Non-pharmacological management of dental fear and anxiety in children and adolescents: An umbrella review



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Abstract

Aim To synthesise knowledge on the relative efficacies of non-pharmacological strategies for managing dental fear and anxiety (DFA) in children and adolescents, specifically their effects on behaviour, anxiety levels and pain perception.

Materials and methods An umbrella review on non-pharmacological strategies used to manage DFA in children and adolescents was conducted based the Joanna Briggs Institute methodology. Searches were performed in 5 main electronic databases and the grey-literature. Two independent reviewers selected and appraised the included studies using the AMSTAR2 tool. Disagreements were resolved by a third reviewer.

Results From 191 studies, 13 systematic reviews (SRs) were included and the majority were of low or critically low quality. Findings from the SRs suggest that audio-visual distraction was the most effective strategy for reducing anxiety, but effects on pain perception and behaviour were inconclusive. Traditional behaviour management techniques and audio distraction had mixed outcomes. Other strategies like aromatherapy and cognitive behaviour therapy were found to be effective for reducing anxiety but the evidence was weak.

Conclusions Audio-visual distraction was effective in reducing anxiety during a variety of dental procedures including those requiring local anaesthesia. A combination of techniques may be more effective in managing DFA in children and adolescents, possibly improving pain perception and cooperative behaviour.

KEYWORDS Dental anxiety; Child behaviour; Meta-Analysis; Systematic Review.

Introduction

Dental fear is an unpleasant emotional reaction to specific threatening stimuli occurring in situations associated with dental treatment, while dental anxiety is an excessive and unreasonable negative emotional state experienced by patients at the dental office [Klingberg and Broberg, 2007]. Dental Fear and Anxiety (DFA) will be used throughout this review when referring to strong negative emotions associated with dental treatment [Klingberg and Broberg, 2007]. A recent systematic review found that DFA prevalence was significant in children and adolescents (aged 0–19 years), with at least 10% having a level of DFA that hindered their ability to tolerate dental treatment. The prevalence varied widely from 10.0% to 29.3%, owing to differences in study design, sampling methods, type of instrument (questionnaires) used, and socio-economic variables [Cianetti et al., 2017].

The methods used to assess DFA often involve (i) behavioural assessment by an observer, (ii) psychometric assessment involving completion of questionnaires by either the child or parental proxy, (iii) physiological response analysis, which measures parameters such as pulse rate [Porritt et al., 2013]. Various psychometric assessments instruments have been developed including the Children's Fear Survey Schedule-Dental Subscale (CFSS-DS), Dental Fear Schedule Subscale-Short Form (DFSS-SF), Modified Dental Anxiety Scale (MDAS), Modified Child Dental Anxiety Scale (MCDAS) and Dental Fear Survey (DFS) [Cianetti et al., 2017].

DFA often leads to uncooperative behaviours at dental visits, compromising dental care [Kyritsi et al., 2009]. Various techniques have been proposed for behaviour guidance, ranging from basic non-pharmacological strategies, to pharmacological interventions such as sedation and general anaesthesia. Non-pharmacological behaviour management strategies are commonly used to shape a child's behaviour in the dental office, equipping the child with coping skills, instilling positive attitudes, building trust, and allowing treatment to be provided effectively and efficiently. These include traditional techniques such as communication and communicative guidance, and non-traditional techniques such as cognitive behavioural therapy (CBT) and audio-visual (AV) distraction (Table 1). Communicative guidance techniques aim to maintain communication, such as tell-show-do, voice control, non-verbal communication, positive reinforcement, modelling, parental presence/absence, and distraction [Subcommittee and Affairs, 2008]. With aims to modify and restructure negative beliefs and improve control of negative thoughts so as to reduce dental anxiety, CBT has proven effective in the extremely anxious and phobic subjects [Gomes et al., 2018]. AV distraction involves diverting patient's attention from perceived unpleasant procedure, so as to avoid negative behaviours. These distraction techniques are particularly useful in young children aged 5 to 9 [Al-Halabi et al., 2018, Al-Khotani et al., 2016].

Numerous systematic reviews have focused on various non-pharmacological strategies in behaviour management, but an overall examination of these disparate reviews is lacking.

	Non-pharmacological strategies	Description
Traditional	Communicative guidance	
	Tell-show-do	The procedure is introduced in a stepwise fashion; a verbal explanation in language appropriate to the child's understanding (tell) is followed by demonstration of the visual/auditory/olfactory/ tactile aspects of the procedure (show), and finally performed immediately without delay (do).
	Voice control	Controlled alterations of voice volume, tone or pace to gain the child's attention and encourage a particular behaviour
	Non-verbal communication	Reinforcement and guidance of behaviour through appropriate contact, posture, facial expression and body language
	Positive reinforcement	Strengthening of desired behaviours through rewards or verbal praise, which makes recurrence of these behaviours more likely
	Modelling	The child observes and imitates a model of similar status and gender
	Parental presence/absence	Parental presence in the dental operatory offers physical and psychological support, and may help the child feel safe in an unfamiliar environment
	Distraction	Diverting the patient's attention from what may be perceived as an unpleasant procedure
Non-traditional	Cognitive behavioural therapy	A combination of behavioural (systematic desensitisation and relaxation) and cognitive (cognitive restructuring) interventions aimed at improving control of negative thoughts so as to reduce dental anxiety
	Audio-visual distraction	Diverting the patient's attention from what may be perceived as an unpleasant procedure, using audio-visual means

TABLE 1 Non-pharmacological strategies in behaviour management.

PICO - Population, Intervention, Comparison, Outcome	
Population	Children and adolescents aged between 0 and 19 years attending a dental clinic for dental visits or treatment
Intervention	Non-pharmacological strategies aimed at managing DFA
Comparison	No interventions and/or pharmacological strategies
Outcomes	Primary outcomes: anxiety levels, pain perception, behaviour rating, completion of procedure (yes/no), adverse events Secondary outcomes: parental satisfaction and acceptance of techniques, duration of dental visit

TABLE 2 PICO framework for review questions.

An "umbrella review" is an increasingly popular approach to analyse systematic reviews on a defined topic. Therefore, the aim of this umbrella review was to appraise the evidence on the effect of non-pharmacological interventions on behaviour, anxiety levels and pain perception in children and adolescents undergoing dental procedures. There are also other non-pharmacological dental anxiety management techniques such as non-traditional caries removal treatments [Cianetti et al., 2018] to avoid the most common fear triggers; however, this review essentially examines the psychological methods of controlling anxiety and uncooperative behaviours in children.

Materials and methods

This umbrella review was developed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [Moher et al., 2009] and Joanna Briggs umbrella review methodology [Aromataris et al., 2014]. The protocol was registered in the Prospective Register of Systematic Reviews (PROSPERO) database, and is publicly available under the registration number CRD42020173846.

Eligibility criteria

Systematic reviews (SRs), with or without meta-analysis, investigating the effects of non-pharmacological strategies to manage DFA in children and adolescents undergoing dental procedures were considered. Only publications written in English were included.

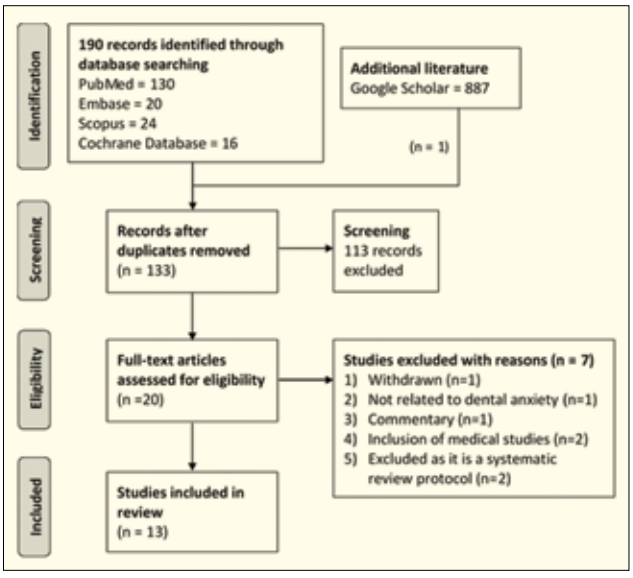


FIG. 1 PRISMA Flow diagram of literature search and selection criteria.

Audio-visual distraction (multimedia devices)						
Author (Year); Journal	Objectives or research question	Databases searched (search date)	Included primary studies	Population characteristics	Description of interventions Setting	
López-Valverde et al. [2020]; Journal of Clinical Medicine	To compare the effectiveness of virtual reality as a method for reducing anxiety and pain levels during dental treatment.	PubMed, EMBASE, MEDLINE, CENTRAL, Wiley Library, Web of Science (Nov 2019)	7 RCT	497 children, age range: 4–11	Virtual reality (glasses, smartphone, earphones) Setting Dental treatment (prophylaxis, restorations, pulp therapy, extractions) ± LA	
Custódio et al. [2020]; Pediatric Dentistry	To investigate the effect of virtual reality glasses as an audiovisual distraction technique on dental anxiety, pain perception, and behaviour triggered during dental treatment in children up to 12 years old.	PubMed (via MEDLINE), Scopus, Web of Science, LILACS, Google Scholar (Sep 2018)	9 RCT	579 children, age range: 4–10 No disabilities, with or without history of previous dental care	Virtual reality (eyeglasses) Setting Dental treatment requiring LA (restorations, pulp therapy, rubber dam)	
Gujjar et al. [2019]; The Journal of Evidence-Based Dental Practice	To evaluate the effectiveness of technology-based interventions for the treatment of dental anxiety in children and adults.	PubMed, EMBASE, MEDLINE, PsycINFO, CINAHL, Scopus, The Cochrane Library (25 Jul 2018)	3 RCT	208 children, age range: 4–16 No mental, physical, learning disability, non-emergency treatment	Audio and AV clips, video, songs, cartoons Modelling using video (2 studies) Setting Dental treatment (restorations, pulp therapy, extractions) ± LA	
Prado et al. [2019]; International Journal of Paediatric Dentistry	To determine whether distraction techniques reduce children's/ adolescent's anxiety and fear during dental treatment.	PubMed, Web of Science, Scopus, The Cochrane Library, LILACS, Google Scholar (Jul 2018)	20 RCT	1407 children, age range: 4–16 No alterations in growth and development, no cognitive disorders or syndromes	Audio distraction AV distraction Instrument camouflage (syringe and needle) Biofeedback therapy Dental operating microscope Toys Setting Dental examination Dental treatment (prophylaxis, restorations, pulp therapy, extractions) ± LA	
Liu et al. [2019]; International Journal of Paediatric Dentistry	To evaluate the efficacy of audiovisual distraction techniques on the management of dental anxiety in children.	PubMed, EMBASE, CENTRAL (Dec 2017)	9 RCT	697 children, age range: 3–16 Healthy with prior dental treatment	Video eyewear/glasses (4 studies) Eyeglass system (3 studies) Laptop with earphones (1 study) Virtual Reality Setting No details given, just stated "dental procedures"	
Barreiros et al. [2018]; Journal of Indian Society of Pedodontics and Preventive Dentistry	To evaluate the effectiveness of audiovisual distraction methods for children who experience anxiety during dental treatment	PubMed, Web of Science, Scopus, Cochrane (Nov 2015)	4 CCT	304 children, age range: 4–10	AV distraction Setting Dental examination Dental treatment (prophylaxis, restorations, fluoride, extractions) ± LA	
Zhang et al. [2019]; Oral Diseases	To perform a systematic review and meta-analysis on the effects of audiovisual distraction on reducing dental anxiety in children during dental treatment under local anaesthesia.	PubMed, EMBASE, CENTRAL (23 Oct 2017)	6 RCT 3 CCT	528 children, age range: 3–14 Normal vision and hearing, without systemic diseases or mental disorders, no previous dental experience in 5 studies	AV distraction Laptop/eyeglass/projector Setting Dental treatment under LA, conducted in paediatric dentistry clinic settings	
Moola et al. [2011]; JBI Library of Systematic Reviews	To evaluate the effectiveness of music interventions on dental anxiety in paediatric and adult patients.	EMBASE, MEDLINE, Web of Science, Scopus, CENTRAL, Cochrane Oral Health Group Database, CINHAL, ERIC, Google Scholar, Index to Theses, Directory of Open Access journals, Networked Digital Library of Theses, Mednar (Oct 2010)	1 Quasi-randomised controlled trial 1 Quasi-experimental study	85 children, age range: 4–8 No pre-existing conditions or special needs	Upbeat music distraction vs relaxing music distraction Instrumental music vs nursery rhymes Setting Dental examination (first visit), dental treatment under LA for restorations and extractions (second, third, fourth visits)	

Audio-visual distraction (multimedia devices)					
	Description of comparators	Risk of bias assessment tools	Main results	Main conclusion	Funding
	No virtual reality	Cochrane Collaboration's risk of bias tool	Anxiety: The composite measure is significant (MD = –1.75; 95% CI, –3.06, –0.43; p = 0.009; I2 = 51%) Tools of measurement: MDAS, VCARS, FLACC pain scale Pain: Children are significantly protected (MD = –1.46; 95% CI, –2.54, –0.37; p = 0.008; I2 = 49%) Tools of measurement: W-BFS, FPS-R	VR is an effective tool to reduce dental anxiety and pain in children during a variety of dental procedures.	Nil
	Behavioural techniques (e.g. distraction, direct observation, tell-show-do, voice control, nonverbal communication, positive reinforcement) Inactive controls (no behavioural techniques mentioned)	Cochrane Collaboration's risk of bias tool GRADE tool	Overall quality of evidence was classified as mostly moderate, due to imprecision of the estimates. Behaviour: VR eyeglasses improved behaviour, measured by FLACC (MD = –0.26; 95% CI, –0.47, –0.06; p = 0.673; I2 = 0%) Anxiety: VR eyeglasses significantly reduced anxiety (MD = –3.37; 95% CI, –4.57, –2.18; p = 0.000; I2 = 70.8%) Tools of measurement: MCDAS, pulse rate Pain: VR eyeglasses significantly reduced pain perception (MD = –0.46; 95% CI, –0.91, –0.01; p = 0.000; I2 = 81.7%) Tools of measurement: W-BFS, FPS-R	The use of VR eyeglasses is an effective tool for improving behaviour, reducing anxiety and pain perception during dental treatment in children.	This study was conducted in a Graduate Program supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES; Finance Code 001), Brasília, Brazil.
	No video Control video (oral hygiene instructions in a non-clinical setting)	Cochrane Collaboration's risk of bias tool	Overall ROB was high. Anxiety: There was significantly greater pre-post reduction in dental anxiety scores after administration of a video modelling intervention. (Al-Namankany A., 2015; A. Al-Namankany, 2016) Behaviour: Children were more cooperative, relaxed and less anxious in the following order: AV>Audio>control group (Kaur, R et al. 2017)	A limited number of studies supported the effectiveness of technology-based interventions in the treatment of dental anxiety in children.	Nil
	Various controls depending on intervention	Cochrane Collaboration's risk of bias tool GRADE tool	Very low certainty of evidence. Major concerns with regard to indirectness (very serious), risk of bias (serious), inconsistency (serious), and imprecision (serious). Audio distraction: Lower levels of anxiety (both objective and subjective measures) in children who listened to songs/nursery rhymes/stories AV distraction: Lower levels of dental anxiety and fear in children using 3D/VR eyeglasses, TV and computer screen for local anaesthesia and other dental procedures. Biofeedback therapy: Lower levels of anxiety (based on pulse rate and blood pressure volume) in children during restorative procedures Camouflaging syringes during local anaesthesia in children <15 years old resulted in better behaviour	There is a very low certainty of evidence that distraction techniques can be effective in managing children's/adolescents' dental fear and anxiety during dental treatment.	Funded by Brazilian agencies: the Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development) (CNPq), the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (Research Support Foundation of the State of Minas Gerais) (FAPEMIG), and the Pró-Reitoria de Pesquisa Universidade Federal de Minas Gerais (PRPq/UFMG)
	Without distraction (3 studies) Placebo, e.g. glasses (2 studies) Other behaviour management (2 studies) iPad (1 study) Projector (1 study)	Cochrane Collaboration's risk of bias tool	All 9 studies were of low quality, none were at low risk of bias. Comparing between AV distraction and control groups, Anxiety: 3 studies reported significant differences in the Faces version of MCDAS (MD = –5.78; 95% CI, –10.82, –0.74; p = 0.02; I2 = 99%) Pain: 3 studies reported no significant difference in the Faces Pain Scale (MD = –0.64; 95% CI, –2.89, –1.60; p = 0.57; I2 = 94%) Behaviour: 6 studies reported inconsistent results on behaviour Vital signs: no significant differences in blood pressure (1 study), oxygen saturation (2 studies), pulse rate (6 studies). For pulse rate; MD = –4.09; 95% CI, –15.35, 7.17; p = 0.48; I2 = 86% Satisfaction: 3 studies reported that the majority of children were significantly more satisfied in the AV group	There is some low quality evidence suggesting that AV distraction during dental treatment may relieve children's dental anxiety.	National Natural Science Foundation of China (Grant/Award Number: 81670978 to XZ), the Key Project for Frontier Research of Science and Technology Department of Sichuan Province (2016JY0006 to XZ), and the Novel Clinical Technology R&D project from West China Hospital of Stomatology (LCXJS2015-3 and LCXJS-2017- 13 to XX).
	No distraction (different group of children) No distraction (cross over)	Cochrane Collaboration's risk of bias tool	A high variability was observed among the papers. AV distraction significantly decreased anxiety; the analysis of the subgroups according to tool of measurement found an association when the MCDAS was used (MD = –8.72; 95% CI, –16.07, –1.38; p = 0.02; I2 = 96%), but there was no association when Venham's picture test was used (MD = –0.15; 95% CI, –0.42, 0.12; p = 0.29; I2 = 0%).	AV distraction is effective for controlling dental anxiety in children	Nil
	No AV distraction Only visual or auditory distraction (e.g. music) Cognitive or behavioural techniques	Cochrane Collaboration's risk of bias tool	All 9 studies had high risk of bias, due to high performance bias. Comparing between AV distraction and control groups, Anxiety (self-reports): 3 studies reported no difference Vital signs: 6 studies reported that AV distraction significantly lowered pulse rate (MD = –3.78; 95% CI, –6.73, –0.83; p = 0.01; I2 = 61%). 2 studies reported no effect on oxygen saturation (MD = 0.47; 95% CI, –0.35, 1.29; p = 0.26; I2 = 44%). Behaviour: 7 studies reported that AV distraction reduced anxiety perception, improved children's cooperation and nurtured a positive dental attitude during dental treatment.	AV distraction effectively reduced dental anxiety among children.	Program for BMP9 Regulates Osteogenic/Odontogenic Differentiation of iSCAP (Stem Cells from the Apical Papilla) through MAPK Pathway and Program for Innovation Team Building at Institutions of Higher Education in Chongqing (CXTDG201602006).
	No music or placebo (headphones without music)	JBI-SUMARI	JBI level of evidence: II Anxiety: There was no significant difference in anxiety (self-reported and parental perception of child's anxiety) or pulse rate of children who listened to upbeat or relaxation music, as compared to no music (control). (Aitken et al 2002) Listening to instrumental music significantly decreased levels of anxiety (self-reported) and mean pulse rate in children, as compared to listening to nursery rhymes. (Marwah et al 2005)	There was inconclusive evidence on the effectiveness of music in reducing dental anxiety in children.	Not stated

TABLE 3 Included SR characteristics.

Audio-visual distraction (multimedia devices)

Author (Year); Journal	Objectives or research question	Databases searched (search date)	Included primary studies	Population characteristics	Description of interventions Setting
Traditional behavioural management techniques					
De Stefano et al. [2019]; Minerva Stomatologica	To evaluate all methods used for management of anxiety and stress during dental therapies including safety and effectiveness	PubMed, EMBASE, MEDLINE, Dentistry and Oral Sciences source (May 2019)	15 RCT	1052 children, age range not stated	Behaviour management: Tell-Show-do (3 studies) Reward (1 study) Distraction (2 studies) Modelling (1 study) Hypnosis (1 study) Computerized anaesthesia (1 study) Pharmacological management (6 studies) Setting not stated
Goettems et al. [2017]; Academic Pediatrics	To systematically review trials on the effect of nonpharmacologic interventions in behaviour, anxiety, and pain perception in children undergoing dental treatment.	MEDLINE, Scopus, Web of Science, CINAHL, Google Scholar, manual search of reference lists (Feb 2016)	21 RCT	1728 children/adolescents, age range: 2–17 Not physically or mentally handicapped, with or without a history of dental care	Virtual reality Music Magic tricks Modelling Exposure to dentally positive images Providing information or preparation Distraction with counter stimulation Distraction with movements Noncontingent stops Camouflage of syringe Setting A wide range of dental treatment (details in supplementary table)
Zhou et al. [2011]; Patient Education and Counseling	To review the literature of the past 30 years on the effects of dental staff behaviour on the anxiety and behaviour of child dental patients.	PubMed, EMBASE, Web of Science, The Cochrane Library, PsycINFO, CINAHL, Google Scholar (Jan 2010)	8 observational 3 CCT	397 children, age range: 3–13 years	Dental staff behaviour: non-procedural touch, voice control, positive and negative reinforcement Setting Dental examination Dental treatment (restorations, extractions) ± LA
Others (aromatherapy, cognitive behaviour therapy)					
Cai et al. [2020]; Oral Diseases	To evaluate the efficacy of aromatherapy on dental anxiety, compared to either negative control without aromatherapy or other positive non-aromatherapy interventions (e.g. music).	PubMed, EMBASE, CDSR, CENTRAL, CNKI, grey literature databases, manual search of reference lists (10 Jan 2020)	2 RCT	60 children, age range: 6–9	Aromatherapy (orange fragrance) Setting Dental examination Dental treatment (restorations, prophylaxis, sealants)
Gomes et al. [2018]; International Journal of Paediatric Dentistry	To systematically review evidence of the effectiveness of cognitive behaviour therapy for children with dental anxiety or dental phobia.	PubMed, EMBASE, Web of Science, Scopus, PsycINFO, The Cochrane Library, LILACS, Clinical trial registries, grey literature databases (Apr 2018)	6 RCT	269 children, age range: 41 months to 18 years	Cognitive behaviour therapy (range from 1 to 10 sessions) through modelling, relaxation training, distraction and positive/calming self-talk Setting Radiographs Dental examination Dental treatment (prophylaxis, restorations, pulp therapy, extractions) ± LA

Notes. All studies declared no conflict of interest. Abbreviations: CDSR, Cochrane Database of Systematic Reviews; CENTRAL, Cochrane Central Register of Controlled Trials; LILACS, Latin American & Caribbean Health Sciences Literature; ERIC, Education Resources Information Center; CNKI, China National Knowledge Infrastructure; ROBINS-I, Risk Of Bias In Non-randomized Studies of Interventions; GRADE, Grades of Recommendation, Assessment, Development and Evaluation; JBI-SUMARI, Joanna Briggs Institute Systems for the Unified Management, Assessment and Review of Information; ROB, risk of bias; RCT, randomised controlled trial; CCT, controlled clinical trial; CI, confidence interval; MD, mean difference; AV, audio-visual; VR, virtual reality; LA, local anaesthesia; CBT, cognitive behaviour therapy; MCDAS, Modified Child Dental Anxiety Scale; MDAS,

Audio-visual distraction (multimedia devices)				
Description of comparators	Risk of bias assessment tools	Main results	Main conclusion	Funding
Traditional behavioural management techniques				
Description of comparators	**Risk of bias assessment tools**	**Main results**	**Main conclusion**	**Funding**
Depends on intervention	Cochrane Collaboration's risk of bias tool	Narrative results of individual studies only	There are many different methods to manage anxiety and fear of dental treatment.	Not stated
Non-intervention (usual treatment or inactive controls) Other interventions or variations of the same intervention (active controls)	Cochrane Handbook for Development of Systematic Reviews of Intervention	Comparing between intervention and control groups, Virtual reality: 2 studies reported that video distraction had no effect on anxiety. 1 study reported that VR eyeglasses reduced anxiety levels and decreased scores on the Faces Pain Scale. 1 study reported that VR eyeglasses resulted in significantly less disruptive behaviour. Music: 1 study reported that music had no significant effect on behaviour, pain perception or anxiety. Another study reported no effect on anxiety. Magic tricks: 1 study reported more cooperative behaviour in the intervention group. Modelling: 1 study reported significantly lower average pulse rate over the entire treatment period among children live-modelled by the mother than among those live-modelled by the father or an inactive control group. Exposure to dentally positive images: 1 study reported significantly lower anxiety scores in the intervention group. Another study reported no effect on anxiety. Providing information or preparation: 1 study reported lower scores of pain and anxiety in the intervention group. Another study reported no differences. Distraction with counter stimulation: 1 study reported reduced pain in the intervention group	Results are mixed, with most studies suggesting that non-pharmacologic interventions had a positive effect on children's behaviour, anxiety, and pain perception.	Not stated
No voice control, reinforcement	Not reported	Anxiety: punishment (verbal statements of criticism for non-compliance) resulted in the highest self-reported fear. Cooperation/behaviour: dental staff behaviours (e.g. giving clear and specific instructions, an empathic communication style, appropriate level of physical contact, verbal reassurance) reduced fear-related behaviours and encouraged children's cooperation. Findings regarding positive reinforcement and dentists' experience increasing cooperative behaviour were inconsistent. Restraining and punishment-oriented behaviours were most likely to result in fearful behaviour.	The review confirmed the existence of a relationship between certain dental staff behaviours and child anxiety and/or behaviour in a dental setting.	Childsmile evaluation programme
Others (aromatherapy, cognitive behaviour therapy)				
Description of comparators	**Risk of bias assessment tools**	**Main results**	**Main conclusion**	**Funding**
No aromatherapy	Cochrane Collaboration's risk of bias tool GRADE tool	Overall ROB was unclear. Certainty of evidence: low to very low Aromatherapy significantly reduced saliva cortisol levels and pulse rate during dental prophylaxis and fissure-sealant therapy compared to no aromatherapy (Jafarzadeh et al 2013). Aromatherapy sustained blood pressure and pulse rate, and relieved dental anxiety during their first dental visit compared to no aromatherapy (Soni et al., 2018).	Aromatherapy used in dental clinics may reduce dental anxiety and anxiety-related physiological parameters compared to no aromatherapy.	Graduate Student's Research and Innovation Fund of Sichuan University (Grant: 2018YJSY108); the China Postdoctoral Science Foundation Funded Project (Grant: 2018M640931); the Science & Technology Key Research and Development Program of Sichuan Province (Grant: 2019YFS0142); and the National Natural Science Foundation of China (Grant: 81901060).
Conventional behavioural management techniques, nitrous oxide/oxygen, sedation, general anaesthesia, non-intervention, sensory information, modelling, information dissemination, and waiting list	Cochrane Collaboration's risk of bias tool GRADE tool	ROB was high in 2 RCTs and unclear in 4 RCTs. Low quality of evidence due to small sample sizes and data imprecision. Comparing between CBT and control groups, Anxiety/fear: 5 studies reported that CBT significantly decreased levels of anxiety/fear, regardless of the evaluation tool of anxiety/fear or the evaluation time of CBT after receiving the treatment. Cooperation/behaviour: 3 studies reported that CBT had a positive effect. Avoidance behaviour to dental clinical situations: 2 studies reported that CBT improved avoidance behaviour.	Cognitive behaviour therapy produces better anxiety reduction than diverse behavioural management techniques but the evidence was of low quality.	CEDACORE (Children Experiencing Dental Anxiety: Collaboration on Research and Education)

Modified Dental Anxiety Scale; VCARS, Venham's Clinical Anxiety Rating Scale; FLACC, Face, Legs, Activity, Cry, Consolability scale; W-BFS, Wong–Baker Faces Scale; FPS-R, Faces Pain Scale-Revised;
The Cochrane Library includes CDSR and CENTRAL.
Grey literature databases for Cai et al 2020 include: ClinicalTrials.gov, International Clinical Trials Registry Platform, ProQuest Dissertation Abstracts and Thesis database, Conference Proceedings Citation Index-Science, Open SINGLE (System for Information on Gray Literature in Europe) database.
Clinical trial registries for Gomes et al 2018 include: ISRCTN registry, UK National Institute for Health and Care Excellence, and International Clinical Trials Registry Platform.

Study	Q1	Q2†	Q3	Q4†	Q5	Q6	Q7†	Q8	Q9†	Q10	Q11†	Q12	Q13†	Q14	Q15†	Q16	Overall confidence
López-Valverde et al. [2020]	Y	N	N	PY	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Critically low
Custódio et al. [2020]	Y	PY	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Medium
Cai et al. [2020]	Y	Y	N	N	Y	Y	N	Y	Y	N	?	?	Y	Y	?	Y	Critically low
De Stefano et al. [2019]	Y	Y	N	PY	Y	Y	N	Y	Y	N	?	?	N	N	?	Y	Critically low
Gujjar et al. [2019]	Y	Y	N	PY	Y	Y	N	Y	Y	N	?	?	Y	Y	?	Y	Low
Prado et al. [2019]	Y	Y	N	Y	Y	Y	Y	Y	Y	N	?	?	Y	Y	?	Y	Medium
Liu et al. [2019]	Y	N	N	N	Y	Y	N	PY	Y	N	Y	N	N	Y	N	Y	Critically low
Gomes et al. [2018]	Y	PY	N	Y	Y	Y	N	Y	Y	N	?	?	Y	Y	?	Y	Low
Barreiros et al. [2018]	Y	Y	N	PY	Y	Y	N	Y	N	N	Y	N	N	N	N	Y	Critically low
Zhang et al. [2019]	Y	N	N	PY	Y	Y	Y	Y	PY	N	Y	N	Y	Y	Y	Y	Low
Goettems et al. [2017]	Y	N	Y	PY	Y	Y	N	Y	Y	N	?	?	Y	Y	?	Y	Critically low
Moola et al. [2011]	Y	Y	N	Y	Y	Y	Y	Y	Y	N	?	?	Y	Y	?	Y	Medium
Zhou et al. [2011]	Y	N	N	PY	Y	N	N	PY	N	N	?	?	N	N	?	Y	Critically low

Notes. Abbreviations: Y, Yes; PY, Partial Yes; N, No; ? – No meta-analysis conducted. † AMSTAR2 identifies 7 domains (items 2,4,7,9,11,13,15) which can critically affect the validity of a review and its conclusions. AMSTAR2 checklist (16 items) as follows:
Q1. Did the research questions and inclusion criteria for the review include the components of PICO?
Q2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
Q3. Did the review authors explain their selection of the study designs for inclusion in the review?
Q4. Did the review authors use a comprehensive literature search strategy?
Q5. Did the review authors perform study selection in duplicate?
Q6. Did the review authors perform data extraction in duplicate?
Q7. Did the review authors provide a list of excluded studies and justify the exclusions?
Q8. Did the review authors describe the included studies in adequate detail?
Q9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
Q10. Did the review authors report on the sources of funding for the studies included in the review?
Q11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?
Q12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?
Q13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?
Q14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?
Q15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?
Q16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

TABLE 4 Study quality assessment using the AMSTAR2 tool.

The review questions were developed based on the PICO (population, intervention, comparison and outcome) framework (Table 2):

- What are the various non-pharmacological strategies to manage DFA in children and adolescents?
- How do the non-pharmacological strategies affect behaviour, anxiety levels and pain perception of children and adolescents during dental procedures, as compared to no interventions and/or pharmacological strategies?
- How do the non-pharmacological strategies affect the ability to complete dental treatment or the duration of the dental visit?
- What adverse events were reported?
- How acceptable are non-pharmacological strategies to parents?

Information sources and search strategy

Relevant SRs using the following MeSH terms to formulate a specific search strategy were identified: dental fear, dental anxiety, non-pharmacological, behaviour management. The electronic search was performed in the following electronic databases: Cochrane Database of Systematic Reviews, Cochrane Database of Abstracts of Reviews of Effects, PubMed, Scopus and Embase. In addition, reference lists of included SRs were hand-searched to identify other relevant SRs. A grey literature search was conducted on Google Scholar. All electronic database searches were performed from 22 May 2020 through 28 February 2021.

Study selection and data extraction

Two independent reviewers (SJQ, SH) screened the titles and abstracts to identify SRs for inclusion. Full-text screening were conducted for SRs considered potentially valid for this review. Disagreements were resolved by discussion and, if necessary, with the help of a third reviewer (AUY). The study screening process followed the PRISMA flow diagram guidelines. Two independent reviewers (SJQ, SH) performed the data extraction and results were consolidated. Pooled results were extracted from reviews containing meta-analyses.

Assessment of methodological quality

Two independent reviewers (SJQ, SH) appraised the methodological quality of included SRs using the AMSTAR2 tool (a measurement tool to assess systematic reviews) [Shea et al., 2017]. A threshold level of at least 80% for degree of agreement between reviewers were accepted. If this threshold was not achieved, a third reviewer (AUY) would arbitrate and obtain consensus. The AMSTAR2 checklist consisted of 16 items, out of which seven domains (items 2, 4, 7, 9, 11, 13, 15) were listed by the AMSTAR2 tool, that could critically affect the validity of a review and its conclusions. Each SR was rated on the overall confidence in its results, based on: high (≤1 non-critical weakness), medium (>1 non-critical weakness), low (1 critical weakness ± non-critical weakness), and critically low (>1 critical weakness ± non-critical weakness) overall confidence. The degree of agreement between the two independent reviewers (SJQ, SH) and intra-examiner agreement in assessing the methodological quality of included SRs were calculated by Cohen's kappa analysis.

Summary measures

A qualitative analysis of results was performed to summarize the efficacy of the non-pharmacological strategies according to the type of intervention. Effects on behaviour, anxiety levels and pain perception were considered. Efficacy through relative or absolute frequencies, standardised or weighted mean differences and qualitative data, were evaluated.

Results

Study selection

Out of 191 references identified, 133 were considered after duplicates were removed. After the title and abstract of identified studies were assessed, 20 articles were selected for full-text screening. A final list of 13 SRs (which cited 90 primary studies) was included for qualitative analysis. The complete process of SR selection is shown in Figure 1 and the excluded full-text screening articles with reasons is shown in Supplemental Table S1.

Study characteristics

All included SRs were published between 2011 and 2020. The types of interventions, settings and key narrative findings are summarised in Table 3. Eight SRs predominantly covered AV distraction [López-Valverde et al., 2020; Gujjar et al., 2019; Prado et al., 2019; Barreiros et al., 2018; Zhang et al., 2019; Liu et al., 2019; Moola et al., 2011; Custódio et al., 2020]. Three SRs focused on traditional behaviour management techniques [De Stefano et al., 2019; Goettems et al., 2017; Zhou et al., 2011] (e.g. tell-show-do, modelling, distraction, positive/negative reinforcement), and 1 each on aromatherapy [Cai et al., 2020] and CBT [Gomes et al., 2018]. None of the included SRs evaluated outcomes regarding successful completion of dental treatment, duration of the dental visit, adverse events and parental acceptance of the non-pharmacological strategies. A list of the primary studies cited across included SRs is shown in Supplemental Table S2.

Quality assessment of included studies

Overall, 3 SRs were judged to be of medium quality [Prado et al., 2019; Moola et al., 2011;Custódio et al., 2020], 3 were of low quality [Gujjar et al., 2019; Gomes et al., 2018; Zhang et al., 2019] and 7 were of critically low quality [López-Valverde et al., 2020; Barreiros et al., 2018; Liu et al., 2019; Cai et al., 2020; De Stefano et al., 2019; Goettems et al., 2017; Zhou et al., 2011] (Table 4). There was very good inter-rater reliability (r = 0.85) between the 2 reviewers using the AMSTAR2 tool.

Effectiveness of interventions

Audio-visual distraction (multimedia devices)

Effects on anxiety levels. The majority of SRs [López-Valverde et al., 2020; Gujjar et al., 2019; Prado et al., 2019; Barreiros et al., 2018; Zhang et al., 2019; Liu et al., 2019; Custódio et al., 2020] suggest that AV distraction was effective in reducing anxiety during a variety of dental procedures including treatment requiring local anaesthesia (LA). However, a wide range of multimedia devices was used, including audio clips, music, video clips, smartphone, laptop with earphones, eyeglass systems and virtual reality (VR). One SR found that AV distraction (3D/VR eyeglasses, TV, computer screen) resulted in lower levels of dental anxiety in children, based on both objective and subjective measures of anxiety [Prado et al., 2019]. The use of VR resulted in a significant reduction (Mean Difference (MD) = –1.75; P=0.009) in self-reported anxiety measured by MDAS and Venham's Clinical Anxiety Rating Scale (VCARS) [López-Valverde et al., 2020]. A significant reduction in anxiety measured using the Faces version of the MCDAS were reported in 2 SRs (MD = –5.78; P=0.02 [Liu et al., 2019] and MD = –8.72; P=0.02 [Barreiros et al., 2018]). The use of VR eyeglasses significantly reduced anxiety measured using MCDAS and pulse rate (MD = –3.37; P=0.000) [Custódio et al., 2020]. However, another SR found no significant differences in anxiety measured by Venham's picture test (MD = –0.15; P=0.29) [Barreiros et al., 2018]. The effect of AV distraction on physiological measures of anxiety was inconsistent. One SR found no significant differences in vital signs such as blood pressure, oxygen saturation, and pulse rate (MD = –4.09; P=0.48) [Liu et al., 2019] while another SR [Zhang et al., 2019] found that AV distraction significantly lowered pulse rate (MD = –3.78; P=0.01) but had no effect on oxygen saturation (MD = 0.47; P=0.26). For audio distraction only (no visual), Prado et al. [2019] found that listening to music and children's stories during some treatment procedures reduced dental anxiety. Conversely, 2 SRs [Goettems et al., 2017, Moola et al., 2011] evaluated the effectiveness of music distraction during dental treatment in children and found no significant difference in anxiety.

Effects on pain perception. The effect of AV distraction on pain perception was inconsistent. Two SRs reported a significant reduction in children's pain perception measured by the Wong Baker Faces Scale and the Faces Pain Scale Revised (MD = –1.46; P=0.008 [López-Valverde et al., 2020] and MD = –0.46; P=0.000 [Custódio et al., 2020]). Conversely, there were no significant differences in pain perception (MD = –0.64; P=0.57), measured using the Faces Pain Scale [Liu et al., 2019].

Effects on behaviour. Four SRs suggest a positive impact, where AV distraction resulted in more cooperative behaviour [Gujjar et al., 2019; De Stefano et al., 2019; Zhang et al., 2019; Custódio et al., 2020]. One SR reported that children were more cooperative and relaxed in the following order: AV distraction > audio distraction > control group [Gujjar et al., 2019]. Another SR reported that AV distraction (eyeglasses) resulted in more positive responses after local anaesthesia (LA) injection and significantly reduced DFA [De Stefano et al., 2019]. In contrast, Liu et al.'s review found inconsistent results on behaviour, although majority of children were significantly more satisfied in the AV group [Liu et al., 2019].

Traditional behavioural management techniques

Out of the 3 SRs investigating the effect of traditional behaviour management techniques on dental anxiety [Goettems et al., 2017; Zhou et al., 2011; De Stefano et al., 2019], 1 SR reported effects on pain perception [Goettems et al., 2017] and 2 SRs reported effects on behaviour [Goettems et al., 2017; Zhou et al., 2011]. Tell-show-do significantly reduced DFA (P=0.007) and pulse rate (P=0.001), as compared to a live modelling intervention in 5 to 7-year-old children undergoing restorative dental procedures [De Stefano et al., 2019]. The relationship between positive reinforcement and cooperative behaviour was inconsistent, but dental staff behaviours such as giving clear and specific instructions, having an empathic communication style, appropriate physical contact and verbal reassurance encouraged children's cooperation [Zhou et al., 2011]. For positive reinforcement in the form of a reward for good behaviour during dental treatment, the authors reported a significant reduction in self-reported dental fear in the intervention group [De Stefano et al., 2019]. Negative reinforcement or punishment, in the form of physical restraint and verbal criticisms for non-compliance, resulted in the highest self-reported fear and uncooperative behaviour [Zhou et al., 2011].

Two SRs [Gujjar et al., 2019; De Stefano et al., 2019] evaluating the effectiveness of modelling cited the same primary study, which reported significantly greater pre-post anxiety reduction (P<0.001) in the modelling group. A second primary study reported significantly lower pulse rate (P<0.01) among

children live-modelled by the mother, compared to those live-modelled by the father or an inactive control group, during dental examination and prophylaxis [Goettems et al., 2017].

Other behaviour management techniques were covered in Goettems et al's review of 21 RCTs [Goettems et al., 2017]. Compared to no counter stimulation, distraction with counter stimulation (intra/extra oral finger vibration and verbal distraction) during administration of LA resulted in significantly less pain (P<0.05). Magic tricks promoted cooperative behaviour; children sat on the dental chair significantly faster (P=0.001) and allowed the dentist to take radiographs more easily (P=0.0013). Exposure to dentally positive images prior to dental treatment, as compared to exposure to dentally neutral images, had mixed results with 1 study [Fox and Newton, 2006] reporting significantly lower anxiety scores (P<0.001), while the other study [Ramos-Jorge et al., 2011] reporting no differences (P=0.660). Similarly, providing information or preparation had inconclusive results on anxiety [Aminabadi et al., 2011; Olumide et al., 2009]. Finally, camouflage of the syringe when administering LA in children younger than 15 years significantly reduced dental anxiety and resulted in better behaviour [Ujaoney et al., 2013].

Others (aromatherapy, cognitive behaviour therapy)

One SR found that aromatherapy with orange fragrance significantly relieved dental anxiety as well as reduced physiological parameters of stress (e.g. saliva cortisol levels, pulse rate, blood pressure) in children undergoing simple dental procedures (e.g. examination, prophylaxis, fissure sealants) [Cai et al., 2020].

One SR compared cognitive behaviour therapy (CBT) against a variety of controls (e.g. traditional behavioural management techniques, nitrous oxide sedation, general anaesthesia) [Gomes et al., 2018]. CBT was applied over 1–10 sessions in the form of modelling, relaxation training, distraction and positive/calming self-talk. Five studies reported that CBT significantly decreased anxiety, regardless of the tool used to measure anxiety or time after CBT intervention. Three studies reported that CBT improved behaviour and 2 studies reported less avoidance behaviour to dental clinical situations.

Discussion

This umbrella review analysed 13 systematic reviews (SRs). The literature suggests there is some evidence supporting efficacy of the various interventions, with AV distraction being the most extensively researched. There is evidence suggesting that AV distraction may relieve children's dental anxiety [López-Valverde et al., 2020; Barreiros et al., 2018; Liu et al., 2019; Gujjar et al., 2019; Zhang et al., 2019; Prado et al., 2019; Custódio et al., 2020], reduce pain [López-Valverde et al., 2020; Custódio et al., 2020] and improve behaviour [Gujjar et al., 2019; De Stefano et al., 2019; Zhang et al., 2019; Custódio et al., 2020]. AV distraction works by diverting the patient's attention away from unpleasant stimuli that may arise during the dental visit, such as pain when LA is administered. The superiority of AV distraction over traditional distraction methods probably results from the immersive experience created when multiple senses are engaged. The use of VR may be especially appealing to children because they have vivid imaginations [Hoge et al., 2012]. Although the quality of SRs were low, it appears to be a useful technique, given the ease of use and lack of adverse effects. However, the high cost of equipment (e.g. VR glasses) may limit widespread use.

There was also variation among the findings of the meta-analyses, specifically with respect to effect size, even when studying similar outcomes [López-Valverde et al., 2020; Liu et al., 2019; Barreiros et al., 2018; Custódio et al., 2020]. It is likely that the inconsistencies are due to the myriad of scales used. Although these scales are well-known and validated, it makes comparison difficult. More high quality RCTs using the same assessments are needed for a more precise quantitative analysis of effect sizes. In addition, anxiety measured using both subjective instruments (e.g. questionnaires evaluating self or parental perception of anxiety) and objective instruments (physiological measures e.g. pulse rate) would be ideal as this provides the most accurate indication of efficacy.

The differences in efficacy of AV distraction between studies may also be due to factors that were not investigated, such as gender differences, patient personality or temperament with greater predisposition to anxiety and type of dental treatment performed (invasive or non-invasive). In addition, a majority of SRs [López-Valverde et al., 2020; Gujjar et al., 2019; Prado et al., 2019; Barreiros et al., 2018; Moola et al., 2011; Custódio et al., 2020] included patients at least 4 years old, with only 3 SRs [Liu et al., 2019, Zhang et al., 2019, Goettems et al., 2017] including children 3 and under. None of the studies evaluated the influence of age on distraction efficacy, though it seems reasonable that younger children with lower cognitive ability may not be able to consciously focus their attention on the distraction instead of the unpleasant stimuli associated with certain dental procedures [Venham et al., 1981]. As such, this distraction technique is possibly less useful in reducing anxiety in very young patients.

It was not surprising that traditional behaviour management techniques had positive effects on anxiety, pain and behaviour. A prime example is tell-show-do, which was found to significantly reduce anxiety during restorative dental procedures [De Stefano et al., 2019]. Tell-show-do is a popular and well-established technique that reduces fear of the unknown, offering the child some degree of control before each new step of a dental procedure, thereby reducing anxiety. Modelling is another technique which significantly reduced anxiety [Gujjar et al., 2019; De Stefano et al., 2019; Goettems et al., 2017], regardless of whether it was implemented live or by watching a modelling video. However, other widely adopted techniques like positive reinforcement, exposure to dentally positive images or preparation, did not show conclusive benefits in improving cooperation. A possible explanation for the mixed results could be the overwhelming dental anxiety and fear of certain procedures, such as an injection, that could not be easily overridden. In reality, behaviour management techniques are rarely used in isolation. It is probable that a combination of techniques (e.g. tell-show-do used together with positive reinforcement) will be more effective in reducing anxiety; however, this was not evaluated in the included studies.

There was limited, low-quality evidence for other non-pharmacological management options to help children cope with dental anxiety. Aromatherapy with orange fragrance significantly relieved dental anxiety and reduced physiological parameters of stress in children undergoing simple, non-invasive dental procedures [Cai et al., 2020]. However, the sample size was small and the effect on invasive procedures, such as injections, is not known. There was also evidence suggesting that CBT resulted in lower levels of anxiety and better behaviour in children [Gomes et al., 2018]. Interestingly, the authors reported that CBT had differential effects on the

cognitive and physiological aspects of anxiety, i.e. physiological parameters of anxiety were elevated but patients learnt to label them in a more positive way. While CBT appears promising in teaching children to cope with anxiety, the extent to which such changes in cognition occur in very young children is unclear and its efficacy may be limited to older children or adolescents capable of complex cognitive processing.

This umbrella review was limited by current available literature. Firstly, the use of different scales made it impossible to merge extracted data. Secondly, the studies included patients of a wide age range, with different levels of cognitive abilities and behaviour, making it difficult to evaluate efficacy in specific age groups. Lastly, most of the evidence were evaluated to be of low quality, limiting generalisability of the results.

Conclusion

Current evidence for non-pharmacological behaviour management in the dental setting supports the use of AV distraction techniques to help reduce DFA in children and adolescents, although its effects on pain perception and behaviour were inconclusive. AV distraction is potentially a useful complement for existing traditional behaviour management techniques which are widely used. It is likely that a combination of techniques will have the best effect on reducing DFA in children and adolescents.

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Study	Reason for exclusion
Robertson et al. [2019]	Commentary on Prado et al.
Eijlers et al. [2019]	Only included 1 study in the dental context; the rest were medical studies
Cianetti et al. [2017]	Systematic review protocol
Anthonappa et al. [2017]	Systematic review protocol
Al-Harasi et al. [2017]	Withdrawn
Rooksby et al. [2015]	Not specific to "dental" anxiety
Klassen et al. [2008]	Only included 4 studies in the dental context; the rest (n=15) were medical studies

Notes. Reference list for excluded studies
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SUPPLEMENTAL TABLE S1 Excluded full text articles with reasons

Primary studies	Included SRs												
	López-Valverde et al. [2020]	Custódio et al. [2020]	Gujjar et al. [2019]	Prado et al. [2019]	Liu et al. [2019]	Barreiros et al. [2018]	Zhang et al. [2019]	Moola et al. [2011]	De Stefano et al. [2019]	Goettems et al. [2017]	Zhou et al. [2011]	Cai et al. [2020]	Gomes et al. [2018]
Stave 1983											X		
Weinstein et al., 1983											X		
Horst et al., 1987											X		
Getz et al., 1984											X		
Prins et al., 1987											X		
Sarnat et al., 2001											X		
Folayan et al., 2004											X		
Greenbaum et al., 1990											X		
Greenbaum et al., 1993											X		
Melamed et al., 1983											X		
Jafarzadeh et al., 2013												X	
Soni et al., 2018												X	
Berge et al., 2017													X
Shahnavaz et al., 2016													X
Kebriaee et al., 2015													X
Del Gaudio & Nevid 1991													X
Treiber et al., 1985													X
Siegel & Peterson 1980													X
Oliveira et al., 2019									X				
Vishwakarma et al., 2017									X				
Subramaniam et al., 2017									X				
Kazancioglu et al., 2017									X				
Gomes et al., 2017									X				
Dantas et al., 2017									X				
Xia et al., 2016									X				
Raghav et al., 2016									X				
Ohkushi et al., 2016									X				
Chen et al., 2016									X				
Antunes et al., 2016									X				
Peerbhay et al., 2016									X				
Thoma et al., 2015									X				
Seet et al., 2015									X				
Queiroz et al., 2015									X				
Gomes et al., 2015									X				
Tanja-dijkstra et al., 2014									X				
Smiley et al., 2014									X				
Silveira-Souto et al., 2014									X				
Xia et al., 2012									X				
Peres et al., 2012									X				
Bhatnagar et al., 2012									X				
Abdullah et al., 2011									X				

SUPPLEMENTAL TABLE S2 List of primary studies cited across included SRs.

Primary studies	Included SRs												
	López-Valverde et al. [2020]	Custódio et al. [2020]	Gujjar et al. [2019]	Prado et al. [2019]	Liu et al. [2019]	Barreiros et al. [2018]	Zhang et al. [2019]	Moola et al. [2011]	De Stefano et al. [2019]	Goettems et al. [2017]	Zhou et al. [2011]	Cai et al. [2020]	Gomes et al. [2018]
Ramirez-Carrasco et al., 2017				X					X				
Kaur et al., 2015				X			X		X				
Marwah et al., 2005				X				X		X			
Nuvvula et al., 2015		X		X	X	X	X			X			
Rojas-Alcayaga et al., 2018				X									
Singh et al., 2014				X									
Yamini et al., 2010				X									
Naithani et al., 2014				X									
Hoge et al., 2012				X	X					X			
Al-Khotani et al., 2016	X	X		X	X		X		X				
Ghadimi et al., 2018				X									
Asvanund et al., 2015	X	X		X									
Garrocho-Rangel et al., 2018		X		X									
Mitrakul et al., 2015	X	X		X	X		X			X			
Aminabadi et al., 2012	X	X		X	X	X				X			
Dedeepya et al., 2014				X									
Rank et al., 2017				X									
Ujaoney et al., 2013				X						X			
Sayed et al., 2016				X					X				
Habib-Agahi et al., 2017				X									
Al-Halabi et al., 2018		X											
Niharika et al., 2018	X												
Nunna et al., 2019	X												
Shetty et al., 2019	X												
Kaur et al., 2017			X										
Al-Namankany 2016			X										
Al-Namankany 2015			X						X				
Agarwal et al., 2017					X		X						
El-Sharkawi et al., 2012		X			X		X			X			
Fakhruddin et al., 2015					X								
Attar & Baghdadi 2015		X			X					X			
Prabhakar et al., 2007						X	X						
Guinot Jimeno et al., 2014						X	X						
Bagattoni et al., 2017							X						
Aitken et al., 2002								X		X			
Allen & Wallace 2002										X			
Aminabadi et al., 2008										X			
Aminabadi et al., 2011										X			
Farhat-Mchayleh et al., 2009										X			
Fox & Newton 2006										X			
Olumide et al., 2009										X			
Peretz & Gluck 2005										X			
Ramos-Jorge et al., 2011										X			
Srai et al., 2013										X			
Venham et al., 1981										X			
Gajan 2008										X			
Kamath 2013										X			
Wright et al., 2010										X			
Weinstein et al., 1982											X		