, with one study involving non-surgical periodontal therapy only [34] and the other three studies involving a combination of oral hygiene instruction and non-surgical therapy [31,32,35].

The oral hygiene education in both cohort studies involved demonstrating tooth brushing techniques and utilization of dental floss. The successful intervention was confirmed by decreases in plaque and bleeding on probing, from 45.7% to 19.4% after intervention [34,35]. These studies reported improvement in periodontal outcomes, including periodontal Pocket Depth (PD), (4 to 5mm in 19.5%-4.9% sites, $P<0.001$ and > 6mm in 9.1%-1.2% of sites, $P<0.02$) and Clinical Attachment Loss (CAL), (4 to 5mm in 23.7%-18.4% of sites, $P<0.014$; CAL≥6 in 24.5%-11.2% of sites, $P<0.002$). Notably in the control group, there was no change in periodontal parameters at baseline at 3 months follow up to the oral hygiene and non-surgical therapy intervention. Furthermore, Caula *et al.* (2014) demonstrated additional improvements in periodontal pocket depth, bleeding on probing, clinical attachment loss, and enhanced indices of oral hygiene at 6 months following the intervention [32].

Periodontal therapy in three studies involved supra and sub-gingival scaling using both manual and ultrasonic machines, alongside root planning to treat periodontal pocket depths greater than 4mm (PDD>4mm). Despite some variation in approach, successful treatment was confirmed by significant ($p<0.05$) reeduction in pocket depths, bleeding on probing and clinical attachment loss at 6 weeks to 3 months [31,32,34].

Primary study outcomes

The intervention led to an immediate decrease in blood pressure after 6 weeks to 3 months in hypertensive patients after treatment [31,34]. Significant decreases in both mean systolic blood pressure, SBP (175 to 157 mmHg) and mean diastolic blood pressure, DBP (from 105 to 95 mmHg) were observed in response to oral hygiene and periodontal therapy.

Confirmation of successful interventions (oral hygiene and periodontal therapy) is essential for the validity of this review, bearing in mind the known variability in the successful management of periodontal disease amongst clinicians [36]. For non-surgical therapy, the intervention in two cohort studies involved supra and sub gingival scaling with both manual and ultrasonic machines along with root planning in periodontal pocket depths of greater than 4mm (PDD>4mm). This resulted in reduced pocket depths, bleeding on probing and clinical attachment loss, all indicative of a reduced severity of periodontal diseases, confirming the successful treatment.

Non-surgical therapy and oral hygiene education intervention in both cohort studies also included a demonstration of tooth brushing techniques and the utilization of dental floss. The success of this intervention was confirmed by decreases in plaque and bleeding on probing, from 45.7% to 19.4% after the intervention. At 6 months follow-up after non-surgical therapy and oral hygiene intervention, blood pressure and periodontal clinical parameters still demonstrated a significant association between successful periodontal

treatment and the reduction of blood pressure during hypertension among study patients, with treatment provided alongside oral health education [31,32].

Secondary outcomes

Hypertensive patients undergoing concurrent periodontal treatment and oral hygiene education concurrently reported a positive impact on reduction of SBP (175 to 157 mmHg) and DBP (105 to 95 mmHg). They also experienced a significant decrease in cardiovascular biomarkers, including fibrinogen (from 376gm/dl to 344gm/dl, p<0.001) CRP (from 0.6mg/dl to 0.3mg/dl; p<0.001) and IL-6 (from 2.1pg/ml to0.9pg/ml) [34,35].

From the two clinical trials included in this systemic review involving hypertensive patients, significant changes were observed at baseline and 3 months follow up after the intervention. One study demonstrated a notable decrease in bleeding on probing (BOP) (45.5%-11.4% of sites; P<0.002), pocket depth (PD) (4 to 5mm in 19.5%-4.9% sites, P<0.001 and > 6mm in 9.1%-1.2% of sites, P<0.02) and CAL (4 to 5mm in 23.7%-18.4% of sites, P<0.014; CAL>or=6 in 24.5%-11.2% of sites, P<0.002). In contrast, the control group showed no change in periodontal parameters. Additionally, a significant reduction in cardiovascular markers was noted in hypertensive patients following the intervention, including IL-6 (24.4-10pg/ml, P=0.03), fibrinogen (407-348mg/dl, P=0.003) and CRP (1.4-0.9mg/dl, P=0.005), all associated with reduced blood pressure, at baseline and 3 months follow up. Conversely, in the control group, levels of CRP (0.5-1.1mg/dl, P=0.01) and IL-6 (7-24.9mg/dl, P=0.01) increased significantly [31]. The two clinical trials included in this review reported a reduction in cardiovascular markers after 3-6 months of follow-up, along with improvement in Systolic Arterial Pressure (SAP) and Diastolic Arterial Pressure (DAP) in hypertensive patients [32].

Discussion

The current systematic review aimed to evaluate the effectiveness of oral hygiene and periodontal treatment interventions (non-surgical periodontal therapy) in reducing high blood pressure among adults with hypertension in Low and Middle-Income Countries (LMICs). The interventions demonstrated concurrent effectiveness in improving periodontal disease indicators, such as bleeding on probing, pocket depths, and clinical attachment loss among hypertensive individuals. The findings of this systematic review align with previous evidence from high-income countries, emphasizing the association between periodontal diseases and hypertension [37-40]. Secondary outcome measures indicated that periodontitis in LMICs was associated with elevated cardiovascular markers, including CRP, IL-6, and fibrinogen, which are predictors of high blood pressure [41,42].

This systematic review affirms the impact of periodontal treatment combined with oral hygiene instruction in reducing blood pressure among hypertensive patients in LMICs. Four included studies support the relationship, in turn supporting the association between periodontal disease and hypertension. The association between periodontal diseases and hypertension is consistent with other studies predicting the gingival bleeding up and probing pocket depth correlating with hypertension in high-income countries [43]. However, the geographical distribution of the included studies, with one cohort study from Syria, and three (two clinical trials and one cohort study) from Brazil, underscores a critical gap in research conducted in Africa, particularly sub-Saharan Africa. This highlights the urgent need for intervention studies addressing the relationship between periodontal diseases and hypertension, in a broader range of geographic locations, especially in Africa.

Regarding follow-up durations, cohort studies from Syria and Brazil reported no reduction in blood pressure among hypertensive patients at 6

to 12 months post non-surgical periodontal treatment together with oral hygiene education. These findings contrast with other studies showing a decrease in blood pressure immediately following interventions, emphasizing the importance of sustained oral hygiene practices for long-term effectiveness [3,5,36,44]. Similarly, in previous studies, there was no decrease in blood pressure within a long-term clinical trial after non-surgical periodontal treatment including oral hygiene education [44,45]. These findings may be related to the fact that excellent personal oral hygiene is key to long-term periodontal treatment effectiveness, yet many patients fail to maintain immaculate oral hygiene. Effective oral hygiene and periodontal therapy were demonstrated in two clinical trials, as evidenced by improved periodontal parameters in the intervention group compared to the control group. These improvements included a significant decrease in bleeding on probing, pocket depth, and clinical attachment loss.

The review also delves into the impact of periodontal therapy on systemic inflammatory biomarkers, such as CRP, IL-6, and fibrinogen, which are elevated in periodontitis patients. The observed reductions in these biomarkers following periodontal treatment and oral hygiene education align with the broader literature associating improved oral hygiene with decreased inflammation and cardiovascular risk [46]. One explanation for increased levels of inflammatory mediators following interventions is that periodontal pathogens reach the bloodstream through periodontal pockets, then initiating inflammatory responses involving elevated inflammatory biomarkers, such as CRP, TNF-α, and IL-6 [3,41,47,48]. Indeed, increases in these systemic inflammatory biomarkers are linked to poor oral hygiene and other cardiovascular diseases, therefore improvement of oral hygiene has a direct effect on the reduction of inflammatory biomarkers [3,48]. Similarly, in the studies reviewed here, periodontal treatment and oral hygiene induced significant reductions in cardiovascular markers, such as IL-6 (P=0.03), fibrinogen (P=0.003), CRP (P=0.005).

Furthermore, if oral hygiene education and periodontal therapy lead to a reduction in cardiovascular biomarkers, as shown in the studies included in this review, this evidence may support a causal explanation for the link between periodontal disease and hypertension. Changes in cardiovascular inflammatory markers in individuals with periodontitis can also contribute to vascular alterations and arterial stiffness, culminating in hypertension [49]. Prolonged vascular alterations may, in turn, progress to atherosclerosis, emphasizing the potential long-term implications of periodontal diseases [41]. The impact of periodontal diseases on systemic vasculature is multifaceted, involving decreased release of endotoxins from oral bacteria. This process, initiates CRP and anti-inflammatory cytokines, leading to endothelial dysfunction [36,50].

The significance of this systematic review extends beyond specific regions or income categories. It holds relevance for scientists and individuals worldwide, reflecting the emergence of global communities with increasingly diverse populations. Despite its valuable insights, the limited number of studies included in this review necessitates caution in drawing conclusive links between periodontitis and hypertension in countries beyond Syria and Brazil. The critical dearth of research in Africa, particularly in sub-Saharan Africa, underscores an urgent need for comprehensive studies due to the high prevalence of periodontitis in these populations. The scarcity of African studies during the literature search resulted in none being included in this systematic review, emphasizing the pressing requirement for research initiatives that can contribute to a more comprehensive understanding of the global implications of the relationship between periodontitis and hypertension.

Moreover, the limited recognition of blood pressure management as a strategy to improve oral health in hypertensive patients, in contrast to

diabetes, where the links between periodontal disease and poor glycemia control have been more widely proven [51,52] underscores the need for increasing awareness and integration of oral health practices in hypertension management guidelines.

The study recommends frequent tooth brushing, effective interdental cleaning, and regular dental service visits for patients with periodontitis particularly those with elevated blood pressure [48]. By reducing oral and then systemic inflammation, oral health promotion may potentially decrease the risk and progression of cardiovascular disease. The four studies in this review suggest that preventing and treating periodontitis may reduce the risk of occurrence of hypertension in certain LMICs, similar to high-income countries where systematic review research has reported a similar association [24,45,47,53].

Limitation

Despite its contributions, this systematic review faces limitations. The scarcity of studies in Africa precluded a comprehensive analysis of the link between periodontitis and hypertension in this region. Methodological variations among the included studies, including population differences, study settings, and diagnostic criteria for periodontitis, further complicate cross-country comparisons. The absence of intraoral radiographic examinations in all studies raises concerns about the accuracy of periodontal disease diagnosis.

Conclusion

In conclusion, this research contributes to the global understanding of the role of oral health in hypertensive patients, advocating for the integration of oral hygiene and periodontal non-surgical therapy in hypertension management in LMICs. The study highlights the potential of periodontal therapy to reduce the risk and progression of cardiovascular diseases by addressing oral and systemic inflammation. The findings underscore the importance of oral health promotion in reducing the occurrence of hypertension, mirroring associations observed in high-income countries. Recommendations for LMICs include prioritizing oral health practices alongside conventional hypertension management strategies.

What is known about this topic

- *Association between periodontal diseases and hypertension has been consistently reported in high-income settings;*
- *People with periodontitis are at higher risk of developing hypertension from increased bacterial load due to sub-gingival plaques.*

What this study adds

- *This study highlights the potential of integrating oral hygiene education and periodontal therapy in the management of hypertension;*
- *Additionally, it also emphasizes on increase oral health knowledge and practices among hypertensive patients.*

Competing interests

The authors declare no competing interests.

Authors' contributions

All authors contributed to the conception, design, and interpretation of results. Agnes Gatarayiha participated in the writing of the first draft. All authors revised critically the manuscript and agreed to submit the final manuscript for publication. All authors contributed to the conception, design, and interpretation of results. All authors They equally read and approved the final manuscript.

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Tables and figures

Table 1: characteristics and main findings of included studies

Figure 1: PRISMA flow diagram/chart illustrating the study selection process

Figure 2: quality assessment of cohort studies included in the review

Figure 3: quality assessment for RCTs included in the review

Annex

Annex 1: list of excluded studies (PDF - 113KB)

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Table 1: characteristics and main findings of included studies

Study details	Intervention	Control/comparison	Study duration	Major findings
Albush M. M., et al. (2013) Study design-Cohort Sample size= 40 Country - Syria	Surgical periodontal treatment	Non-surgical treatment, full mouth scaling and root planning	6 weeks	Improvement of periodontal status Activation of the coagulation system Reduction in BOP, CAL, PDD
Caúla AL *et al.* (2014) Study design-Clinical trial Sample size=64 (32 test group, 32 control group) Country-Brasilia	Periodontal treatment, oral hygiene instruction and monitoring, supra and subgingival scaling and root planning	Delayed periodontal treatment without periodontal treatment	1 year 6 months	Improvement of periodontal status in the test group. Worsening of periodontal status in the control group. Reduction of erythrocyte sedimentation rate (ESR) in the test group. Reduction of triglycerides in the test group Reduction of C-reactive protein (CRP) in the test group, Reduction in blood pressure in the test group, Reduction of BOP, CAL, PDD
Vidal F *et al.* (2013) Study design-Interventional prospective cohort Sample size=26 Country-Brasilia	Periodontal treatment, oral hygiene instruction, supra and subgingival scaling and root planning	None	unknown	Improvement of periodontal status Reduction of erythrocyte sedimentation rate (ESR), Reduction of triglycerides Reduction of C-reactive protein (CRP) Reduction in blood pressure Reduction of arterial stiffness and Reduction of BOP, CAL, PDD
Vidal F *et al.* (2009) Study design-Clinical trial Sample size=22 Country-Brasilia	Periodontal treatment, oral hygiene instruction, supra and subgingival scaling and root planning	Delayed periodontal treatment	3 months	Improvement of periodontal status in the intervention group Reduction of erythrocyte sedimentation rate (ESR) in the test group Reduction of triglycerides in the test group Reduction of C--reactive protein (CRP) in the test group, Reduction in Blood pressure and Reduction of BOP, CAL, PDD

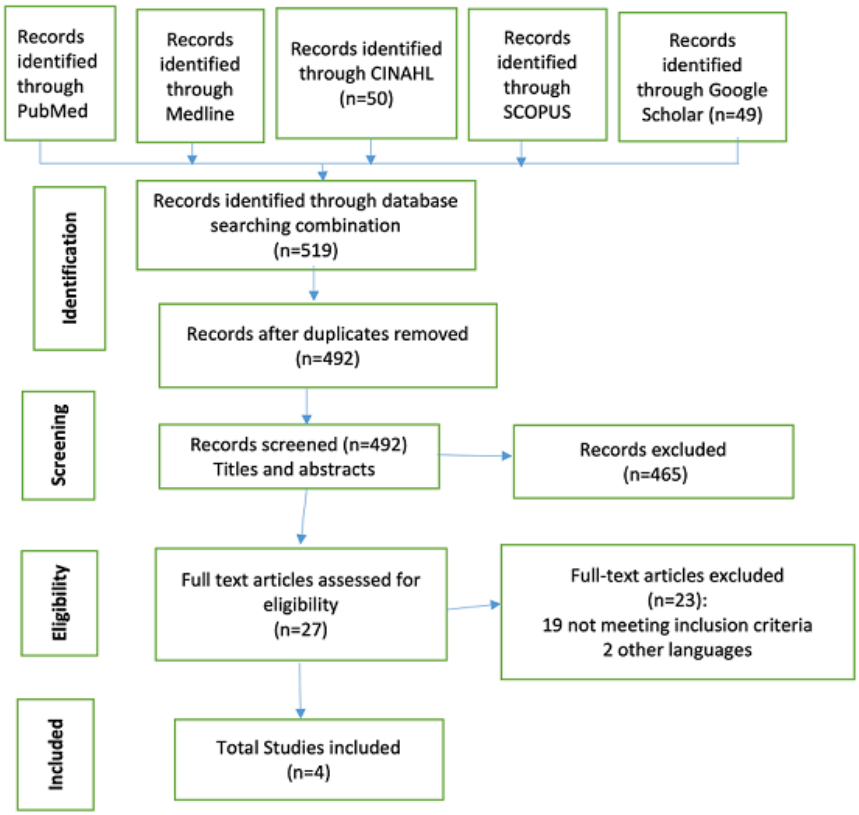

Figure 1: PRISMA flow diagram/chart illustrating the study selection process

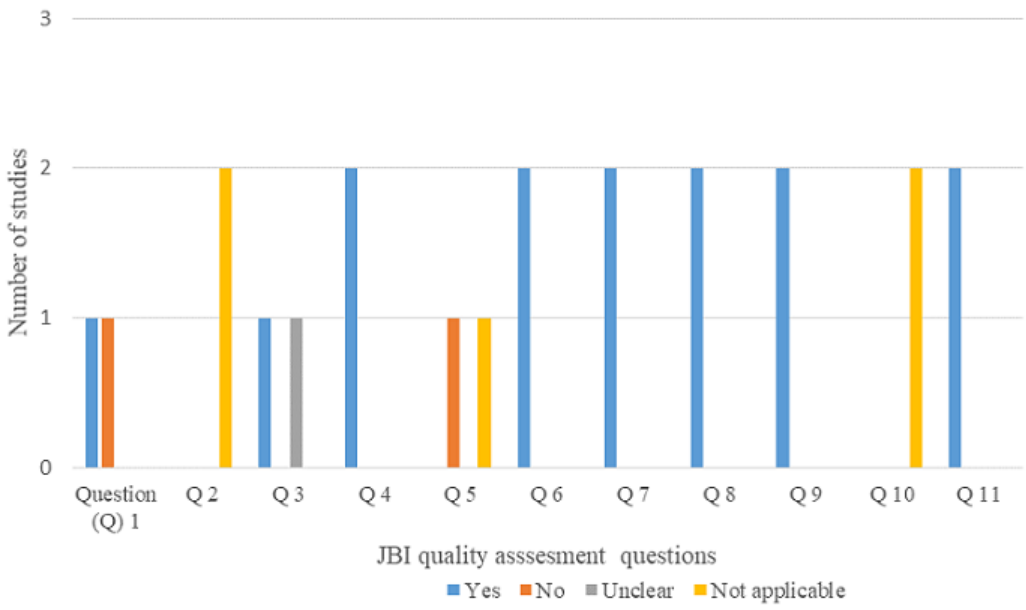

Figure 2: quality assessment of cohort studies included in the review

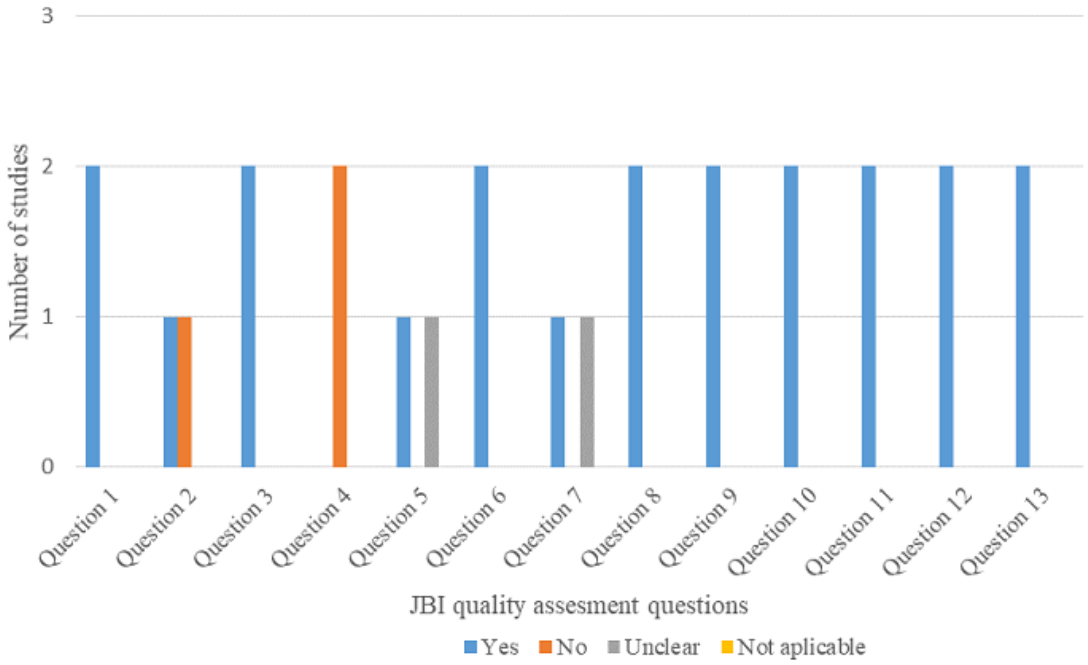

Figure 3: quality assessment for RCTs included in the review