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REVIEW ARTICLE

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Home-based toothbrushing interventions for parents of young children to reduce dental caries: A systematic review

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Abstract

Background: Dental caries is the most prevalent preventable condition in children. A key preventive home-based oral health behaviour is the adoption and maintenance of parental supervised toothbrushing until 8 years of age.

Aim: To examine interventions promoting parental supervised toothbrushing practices to reduce dental caries in young children (<8 years old).

Design: Interventions promoting parental involvement in home-based toothbrushing in children under 8 years old and their impact on caries were subjected to review. Electronic databases (MEDLINE, EMBASE, PubMed, Web of Science, PsycINFO, Scopus, and the Cochrane Library), references, and unpublished literature databases were searched for relevant literature.

Results: Of the 10 176 articles retrieved, forty-two articles were included. The Theoretical Domains Framework was used to code intervention content, with the main domains addressed being knowledge (41/42), skills (35/42), and environmental context and resources (22/42). Sufficient descriptions of the intervention development, delivery, and evaluation were lacking, with only 18 studies being underpinned by theory. Twenty-nine studies explored the impact on caries yielding mixed results.

Conclusions: There are few interventions targeting home-based oral health behaviours underpinned by theory and methodological rigour in their development and evaluation. This demonstrates a clear need for future interventions to be guided by complex intervention methodology.

KEYWORDS

children, dental caries, intervention, parents, systematic review, theory

1 | BACKGROUND

Dental caries is the most prevalent preventable condition in children and remains a key public health priority both in the UK and internationally.[1,2] In some parts of the UK, typically the most deprived areas, just under half of children have dental caries affecting multiple teeth by the age of five.[3] In England, it is the most common reason why young children have a general anaesthetic.[4] Yet, caries is preventable, and UK guidance recommends twice daily parental supervised brushing (PSB) using fluoride toothpaste from the emergence of the first tooth up to the age of 8 years.[5-7]

Currently, there is no robust evidence to guide healthcare workers, dental teams, or nursery nurses on how best to support parents to provide PSB and embed it into the young child's daily home routine.[5-7] This is a major concern as children who are left unsupervised to brush their teeth are at a greater risk of developing caries. For instance, there is evidence from a longitudinal cohort study[8] that children are at increased risk of developing dental caries where PSB is not carried out, and an international cross-sectional study of 2822 children aged 3.5 to 4.5 identified a 30% reduction in caries between optimal and suboptimal PSB[9]

Different studies[10-14] report a wide range, 9%-72%, of young children, between 1 ½ and 5 years old, brushing their own teeth without parental assistance. Where young children are left on their own to brush their teeth, a small study has demonstrated minimal time (a mean of 10 seconds) is taken up with active toothbrushing.[14] In addition, a lack of parental brushing may in turn suggest a lack of supervision with the amount of toothpaste used. Parental supervision is not just about ensuring effective plaque removal through appropriate brushing technique, but also ensuring children do not eat or lick the toothpaste in order to reduce the incidence of fluorosis.

Identifying high-quality interventions, which encourage appropriate home-based toothbrushing practices, need to be assimilated and compared. Moreover, it will be important to not only identify the short-term effects on appropriate PSB behaviours, but also the long-term impact on caries reduction. However, despite the importance and the wealth of research investigating the oral health practices of parents of young children, to our knowledge no systematic reviews to date exist synthesizing the literature on interventions promoting home-based PSB.

In summary, the present systematic review aims to examine interventions promoting parental supervised toothbrushing practices to reduce dental caries in young children (under the age of 8 years old). The main objective of the review is to identify interventions and their effectiveness in promoting home-based toothbrushing by parents of young children.

Why this paper is important to paediatric dentists

- Supporting parents to develop appropriate home-based oral health behaviours for their children is critical to long-term oral health. This is the first review to identify home-based toothbrushing interventions for parents of young children using robust scientific methodology.
- The review describes the content and efficacy of current interventions targeting home-based oral health behaviours on both the uptake of appropriate oral health behaviours and caries prevalence in young children. By understanding what interventions are effective and ineffective, we can better tailor future interventions and oral health promotion.
- This review highlights barriers to good oral health behaviours that are targeted by the included interventions. By understanding the challenges faced by families with young children, it will allow us to provide better support for patients.

2 | METHODS

2.1 | Search and inclusion/exclusion criteria

Literature searches were undertaken between December 2014 and May 2016 by an information specialist on several databases, including MEDLINE, EMBASE, PubMed, Web of Science, PsycINFO, Scopus, and the Cochrane Library using the search terms "toothbrushing", "caries", "children", and "parent/carer". References of included studies and 'near misses' were checked to identify other relevant publications, and unpublished literature was electronically searched through ClinicalTrials.gov and the National Research Register. The search strategy and full protocol was registered on the PROSPERO website (PROSPERO. 2014:CRD42014009316, http://www.crd.york.ac.uk/PROSPERO_REBRANDING/display_record.asp?ID=CRD42014009316),[15] and an example search strategy can be seen in Box 1. The literature searches were updated on November 2019 to include data published after January 2015 until November 2019, since the original literature searches were conducted. All of the previously mentioned databases were searched following the same previous search strategy. Some of databases were not available to search, including Cochrane Methodology Register (Wiley), which was only available until 31st May 2012, NHS Economic Evaluation Database (NHS EED) (Wiley), and Database of Abstracts of Reviews of Effect (DARE) (Wiley); NIHR funding to produce DARE and NHS EED ceased at the end of March 2015. For the database of UK Clinical Trials Gateway (NIHR) http://www.ukctg.nihr.ac.uk/default.aspx, the web page was not found (not available for search).

The updated searches retrieved 2797 records, from which 1411 records were identified after removing duplicates. The title and abstract of the identified articles were evaluated by two researchers (SE, KG-B) for whether they met the predefined inclusion criteria for the review. The full text of 51 records was independently reviewed by two reviewers (SE, KG-B) for inclusion/exclusion, and the reason for exclusion was recorded.

Studies were included if they investigated parental involvement in toothbrushing in children under 8 years old and the impact on caries and were available in English. Studies were excluded if (a) there was no parental involvement; (b) they examined school or nursery based toothbrushing; (c) they included children 8 years old and above where it was not possible to identify the data specifically relating to the children under 8 years old; (d) they investigated the effectiveness of toothbrushing on plaque removal or improving gingival health; (f) they did not report primary data (eg, editorials, commentaries, discussion pieces); (g) they investigated children with disabilities (including learning, physical and medical) where these disabilities may necessitate long-term parental toothbrushing. As this is the first, to our knowledge, systematic review of home-based toothbrushing interventions, it was decided to keep the inclusion criteria sufficiently broad to allow us to produce as comprehensive a review as possible that would also allow us to develop recommendations by understanding both the strengths and weaknesses of the studies currently in the field. This involved including studies that did not report statistical data on the interventions impact on dental caries, especially as caries takes a significant amount of time to develop (ie, 3-5 years), but did report on PSB behaviours; therefore, although a study may not show a clear effect on caries levels as of yet, we can still learn useful information regarding intervention development and evaluation.

2.2 | Coding

Following a preliminary screening of abstracts and titles, the abstracts of 10% of the potentially relevant studies were screened by all the authors against the inclusion/exclusion criteria and any disagreement was discussed and a consensus agreed. Three reviewers (EA, KV-C, and KG-B) screened the remainder of titles and abstracts independently to identify potentially relevant studies. For those studies which appeared to meet the inclusion criteria, the full text of the study was reviewed by the three reviewers (EA, KV-C, and KG-B) independently. Full papers that did not meet the inclusion criteria at this stage were excluded and the reasons for exclusion recorded. References in the identified

Box 1 Example search strategy

MEDLINE (OVID)

1. Toothbrushing/ed, is, mt, nu, px, sn, td, ut [Education, Instrumentation, Methods, Nursing, Psychology, Statistics & Numerical Data, Trends, Utilization]
2. Toothbrush*.mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].
3. (brush* adj4 teeth).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].
4. (brush* adj4 tooth).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].
5. 1 or 2 or 3 or 4.
6. *Oral Health/ed, mt, sn, td [Education, Methods, Statistics & Numerical Data, Trends].
7. *Oral Hygiene/ed, mt, nu, px, sn, td, ut [Education, Methods, Nursing, Psychology, Statistics & Numerical Data, Trends, Utilization].
8. 5 or 6 or 7.
9. *Dental Care for Children/is, ma, mt, nu, og, px, st, sn, td, ut [Instrumentation, Manpower, Methods, Nursing, Organization & Administration, Psychology, Standards, Statistics & Numerical Data, Trends, Utilization].
10. Parent*.mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].
11. Carer*.mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].
12. *Parents/ed, px [Education, Psychology].
13. *maternal behavior/ or *parent-child relations/ or *parenting/ or *paternal behavior/
14. 9 or 10 or 11 or 12 or 13.
15. 8 and 14.

studies were checked and other studies included where relevant, and duplicates were recorded and discarded.

For studies meeting the inclusion criteria, data extraction was undertaken using the customized data extraction pro forma for included studies by three reviewers (EA, KV-C, and KG-B) independently. This data extraction process was piloted by the authors to ensure the approach was appropriate and enabled collection of the relevant data by each member extracting data from seven papers each and discussing their findings. From this process, a consensus was reached, and the data extraction form modified accordingly. Efforts were made to extract the relevant data needed to undertake a meta-analysis; however, due to the varied nature of the statistical reporting this was not deemed as possible, and thus, a narrative approach was taken. Once this process was completed, the reviewers met and examined if similar data had been extracted from each included paper. Discrepancies were resolved by consensus or recourse to another researcher where necessary.

2.3 | Theoretical Domains Framework (TDF)

The Theoretical Domains Framework (TDF)[16] was used as a tool to classify the interventions identified in a uniform way to enable a systematic approach to data synthesis. The TDF is a psychological framework that outlines 12 key domains that explain health behaviour, which have been derived from 33 behaviour change theories. This comprehensive list of psychological constructs was designed to increase the accessibility of psychological theory in research, especially to those involved in implementation research, and can be applied to any behaviour. Indeed, the TDF has been used to identify important theoretical determinants of dental behaviours previously.[17] In the current review, the TDF was adapted to reflect toothbrushing behaviours. Each paper was assessed to identify which barriers appeared to be addressed by the intervention through careful reading of their description of the intervention, and this data extracted verbatim. Each description was then coded in conjunction with our adapted TDF to ascertain which of the domains most accurately reflected the description of the barrier addressed by a behavioural scientist (KG-B). Each description and accompanying coding were then discussed by two reviewers (KG-B, EA) to ensure agreement.

2.4 | Quality assessment

All included studies were assessed for risk of bias. This was undertaken independently by three reviewers (EA, KG-B, and SE), and disagreements were resolved by discussion or passed to another reviewer (PD). The quality assessment tool (QATSDD), developed by Sirriyeh, Lawton, Gardner, Armitage,[18] was used to assess the quality of all included studies. This tool includes 16 items, scored between 0 and 3, and can be applied to different types of studies using different approaches. This tool was therefore used as it enabled us to compare the quality of quantitative, qualitative, and mixed methods papers within the same field of research. Applying this method, each paper was given a quality score ranging between 0-48, and the sum of these provided an overall score for the body of evidence, which is expressed as a percentage of the maximum possible score. Although, we deemed this tool as most appropriate to use within the current systematic review, it is worth acknowledging that there are other tools which could be used to assess the quality of evidence within evidence syntheses, for example GRADE/GRADE-CERQual.[19]

3 | RESULTS

3.1 | Study characteristics

Initial screening identified 10 176 papers eligible for inclusion after duplicates removed, 467 underwent full-text analysis, and 42 were identified as meeting the inclusion criteria and data extracted (See Figure 1). The summary of studies investigating PSB interventions is reported in Table 1. Regarding study design, 15 studies were randomized control trials, 4 were community-based/ randomized cluster trials, 5 were mixed methods, 4 quasi-experimental, 3 were prospective with an additional 3 prospective cohort studies, and 1 retrospective cohort study. Three were observational, including 1 case-control and 1 case-cohort study; 3 were pre-/post-test design, and 1 had a serial cross-sectional design. The follow-up period was between immediately post-intervention and 5 years for those studies where this was clearly reported.

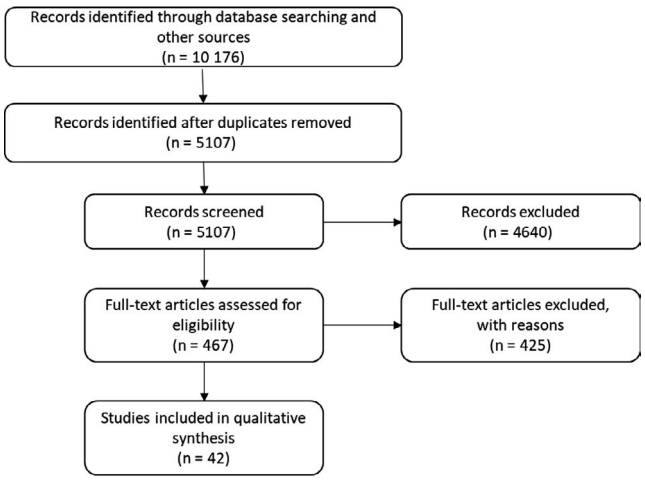

FIGURE 1 Systematic review search strategy and screening process

3.2 | Quality assessment

The quality scores for studies included within the review ranged between 13-34 (See quality assessment scores in Table 1), with the highest quality paper being Batliner, Tiwari, Henderson, Wilson, Gregorich, Fehringer, Brega, Swyers, Zacher, Harper, Plunkett, Santo, Cheng, Shain, Rasmussen, Manson, Albino.[20]Where quality was diminished was in terms of the research either not being underpinned by an explicit theoretical framework or not providing enough detail on exactly what theory was applied and how it was applied to the intervention. Furthermore, there was a lack of sufficient rationale and justification for the choice of data collection measures and data analysis strategy. Moreover, very few studies demonstrated evidence of user involvement in the design of their study (ie, consultation with relevant stakeholders, be they professional or general public). It is now recommended that any intervention should be outlined using the TIDieR guidelines,[21] which is a 12-item checklist of the key pieces of information to include in a description of an intervention to ensure completeness and allow replication; however, few of the included studies completely adhered to this checklist, with many studies lacking sufficient descriptions of the intervention development, delivery, and evaluation. Indeed, information regarding intervention fidelity was notably missing from most of the studies.

3.3 | Interventions

3.3.1 | TDF categorization

The intervention studies were mapped onto the TDF in terms of the barriers they appeared to address. It was found that 10 of the 12 defined constructs in the TDF were addressed in the interventions (see Table 2 for a full list of the TDF domains covered and the number of studies). All but one study[22] addressed knowledge, with skills closely following behind as the most commonly addressed domain (35 studies). Environmental context and resources (22 studies) and social influences (20 studies) were the next most common domains addressed.

In terms of a specific theoretical framework being applied to the intervention development and evaluation, only 18 interventions explicitly stated that they were based on psychological theory and that this was used to inform intervention delivery and measures.[20,22-38]

3.3.2 | Intervention delivery

With regard to intervention delivery, 27/42 interventions were delivered in health settings (clinic/hospital/health centre), 4/42 were undertaken at home, and 4/42 utilized a range of existing community settings; 3/42 were in outreach facilities/day care centres, 2/42 were in preschool, 1/42 appeared to be in a university setting, and 1/42 was multi-site. Home visits were additionally utilized in 2/42 interventions, and 6/42 supplemented their interventions with phone calls/texts to participants. Accordingly, 28/42 interventions were delivered via health practitioners, including primary care providers, health visitors, nurses, health centre/healthcare unit staff, vaccination staff, dental health educators, and lay health workers, with the majority utilizing dental practitioners, including graduate and undergraduate dental students. Researchers led or worked in conjunction with health practitioners in 5/42 studies, peers trained in oral health and intervention delivery provided 6/42 interventions, 1/42 intervention was delivered via an app, and 1/42 was delivered by an interdisciplinary team, including gynaecologists, midwives, paediatricians, dentists, municipal social services, and the public health office. It was unclear in 3/42 interventions who delivered the intervention to parents. Twenty-six of the 42 interventions were delivered on a one-to-one basis, whereas 11/42 were delivered to parents in groups, 3/42 used a combination of one-to-one and group sessions, and 2/42 did not explicitly make clear how the intervention was delivered.

3.3.3 | Associations

A number of associations were found in the literature between the interventions and PSB practices, namely active engagement in children's toothbrushing by parents, the frequency of toothbrushing, and use of fluoride toothpaste. Of the 42 interventions, 16 studies showed significant self-reported improvements in PSB practices,[22,23,27,28,32,36,39-49] five showed significant improvements across intervention and control groups,[25,26,50-52] and two studies showed mixed results with significant differences being found in fluoride toothpaste use and toothbrushing frequency,[24,34] again across both intervention and control groups,[24] but no difference in parental toothbrushing. Furthermore, one study reported differences, but did not report the statistical analysis.[53]

Twenty-nine studies explored the impact of their intervention on caries. Of these, 19 studies showed significant reductions in caries experience.[28-30,38,40-43,45,47,48,53-60] Again, however, one study found these improvements across both intervention and control groups,[54] another only identified small changes in caries experience,[56] and although there was a significant reduction in dentine caries, enamel caries was still highly prevalent in the intervention group of Villena, Pesaressi, Frencken,[59] suggesting a slowed, but not halted rate of caries progression in the intervention group post-intervention. One study reported changes in caries experience, but did not explicitly report significance statistics within their

TABLE 1 Summary of studies reporting home-based toothbrushing interventions ordered by study design

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Randomized control trials (N = 15)					
Basir et al (2017)[45]	33	An educational intervention consisting of one individual session and a group session (4-6 people) lasting 30 min. Sessions were undertaken with mothers while waiting for their children's standard care growth monitoring to be performed. Sessions took the form of question and answer, lectures, and group discussions. In addition, educational short message service (SMS) reminders were sent fortnightly for 6 mos to encourage motivation. During the educational intervention, Mothers were provided with basic information about children's oral health, including appropriate nutritional patterns, tips on night-time breastfeeding, and how to brush/clean children's teeth. Statistics on caries and their complications were supplied. Also, the mothers were asked to evaluate whether prevention or treatment was a better form of dental care. Photographs of children with either healthy or decayed teeth were shown, and mothers were asked to evaluate, which child's smile was more beautiful. The costs of preventive behaviours versus dental treatments were explained using simple examples, and the mothers were asked to evaluate which one is better: taking preventative care or treatment. Finally, mothers were given a pamphlet containing brief, important tips on the promotion of educational items, and the need for oral health care for their children. The Control group received 'standard well baby care'	Knowledge Skills Beliefs about consequences Motivation and goals Memory, attention, and decision processes	Experimental RCT	104 children (52 in each group)
Batliner et al (2018)[20]	34	The Intervention group received Motivational Interviewing (MI) and Enhanced Community Services (ECS). The MI intervention consisted of 4 visits: the first shortly after childbirth and again when the child was 6, 12, and 18 mo old. Visits were expected to last between 45 and 60 min. At each visit, the mother selected 2 topics to address from a list of 8 options. Topics included the following: taking your child to the dentist, only water in sippy cup in bed, transition to cup by 1 y, offer non-sugary foods, germs cause cavities, protect with fluoride, clean mouth/brush 2 times daily, and take care of your own teeth. The mother and MI interventionist then worked together to discuss her ambivalence, concerns, or hesitations and to establish goals and a plan of action. In subsequent visits, discussion focused on progress and obstacles and goals and action plans were amended accordingly. New topics were discussed as needed. Mothers could request for a topic to be repeated, but at least one new topic was added in these instances. ECS included public service announcements broadcast on the tribal radio station, billboards, and broad distribution of brochures focused on behavioural risk factors for early childhood caries and oral health topics that were covered in the MI sessions. Everyone also was provided with oral health brochures targeting the age of the child, as well as toothbrushes and toothpaste for all family members. The Control group received ECS only	Knowledge Skills Motivation and goals Environmental context and resources Social influences	Randomized control trial	579 mother-newborn dyads
Davies et al (2005)[40]	28	Five stage intervention: 8 mo old—health check (leaflet and trainer cup provided) 12-15 mo old—MMR vaccination (fluoride toothpaste and toothbrush provided). Furthermore, given written and pictorial instructions to brush twice daily with a pea-sized amount of toothpaste 18 mo old—invitation to local community dental clinic (fluoride toothpaste and toothbrush provided). Further provisions (toothpaste and toothbrush) were posted to parents if they did not return within 2 mo of dental clinic visit 26 and 32 mo—Toothpaste, toothbrush, and leaflet posted to parents	Knowledge Skills Environmental context and resources	RCT	1,545 children examined at 3-4 y old 839 (intervention group); 706 (control group) 168 Parents/carers (79 intervention, 89 control) completed questionnaires

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
12-36 mo	6 mo	Perceived threat, health literacy, oral health behaviours, and the incidence of early childhood caries	NR	Significant differences were observed between the experimental and control groups regarding: Perceived threat (Experimental group 41.15 ± 4.46; Control group 38.26 ± 4.21, $P = .001$) Health literacy (Experimental group 20.98 ± 2.15; Control group 19.76 ± 2.70, $P = .01$) Oral health behaviours (Experimental group 7.75 ± 2.30; Control group 6.15 ± 2.65, $P = .01$)	Significant difference in the incidence of early childhood caries (Experimental group 13%; Control group 35%, $P = .001$).
0-36 mo	12, 24, and 36 mo of age	Primary outcome: dmfs Secondary outcomes: decayed surfaces (ds) and caries prevalence. Mothers' oral health knowledge and parental oral health behaviours	NR	Oral health knowledge was significantly higher in the MI group at 12 mo ($P = .0006$) and 24 mo ($P = .006$), but the groups no longer significantly differed at 36 mo. No significant difference in oral health behaviours.	No significant difference in dmfs, ds and caries prevalence.
8 mo - 4 y	40 mo (3-4 y of age)	Severity and prevalence of caries and adoption of dentally healthy behaviours	No pre-prevention data available	16.6% had ECC in the intervention group, whereas 23.5% had ECC in the control group The mean dmft (1.17) and prevalence of general caries experience (28.7%) was significantly lower in the intervention group than in the control group (39.2%). Analysis of all the children from both communities showed the prevalence of ECC in the intervention group was 21.3% and in the control group 22.8%. The mean dmft (1.47 intervention; 1.72 control) and prevalence of general caries experience (33.8% intervention; 39.9% control) was statistically significant Reports showed parents in the intervention group were more likely to begin TB before the child's first birthday (45% vs 27%) and twice daily brushing (52% vs 34%)	29% reduction in ECC in intervention group compared to control group ($P = .003$)

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Davies et al (2007)[54]	22	Same as Davies et al (2005)	Knowledge Environmental context and resources	RCT	842 children participants (attended health checks): 253 in intervention group and 286 in control group Non-participants (not attended health checks): 224 intervention and 79 control area
Freudenthal et al (2010)[22]	29	Twenty- to thirty-minute individualized motivational interview with mother's involving rapport building, open discussion, reflective listening, and clarification about the desired outcomes for strategies related to the oral health of the child. Based upon the mother's readiness to change (based upon the stages of the Transtheoretical Model), strategies for better oral health were offered. Strategies identified by the mother as desirable were reinforced. Follow-up telephone calls were made 1 and 2 wk later to ascertain if there were any further questions, offer suggestions, and provide support and praise for current efforts. Pamphlets were available to the control group	Beliefs about consequences Social influences	RCT	72 mothers originally After dropout and exclusion: 39 in treatment and 29 in control groups
Jiang et al (2014)[50]	25	Group 1: One-off oral health talk and printed materials. No further reinforcement of the oral health education messages provided Group 2: Received same talk and materials as group 1 and hands-on training on brushing their child's teeth (demonstration by dental hygienist and practice with own child in front of dental hygienist). Follow-up visits were made every 6 mo to reinforce the dental health messages, monitor parental TB, and provide a new toothbrush. Furthermore, a placebo was applied to the children's teeth to blind parents to whether the child was receiving fluoride varnish or not. Group 3: Same as group 2 except a 5% sodium fluoride varnish was applied during the semi-annual follow-up. A placebo was applied to the children's teeth	Knowledge Skills Environmental context and resources	RCT	450 children and their parents (415 completed the trial)
Joury et al (2016)[49]	26	Intervention group: Provided with an oral health promotion package including an infant oral health pamphlet, a baby toothbrush, fluoride toothpaste (1000 mg/L; 1000 ppm), and a trainer cup. The pamphlet was designed in line with the evidence-based guidelines for the prevention of caries in children aged 0-3 y old and included the topics: bottle-feeding termination at 1 y, the use of a trainer cup, and brushing baby's teeth twice a day with a smear of fluoride toothpaste (1000 mg/L) since the first tooth is erupted, which was accompanied with illustrative photographs. Control group—Provided with infant oral health pamphlet Control group 2—no intervention	Knowledge Skills Environmental context and resources	Randomized controlled parallel-group trial	92 mothers
Manchanda et al (2014)[39]	23	Group A: Education on primary dentition and oral hygiene practices via PowerPoint presentation and pamphlets Group B: Same as group A. In addition, group B received two phone calls reinforcing message 2 wk and 1 mo after initial invitation to attend health centre. Home visits were made to those mothers who did not attend Group C: No intervention received	Knowledge Skills Social influences	Parallel double blind randomized intervention study	480 mothers (160 in each group)

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
0-18 mo	5 y (5 y old)	dmft and extraction	Mean dmft of intervention group: 3.4 Mean dmft of control group: 3.4	Mean dmft of intervention group: 3.1 Mean dmft of control group: 3.6 Participants mean dmft: 2.23 Non-participants mean dmft: 4.11	Caries for intervention group decreased from 65% to 63% and for the control group decreased from 68% to 64%
6-24 mo old 39 male and 33 female	4 wk	Frequency of TB	Pretest: Mean frequency of TB in control group was 3.2 and in treatment group: 2.8	Post-test: Mean frequency of TB in control group 3.3 (comparing pre- and post-test in control group: $P = .796$) Mean frequency in treatment group: 3.7 (comparing pre- and post-test $P = .001$)	NR
8-23 mo	24 mo	Incidence of ECC, dmft and TB behaviour	No separate group data, but overall dmft: 0.03 ± 0.24 (no significant difference between groups). Parents brushing child's teeth>/=2 Group 1:9% Group 2:13% Group 3:15%	Overall dmft 0.2 ± 0.8 (no significant difference between groups) Parental TB>/=2 Group 1:62.7% Group 2:60.4% Group 3:65.7% Overall 74% used FTP, 14% non-FTP, and 12% did not use TP	
1 y old	1 mo	Toothbrushing behaviour (presence of old plaque) and bottle-feeding use	Old plaque presence (% of infants) Intervention group - 100 Control group 1 - 100 Control group 2 - 100	Old plaque presence (% of infants) Intervention group – 9.4 Control group 1 - 90 Control group 2 - 93.3 ($P < .001$)	NR
6-18 mo old	8 mo	Frequency of TB and TB use	Using a brush to clean child's teeth: Group A: 35.04% Group B: 27% Group C:22.13% Brushing twice a day by parents: Group A: 2.92% Group B: 3.90% Group C: 4.10%	Using a brush to clean child's teeth: Group A: 42.34% $P < .001$ Group B: 43.75% $P < .001$ Group C: 43.44% $P = .002$ Brushing twice a day by parents: Group A: 59.12% Group B: 21.88% Group C: 4.92%	The mean dmft was less in the intervention groups than the control group (no p-value reported) Mean dmft: Group A: 0.23 + 0.58 Group B: 0.39 + 0.79 Group C: 1.17 + 1.32

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Memarpour et al (2016)[47]	26	Group 1 (Control): Received no intervention. Placebo fluoride varnish applied at baseline and at 6-mo follow-up appointment Group 2 (Oral health counselling): Parents provided with a free gift bag containing an educational pamphlet and a toothbrush at first appointment. The pamphlet explained the importance of caring for primary teeth, the factors influencing severe early childhood caries, and preventive instructions on a non-cariogenic diet and feeding methods, and oral hygiene. Parents received face-to-face oral health instructions in line with the pamphlet and trained how to properly use a toothbrush. Subsequent appointments were scheduled until the end of the follow-up period. Placebo fluoride varnish was applied at baseline and at the 6-mo follow-up appointment. Group 3 (Oral health counselling and fluoride varnish): Parents received the same oral health counselling as group 2, but fluoride varnish was also applied to the child's teeth at baseline and 6-mo follow-up. Each child received a new toothbrush every 3 mo. Also, if necessary, children were referred for caries treatment.	Knowledge Skills Environmental context and resources	Parallel, single-blind randomized clinical trial	300 children
Mohebbi et al (2009)[56]	23	Parents attending health centres for vaccination Group A (Pamphlet and Reminder): Pamphlet provided by vaccination staff on caries prevention including oral hygiene instruction (Brush/wipe child's teeth after first tooth eruption, use less than a pea size amount of the children's fluoride toothpaste to brush your child's teeth at least twice daily), and 5 min of oral health instruction in early childhood. Furthermore, health centre staff phoned twice at 2-mo intervals to remind parents of the oral health instructions. Group B (Pamphlet Only): Received same pamphlet and Group A, but no verbal instructions or follow-up phone calls. Group C (Controls): No oral health information received during the 6-mo period. After a final outcome, examinations, however, had taken place were provided with pamphlet given to groups A and B.	Knowledge	RCT	177 parents and their children (Group A = 55, Group B = 59, Group C = 63)

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
12-24 mo	4, 8 and 12 mo	Caries risk reduction, and mother's oral health knowledge and behaviours	Knowledge (Mean, SD): Group 1 - 31.11 (3.18) Group 2 - 31.97 (3.83) Group 3 - 32.42 (3.94) Performance (Mean, SD): Group 1 - 21.66 (3.70) Group 2 - 22.96 (4.24) Group 3 - 22.67 (4.30)	Knowledge (Mean, SD): 4 mo Group 1 - 31.19 (3.37) Group 2 - 39.78 (3.70) Group 3 - 40.42 (3.43) ($P < .001$) 8 mo Group 1 - 31.16 (3.31) Group 2 - 42.42 (3.29) Group 3 - 43.27 (2.28) ($P < .001$) 12 mo Group 1 - 31.26 (3.39) Group 2 - 44.21 (2.51) Group 3 - 45.16 (2.30) ($P < .001$) Performance (Mean, SD): 4 mo Group 1 - 21.25 (2.95) Group 2 - 27.28 (4.17) Group 3 - 26.81 (2.88) ($P < .001$) 8 mo Group 1 - 20.27 (2.83) Group 2 - 27.05 (2.14) Group 3 - 27.16 (2.41) ($P < .001$) 12 mo Group 1 - 20.57 (2.67) Group 2 - 28.13 (2.18) Group 3 - 28.29 (2.44) ($P < .001$) Reduction in caries incidence: 4 mo Group 1 - 3.12 (0.00-6.60) Group 2 - 2.06 (0.00-4.92) Group 3 - 1.05 (0.00-3.10) 8 mo Group 1 - 15.96 (9.01-22.91) Group 2 - 3.19 (0.00 - 6.74) Group 3 - 1.08 (0.00-3.16) 12 mo Group 1 - 32.95 (23.13 –42.77) Group 2 - 4.71 (0.21-9.21) Group 3 - 1.15 (0.00-3.39)	There was a significant difference in caries risk reduction in Group 2 (28%; 95% CI: –39.05 to –17.45) and Group 3 (31%; in group 3 95% CI: –41.88 to –21.73) compared to Group 1, but significant difference between Groups 2 and 3 (95% CI: –8.58 to 1.47).
12-15 mo old	6 mo	Dentinal caries of upper central incisors	Decayed teeth (dt): Group A: 0.04 ± 0.19 Group B: 0.02 ± 0.13 Group C: 0.03 ± 0.25 ($P = .719$) Enamel caries (de): Group A: 0.05 ± 0.67 Group B: 0.15 ± 0.48 Group C: 0.08 ± 0.37 ($P = .283$)	Incremental changes in dt and de. dt: Group A: 0.1 ± 0.6 Group B: 0.1 ± 0.1 Group C: 0.2 ± 0.7 (p(A vs C)=0.188; (B vs C) =0.265 de: Group A: 0.0 ± 0.0 Group B: 0.2 ± 0.6 Group C: 0.4 ± 0.7 (p(A vs C)<0.001; (B vs C) =0.066)	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Saengtipbovorn (2017)[38]	27	Intervention group—The Motivational Interviewing in Conjunction with Caries Risk Assessment (MICRA) Programme is based on the PROCEED-PRECEDE and Transtheoretical model and entails an initial visit lasting approximately 15 min, whereby a caries risk assessment, oral examination, and application of fluoride varnish in moderate and high-risk children is undertaken by a dental hygienist. Oral hygiene instruction and individual counselling using motivational interviewing are then provided covering the following topics: oral health and hygiene, oral development, fluoride adequacy, oral habits, diet and nutrition, and injury prevention. Parents then chose one self-management goal from the following list: regular dental visits for children, the family receiving dental treatment, weaning the child from the bottle, brushing with fluoride toothpaste at least twice a day, giving only water or milk in a sippy cup, less or no juice, healthy snacks, no soft drinks, drinking tap water, and providing less or no candy or junk food. Follow-up visits (lasting approximately 10 min) occurred at 3 and 6 mo, whereby reinforcement education, individual counselling, and reinforcement of goals were provided. Control group—Received the routine programme of care, which included oral examination of the child, individual oral hygiene instruction, and fluoride varnish application to children showing white spot lesions	Knowledge Skills Motivation and goals Social influences	RCT	214 parents/ caregivers and their children
Vachirarojpisan et al (2005)[26]	24	Intervention group: Three group discussions lasting 40-60 min with 6-8 mothers/caregivers covering issues regarding their children's oral health and causes and prevention of ECC. Mothers were encouraged by health centre staff to develop their own appreciation and opinions on the ECC problem and choose the most suitable preventive ECC method for their child. Free TB and FTP (500ppmF) were provided after each session Control group: Dental health education programmer provided teaching about ECC prevention. Free TB was provided at the age of 8 and 18 mo	Knowledge Social influences Environmental context and resources	RCT	Intervention: 270 Control: 250 After 1 y Intervention: 213 Control: 191
Villena et al (2019)[59]	27	The active intervention group (AG)—Received age-specific (0-3 y) oral health-related information (leaflets) and activity record cards were developed and validated for nurses to use after being educated about oral health issues and mouth inspection. Any children who showed signs of a carious lesion were referred by the nurses to health centre dentists for further diagnosis and treatment. Treatment typically included fluoride varnish application (every 6 mo or as needed) and provision of atraumatic restorative treatment (sealants and restorations). Also, self-care activities at home (eg, reducing sugar consumption, promoting a healthy diet, and toothbrushing with paediatric fluoride toothpaste and using good toothbrushing techniques) were emphasized. The passive intervention group (PG)—Nurses received the oral health-related information leaflets and activity record cards The control group (CG)—Nurses received a 45-min lecture on the importance of oral health	Knowledge Skills	RCT	368 children
Wennhall et al (2005)[43]	24	Intervention delivered by two specially trained dental assistants 24 mo (baseline): Toothbrushing instruction F-toothpaste (1000-1100 ppm NaF) discount offer diet recommendations 27 mo: Toothbrushing instruction F-toothpaste discount offer F-tablets provided (0.25 mg/d) Oral health and diet problem-solving 30 mo: Toothbrushing instruction F-toothpaste discount offer F-tablets provided (0.25 mg/d) Feedback and problem-solving 33 mo Toothbrushing instruction F-toothpaste discount offer F-tablets provided (0.25 mg/day) Feedback and problem-solving 36 mo (final session): Toothbrushing instruction F-toothpaste discount offer F-tablets provided (2 × 0.25 mg//d) Feedback and problem-solving	Knowledge Skills Environmental context and resources	Control trial and interview with structured questionnaire	Randomized via coin toss to intervention group (738) or control group (217)

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
6 mo – 5 y old	3 and 6 mo	Caries (non-cavitated plus cavitated carious lesions, and cavitated carious lesions), and plaque index	Non-cavitated lesions plus cavitated carious lesions: Mean difference between intervention and control groups 0.184 (SE 0.285; 95% CI −0.375- 0.745; $P = .520$) Cavitated carious lesions: Mean difference between intervention and control groups 0.163 (SE 0.259; 95% CI −0.347-0.673; $P = .528$)	Non-cavitated lesions plus cavitated carious lesions: 3 mo -Mean difference between intervention and control groups 0.235 (SE 0.332; 95% CI −0.421-0.890; $P = .481$) 6 mo – Mean difference between intervention and control groups 1.041 (SE 0.383; 95% CI 0.286-1.796; $P = .007$) Cavitated carious lesions: 3 mo - Mean difference between intervention and control groups 0.265 (SE 0.287; 95% CI −0.301-0.832; $P = .357$) 6 mo – Mean difference between intervention and control groups 0.806 (SE 0.352; 95% CI 0.111-1.501; $P = .023$)	The intervention group had a significantly lower caries incidence, non-cavitated plus cavitated carious lesions (1.81 times) and cavitated carious lesions (2.04 times) compared to the control group at 6-mo follow-up
6-19 mo old	1 y	Supervised TB, use of FTP and caries	Parent brushing their child's teeth: Intervention: 13.6% Control: 15.2% (NS) Brushing twice a day: NR FTP use: Intervention: 8.9% Control: 7.3% (NS) Proper amount of TP used the following: NR Non-Cavitated lesions: Intervention: 1.38(2.12) Control: 1.47(2.14) (NS) Cavitated lesions: Intervention: 0.36(1.06) Control: 0.51(1.38) (NS)	Parent brushing their child's teeth: Intervention: 76%% Control: 59.7% ($P = .001$) Brushing twice a day: Intervention: 41.8% Control: 26.7% ($P = .001$) FTP use: Intervention: 87.3% Control: 58.1% ($P = .001$) Proper amount of TP used: Intervention: 73.2% Control: 38.2% ($P = .001$) Non-Cavitated lesions: Intervention: 3.98(3.08) Control: 4.04(2.99) (NS) Cavitated lesions: Intervention: 3.82(3.65) Control: 3.74(3.93) (NS)	There was a significant difference between the intervention and control groups regarding parents brushing their child's teeth, twice, use of FTP and using the proper amount of TP ($P = .001$) No significant differences were found in cavitated and non-cavitated carious lesions between the groups at baseline and 1-y follow-up
0 -3 y old	3 y	Caries	NR	The prevalence of cavitated dentin carious lesions was significantly lower in the Active Intervention Group (10.0%, confidence interval [CI] 4.1 to 19.5) compared to the Passive Group (60.5%, CI 48.6 to 71.5) and Control Group (63.0%, CI 50.9 to 74.0) at 3 y follow-up ($P < .001$). In the Active Intervention group enamel carious lesions (62.9%) were the most prevalent in, whereas in the Passive Group (28.9%) and Control Group (32.9%) carious lesions were the most prevalent. 27.1% of the children in the Active Intervention Group, 15.8% in the Passive Group and 8.2% in the Control Group had a healthy dentition at 3 y	The prevalence of cavitated dentin carious lesions was significantly lower in the Active Intervention Group (10.0%) than in the Passive Group (60.5%) and Control Group (63.0%; ($P < .001$).
2 y	1 y (3 y old)	Caries, supervised TB, FTP and F-tablet use	Baseline data provided for intervention group only: 13.2% no parental assistance provided 7.5% FTP not used 94.2% F-tablets not used	Intervention group: 5.6% no parental assistance provided ($P < .001$) 2.1% FTP not used ($P < .001$) 8.6% Fluoride tablets not used ($P < .001$) 37% caries free ($P < .001$) 52% initial lesions ($P < .001$) 29% cavitated lesions ($P < .001$) Reference group: 21.1% no parental assistance provided ($P < .01$) 1.8% FTP not used (NS) 88.8% Fluoride tablets not used ($P < .001$) 15% caries free ($P < .001$) 45% initial lesions (NS) 55% cavitated lesions ($P < .001$)	See pre- and post-intervention columns

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TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Whittle et al (2008)[61]	21	8 mo: Oral health advice provided by health visitor/researcher based on Health Education Authority recommendations. A leaflet, a tube of 440ppm FTP, and a child's toothbrush were also provided. The leaflet covered topics including commencement of TB, how to teach your child to brush and what toothbrush and TP to use. 20 mo: Oral health messages reinforced in intervention group 3 y: An experienced dentist (blind to condition) carried out dental examination (recorded dmfs) 5 y: children were examined for dmfs.	Knowledge Skills	RCT	251 control group 250 intervention group At 3 y: 171 (Control) and 181 (intervention) were examined At 5 y: 129 (control) and 147 (intervention), 2253 (census)
Community-based/randomized cluster trials (N = 4)					
Colvara et al (2018)[29]	28	The Intervention group received motivational interviewing delivered by the oral health team at a Health Care Unit The Control group received conventional oral health education. During the visits (lasting approximately 20 and 40 min), information about breastfeeding, child nutrition, and oral hygiene is provided and a clinical oral examination of the child is performed. The same information is delivered to both groups, but the delivery style differs. In the MI group, the oral health team employed empathic communication skills, using simple and complex reflexive listening to work with resistance and ambivalence, developing discrepancy, listening, and encouraging change talk.	Knowledge Skills Social influences	Community-based randomized cluster trial	320 children Intervention group: 175 children Control group: 145
Faustino-Silva et al (2019)[30]	26	Same as Colvara et al (2018)	Knowledge Skills Social influences	Controlled, double-blind, cluster-randomized, community-based clinical trial, with two parallel groups	414 children
Henshaw et al (2018)[33]	31	The control group received (a) on-site child clinical examinations, with a report on current oral health status and a dental referral list; (b) fluoride varnish; (c) a toothbrush and toothpaste; and (d) written handouts about 1 of the 9 topics described below. The intervention group received the same as the control group along with quarterly motivational interviewing counselling. A maximum of 9 sessions were delivered by oral health advocates in families homes lasting 30 min each over a 24-mo period. Families were presented 9 early childhood caries prevention strategies to discuss with the oral health advocate. This included the following: bottle and sippy cup use; cleaning your child's mouth; drinking fluoridated water; good-bye bottle; hello sippy cup; healthy snacks; keeping germs away; lift the lip; sleep time routine; and visiting the dentist. Handouts helped guide the discussions. Motivational interviewing skills were employed by the oral health advocates throughout the sessions, including the following: rapport building, open-ended questions, reflections, affirmations, and strategies (eg, 'typical day', pros and cons of behaviour change, values identification). Topic relevant behaviour change goals were set together, and potential strategies to overcome barriers were discussed at the end of each session. Goal progress was reviewed and additional challenges discussed before moving onto a different topic.	Knowledge Skills Beliefs about consequences Motivation and goals Environmental context and resources Social influences Behaviour regulation	Community-based cluster-randomized controlled trial	1065 children and caregivers

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
8 mo - 5 y old	2 y (5 y old)	dmfs	3 y of age Intervention group: 2.03 (CI 1.39-2.67) Control group: 2.19 (CI 1.41-2.97)	5 y of age Intervention group: 3.99 (CI 2.94-5.04) Control group: 4.84 (CI 3.39-6.29) Census group: 5.94 (CI 5.55-6.33)	Mean dmfs lower for intervention group compared to census group (no statistics reported)
0 - 52 mo	3 y (mean 1.9 y)	Caries rate and dmfs	NR	NR	A significant difference in caries rate (per 100 surface-y, $P = .021$) and dmfs ($P = .014$)
0-52 mo	3 y (mean 1.7 y)	Caries	NR	NR	The MI intervention was significantly effective for lower-income families ($P = .03$), preventing 57% of carious lesions (IRR = 0.43, 95% CI 0.22-0.83) and reducing caries occurrence on more than one surface per 100 followed surface-year (IRD = −1.37, $P = .04$)
0-5 y	2 y	Increment in dmfs Caregiver oral health knowledge and child oral health behaviours (toothbrushing and sugar-sweetened beverage consumption	Mean (Standard error) or percentage Caries prevalence: Intervention group 20 Control group 22.2 How often are child's teeth brushed? (child > 1 y old) Intervention group 2.7 (0.03) Control group 2.7 (0.03) How often are child's teeth and gums brushed or wiped? (child <1 yold) Intervention group 1.6 (0.18) Control group 1.3 (0.12) Usually use fluoride toothpaste for toothbrushing: Intervention group 84.7 Control group 87	The intervention groups mean increase in knowledge was significantly greater than the control group ($P = .0310$), but there were no significant effects on toothbrushing.	Caries increment increased in both groups at follow-up, but there were no significant differences between the groups.

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Makvandi et al (2015)[27]	33	The intervention consisted of three sessions lasting 45-60 delivered by researchers at day care centres, a booklet, and mobile phone text message reminders Session 1 and booklet: general information on role of oral health in child's health, importance of primary teeth, factors influencing early childhood caries, discussion about ways of preventing early childhood caries Session 2: information and discussion on what will happen if mothers do or do not clean child's teeth. Discussion about ways of preventing early childhood caries Session 3 and booklet: discussion about how to overcome potential barriers of cleaning children's teeth, mothers who were successful in cleaning their child's teeth asked to talk about their experiences Booklet: mothers asked to complete a 1-wk diary regarding cleaning of child's teeth and encouraged to set goals in relation to cleaning their child's teeth. Text message reminders: Mothers received eight different motivational text messages (eg, healthy smile, happy child with cleaning child's teeth) 45 d after final session. Over four working days, two text messages (one at 9 AM and one at 7 PM) were sent daily	Knowledge Skills Beliefs about consequence Beliefs about capabilities Motivation and goals Social influences	Two-arm cluster-randomized controlled trial	90 Mothers 45 intervention group 45 control group
Mixed methods (N = 5)					
Gibbs et al (2015)[31]	31	The Teeth Tales intervention has two components: (1) a peer led community oral health education programme delivered in culturally appropriate settings to improve parent knowledge, and behaviours in relation to child oral health needs; (2) a cultural competence organizational review (CORe). The sessions were aimed at parents and delivered over 2-3 wk. This included two 3 h sessions of oral health education followed by a site visit to the local community health dental service to be familiarized with the service and other local family services. Topics covered were as follows: Eat Well, Drink Well, Clean Well, and Stay Well adapted from the Dental Health Services Victoria (DHSV) Smiles 4 Miles programme. The sessions provided parents with opportunities to discuss their own oral health beliefs, practices and strategies for managing change. A free oral health pack (toothbrush, toothpaste, and oral health information) was also provided. Parents' were given an opportunity to practice brushing their own teeth using plaque disclosing agents. Follow-up reminders of the key oral health messages (one per month for 4 mo sent via text, e-mail or post based on preference) were sent by peer educators to parents at regular intervals following completion of the programme	Knowledge Skills Beliefs about consequences Motivation and goals Memory, attention, and decision processes Environmental context and resources Social influences Behaviour regulation	Longitudinal, mixed methods	692 children

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
1-2 y olds	10 d and 3 mo	Changes in dental cleaning behaviour, knowledge and Theory of Planned Behaviour cognitions (Attitude, Perceived behavioural control and behavioural intention)	Knowledge (Mean, SD) Control: 4.82, 1.21 Intervention: 4.80, 1.12 ($P = .928$) Attitude (Mean, SD) Control: 80.39, 17.21 Intervention: 77.65, 18.40 ($P = .491$) Perceived behavioural control (Mean, SD) Control: 58.58, 29.36 Intervention: 58.29, 30.09 ($P = .964$) Intention (Mean, SD) Control: 4.27, 0.93 Intervention: 4.09, 0.97 ($P = .380$) Percentage of mothers cleaning children's teeth Control: 29% Intervention: 24% ($P = .635$)	10-day follow-up (Mean, SD, p-value) Knowledge: Control: 5.00, 0.89, $P = .118$) Intervention: 6.32, 0.61, $P = .001$ ($P = .001$) Attitude Control: 83.49, 14.19, $P = .070$ Intervention: 91.17, 8.15, $P = .001$ ($P = .004$) Perceived behavioural control Control: 61.88, 29.20, $P = .345$ Intervention: 76.90, 19.60, $P = .001$ ($P = .008$) Intention Control: 4.49, 0.77, $P = .060$ Intervention: 4.55, 0.67, $P = .001$ ($P = .703$) Percentage of mothers cleaning children's teeth Control: 36.6%, $P = .453$ Intervention: 65%, $P = .001$ ($P = .011$) 3-mo follow-up (Mean, SD, p-value): Knowledge Control: 5.17, 0.80, $P = .011$ Intervention: 6.68, 0.47, $P = .001$ ($P = .001$) Attitude Control: 82.80, 13.40, $P = .118$ Intervention: 95.00, 4.80, $P = .001$ ($P = .001$) Perceived behavioural control Control: 59.17, 28.27, $P = .901$ Intervention: 83.35, 15.70, $P = .001$ ($P = .001$) Intention Control: 4.44, 0.80, $P = .070$ Intervention: 4.72, 0.45, $P = .001$ ($P = .053$) Percentage of mothers cleaning children's teeth Control: 46.3%, $P = .116$ Intervention: 87.5%, $P = .001$ ($P = .001$)	NR
1-4 y	18 mo	Health, knowledge and behavioural changes	Tooth cleaning at least twice a day: Comparison group 26% Intervention group 23% Clean child's teeth when first baby teeth appear Comparison group 37%: Intervention group 37% Had been shown how to clean your child's teeth/mouth Comparison group 29%: Intervention group 39% Agrees fluoride in water prevents caries: Comparison group 45% Intervention group 53% Knows what to do if child has a dental problem: Comparison group 47% Intervention group 46% Agrees having a bottle in bed causes caries: Comparison group: 63% Intervention group: 65% Tooth debris present: Comparison group 52% Intervention group 60% Presence of gingival inflammation: Comparison group NR Intervention group NR	Tooth cleaning at least twice a day: Comparison group 37% Intervention group 42% Clean child's teeth when first baby teeth appear: Comparison group 28% Intervention group 38% Had been shown how to clean your child's teeth/mouth: Comparison group 43% Intervention group 68% ($P = .001$) Agrees fluoride in water prevents caries: Comparison group 46% Intervention group 60% Knows what to do if child has a dental problem: Comparison group 75% Intervention group 70% Agrees having a bottle in bed causes caries: Comparison group 71% Intervention group 72% Tooth debris present: Comparison group 86% Intervention group 73% ($P = .021$) Presence of gingival inflammation: Comparison group 74% Intervention group 46% ($P < .001$)	No differences in caries experience

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Heilbrunn-Lang et al (2019)[46]	21	The Tooth-Packs intervention was offered to all families accessing Maternal and Child Health Centre's for their child's 18 mo and 24-mo visits. The intervention aimed to improve knowledge, behaviours, and awareness of oral health, particularly oral hygiene practices, among primary caregivers and increasing the proportion of children that brush their teeth twice daily. Each pack contained an age-appropriate toothbrush and toothpaste for every family member living with the child. Information about oral health and dental services was also included.	Knowledge Skills Environmental context and resources	Mixed methods evaluation	1585 families

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
1-3 y	30 mo	Oral health knowledge and behaviours	How often do you assist your child to clean/brush their teeth? Once a day or less 58.3% Twice a day or more 41.7% Brush with child paste > once/day: No 66.1% Yes 33.9% Has anyone ever shown you how to clean/brush your child's teeth/mouth? No 69.6% Yes 30.4% How would you rate the oral health of your child? Good/fair/poor 22.3% Very good/excellent 77.7% How confident are you to clean/brush your child's teeth? Not confident 6.5% Confident/somewhat confident 93.5% When should parents/caregivers start cleaning their child's teeth? Other (incorrect responses) 42.3% When first tooth comes into mouth 57.7% My child's oral health is very important: Disagree/strongly disagree/undecided 2.2.% Agree/strongly agree 97.8% There are some things I can't control that might make my child's oral health worse: Disagree/strongly disagree/undecided 60.5% Agree/strongly agree 39.5% I can manage my child's oral health well: Disagree/strongly disagree/undecided 13.6% Agree/strongly agree 86.4% I can easily get good advice about my child's oral health if I need to: Disagree/strongly disagree/undecided 17.9% Agree/strongly agree 82.1% Only bottle fed children get tooth decay: Agree/strongly agree/undecided 22.9% Disagree/strongly disagree 77.1% White spots on the teeth may be a sign of early dental decay: Disagree/strongly disagree/undecided 68.1% Agree/strongly agree 31.9% If a child uses a bottle in bed it should only contain water: Disagree/strongly disagree/undecided 44.9% Agree/strongly agree 55.1%	How often do you assist your child to clean/brush their teeth? Once a day or less 50% Twice a day or more 50% ($P = .030$) Brush with child paste > once/day: No 52.6% Yes 47.4% ($P < .001$) Has anyone ever shown you how to clean/brush your child's teeth/mouth? No 52% Yes 48% ($P < .001$) How would you rate the oral health of your child? Good/fair/poor 30.1% Very good/excellent 69.9% ($P = .027$) How confident are you to clean/brush your child's teeth? Not confident 3.5% Confident/somewhat confident 96.5% When should parents/caregivers start cleaning their child's teeth? Other (incorrect responses) 39.5% When first tooth comes into mouth 60.5% My child's oral health is very important: Disagree/strongly disagree/undecided 2.6.% Agree/strongly agree 97.4% There are some things I can't control that might make my child's oral health worse: Disagree/strongly disagree/undecided 52.3% Agree/strongly agree 42.7% I can manage my child's oral health well: Disagree/strongly disagree/undecided 13.6% I can easily get good advice about my child's oral health if I need to: Disagree/strongly disagree/undecided 16.4% Agree/strongly agree 83.6% Only bottle fed children get tooth decay: Agree/strongly agree/undecided 13.6% Disagree/strongly disagree 86.8% ($P = .002$) White spots on the teeth may be a sign of early dental decay: Disagree/strongly disagree/undecided 65.2% Agree/strongly agree 34.8% If a child uses a bottle in bed it should only contain water: Disagree/strongly disagree/undecided 38.5% Agree/strongly agree 61.5%	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Lozoya et al (2019)[35]	26	The Theory of Planned Behaviour was applied to a smartphone app, ToothSense is a smartphone app based on the Theory of Planned Behaviour. It aims to educate parents on the importance of good oral health behaviours for children. The app was designed using the Behavior Intervention Technology (BIT) model allowing 'why, how, what and when' type questions to be integrated into the intervention strategies. ToothSense provides support through documents and videos on oral hygiene instructions, timer videos, a journal to track toothbrushing times, toothbrushing reminders, and a social feed to share toothbrushing and flossing experiences with family and friends.	Knowledge Skills Beliefs about capabilities Beliefs about consequence Motivation and goals Memory, attention and decision processes Social influences Behaviour regulation Nature of behaviours	Two-phase, sequential, embedded mixed methods design Phase 1: quasi-experimental, one-group pretest-post-test design Phase 2: Qualitative interviews	26 parents of preschool children
Mattheus (2014)[52]	21	Intervention: Standard oral care during two well child visits and two additional enhanced oral health visits Standard oral health care was delivered in a 30-min visit and included the following: caries risk assessment, oral health examination, fluoride varnish application, anticipatory guidance, attempted referral to a dental home and provision of a toothbrush. Enhanced oral health visits were two 20-min visits delivered by a primary care provider. This visit included an extensive oral health history and caries risk assessment, medical history, and an oral health examination. Child and family oral health education was discussed using a handout focusing on common early childhood caries risk factors. A toothbrush and education on how to brush, proper use of fluoride toothpaste and the importance of regular brushing was provided at the first visit. At the second visit, a sippy cup was provided to reinforce correct oral health beliefs and behaviours and included information on foods to avoid to prevent caries development. At both visits, the family was given dental provider information and attempts were made to refer them for future assessment and care. Control: Standard oral care during two well child visits	Knowledge Skills Beliefs about consequences Environmental context and resources Social influences	Mixed methods	100 parents

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
Mean age 3.48 y old (SD 0.93)	Post-app installation	The attitudes, beliefs, perceived behavioural control, intentions and oral health behaviours of parents for their children	Oral health Attitudes (Mean, SD):15.46 (2.37) Oral health Norms (Mean, SD): 54.96 (13.11) Oral health Perceived Behavioural Control (Mean, SD): 14.92 (1.74)	Oral health Attitudes (Mean, SD): 16.08 (2.12) Oral health Norms (Mean, SD): 56.58 (10.12) Oral health Perceived Behavioural Control (Mean, SD): 15.00 (1.60) How often do your child's teeth get brushed: Less than once a week 0% At least once a week but not every day 3% Once a day 42.4% Twice a day or more 33.3% Frequency of parents whose scores changed pre- to post-intervention: Oral health Attitude No change 30.8% Change 69.2% Oral health Perceived Behaviour Control No change 34.6% Change 65.4% Toothbrushing Intention No change 76.9% Change 23.1% Toothbrushing frequency No change 65.4% Change 34.6% The was no significant difference in intentions or oral health behaviours pre- to post-intervention ($P > .05$). Social norms ($P = .04$) and perceived behavioural control ($P = .02$), however, significantly predicted intentions pre-intervention and changes in oral health behaviour post-intervention	NR
6 or 9-mo olds	Children recruited at 6 mo were followed up at the 12 mo well child care visit. Children recruited at 9 mo were followed up at the 15 mo well child care visit.	Oral health beliefs and behaviours	NR	There were no statistically significant differences between the intervention and control group Analysis in both groups showed significant improvements in their perception of the importance of oral care for primary teeth compared to general health ($P < .05$), brushing their children's teeth ($P < .0001$), confidence in brushing their children's teeth ($P < .05$) and frequency of brushing ($P < .0001$).	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Naidu et al (2015)[36]	30	Control group (Dental Health Education) -Received a 30-min talk delivered within a group setting by a Dental Nurse about the oral health care of their children's teeth. Advice on diet, oral hygiene, fluoride use, and dental attendance was provided in the talk. Parents were then provided with a leaflet reinforcing the information provided in the talk to take home. Dental health products, such as, toothpaste and floss, were also provided. Intervention group (Motivational Interviewing & Dental Health Education)—Parents received the same as the control group; however, the talk was based on a Motivational Interviewing Approach and delivered by an Motivational interviewing counsellor/educator (a dentist trained in Motivational Interviewing), assisted by a Dental Nurse. This included the following: 1) Establishing rapport, showing concern, and encouraging parents to talk about their own oral health and their child's, and their goals for both their own and child's oral health and healthcare by using open-ended questions and affirming positive efforts; 2) using reflective listening to paraphrase parents' wishes for their child's oral health and summarizing their goals; and 3) presenting a menu of preventive oral health options to discuss. Menu options included the following: If breastfeeding discontinue. Stop bottle feeding (switch to cup). Do not give sugary drinks at night. Limit sweet drinks to mealtimes and try to give natural fruit juice instead of colas or other sweet drinks. Help to brush your child's teeth twice a day (one of which should beat bedtime) Help to brush from behind your child. Use fluoride toothpaste (pea size amount) Limit sweet snack to no more than three times a day at mealtime. Use fruits and savoury snacks instead of chocolates and candies. Register child with a dental clinic. Take your child for a dental check-up and fluoride varnish treatment every 6 mo. Parents' were asked to choose those option they felt they were able to commit to. Telephone contact was made by a dental nurse at 2-wk and one-mo follow-up to maintain contact between parents and the Motivational Interviewing team, problem solve, reinforce commitment, and provide support.	Knowledge Skills Beliefs about capabilities Motivation and goals Environmental context and resources Social influences Behaviour regulation	Mixed methods: Exploratory cluster-randomized controlled study and semi-structured focus groups	79 parents/ caregivers

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
1-5 y	4 mo	Oral health knowledge, beliefs, attitudes, brushing behaviour, oral health self-efficacy, oral health fatalism and 'readiness for change'	Bacteria on the teeth of young children can cause cavities: Control group Yes 92.6% No 1.5% Don't Know 5.6% Intervention group Yes 88% No 0% Don't Know 12% What size of toothbrush is best for a young child: Control group Small 79.2% Medium 15.1% Don't know 5.7% Intervention group Small 79% Medium 16.7% Don't know 5.3% How much toothpaste should be placed on the toothbrush: Control group Enough to cover brush 18.5% Pea size 61.1% Smear 14.8% Don't know 5.6% Intervention group Enough to cover brush 24% Pea size 56% Smear 8% Don't know 12% From what position should you help to brush: Control group In front of the child 64.8% Behind the child 16.7% From the side 7.4% Don't know 11.4% Intervention group In front of the child 44% Behind the child 24% From the side 16% Don't know 16% How much fluoride should be in the toothpaste: Control group Not less than 1000 ppm 1.9% 450-600 ppm 5.6% Don't know 92.6% Intervention group	Bacteria on the teeth of young children can cause cavities: Control group Yes 90% No 5% Don't Know 5% ($P = .758$) Intervention group Yes 85.7% No 0% Don't Know 14.3% ($P = .819$) What size of toothbrush is best for a young child: Control group Small 90% Medium 10% Don't know 0% ($P = .447$) Intervention group Small 81% Medium 19% Don't know 0% ($P = .633$) How much toothpaste should be placed on the toothbrush: Control group Enough to cover brush 15% Pea size 85% Smear 0% Don't know 0% ($P = .144$) Intervention group Enough to cover brush 0% Pea size 90.5% Smear 9.5% Don't know 0% ($P < .05$) From what position should you help to brush: Control group In front of the child 45% Behind the child 45% From the side 10% Don't know 0%($P < .05$) Intervention group In front of the child 0% Behind the child 90.5% From the side 9.5% Don't know 0%($P < .001$) How much fluoride should be in the toothpaste: Control group Not less than 1000 ppm 5% 450-600 ppm 10% Don't know 85%($P = .590$) Intervention group Not less than 1000 ppm 4.8% 450-600 ppm 19% Don't know 76.2%($P = .071$) Child weekly toothbrushing:	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Quasi-experimental studies (N = 4)					
Azevedo et al (2015)[57]	31	Oral health education provided through a pamphlet and verbal explanation to mothers and children by graduate and undergraduate dental students covering 3 previously selected items from the pamphlet lasting 5 min. The pamphlet included information regarding oral bacteria and transmission pathways, oral hygiene (for mothers and children), and appropriate dietary habits, such as avoiding both sugar intake (for mothers and children) and sleeping with a bottle at night.	Knowledge Skills	Quasi-experimental	Study group: 271 children Control group: 251 children

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
			Not less than 1000 ppm 4% 450-600 ppm 0% Don‘t know 83.3%	Control group (Mean 10.55; SD 4.07; 95% CI 8.77-12.33) Intervention group (Mean 13.09; SD 1.44; 95% CI; 12.47-13.71; $P < .01$) Self-efficacy: Control group (Mean 24.60; SD 6.91; 95% CI 21.57-27.62) Intervention group (Mean 26.79; SD 5.14; 95% CI 24.59-28.99; $P = .379$) Oral health fatalism: Control group (Mean 5.95; SD 2.04, 95% CI 5.06-6.84) Intervention group (Mean 4.09; SD 1.73; 95% CI 3.35-4.83; $P < .05$) Openness to health information: Control group (Mean 15.35; SD 2.64; 95% CI 14.19-16.51) Intervention group (Mean 15.86; SD 3.32, 95% CI 14.73-16.99; $P = .593$) Valuing dental health: Control group (Mean 19.80; SD 8.71; 955 CI 16.07-23.52) Intervention group (Mean 19.42; SD 0.81; 95% CI 19.07-19.77; $P = .847$) Convenience and change difficulty: Control group (Mean 9.58; SD 2.34; 95% CI 9.23-9.94) Intervention group (Mean 7.67; SD 3.21; 95% CI 6.30-9.04; $P = .410$) Child permissiveness: Control group (Mean 8.30; SD 3.86; 95% CI 6.61-9.99) Intervention group (Mean 7.33; SD 3.63; 95% CI 5.78-8.88; $P = .352$) Readiness Assessment of Parents Concerning Infant Dental Decay (RAPIDD) Pros: Control group (Mean 35.15; SD 9.58; 95% CI 30.95-39.35) Intervention group (Mean 35.29; SD 3.38; 95% CI 33.84-36.74; $P = .952$) RAPIDD Cons: Control group (Mean 17.37; SD 4.98; 95% CI 15.13-19.61) Intervention group (Mean 15.00; SD 5.28; 95% CI 12.74-17.26; $P = .154$)	
0-12 mo	1 y	Dental caries	Not reported (NR)	Proportion of children with dental caries (enamel and dentine) Study group: 12.9% Control group: 17.9% Proportion of children with dentine Caries Study group: 1.5% Control group: 2.4% Proportion of children with white spot lesions Study group: 11.4% Control group: 16.7%	Significantly fewer carious lesions in children in the Study group compared to the control group ($P = .037$). After adjusting for number of teeth and child's age the odds of dental caries were 80% greater in the Control group compared to the Study group (OR, 1.8; 95% CI, 1.04-3.16)

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Lai et al (2018)[58]	29	The intervention group received a risk-based preventive programme, which included the following: 1) Oral health education about the aetiology of dental caries, caries progression and prevention, and parental oral health; 2) anticipatory guidance on diet, oral health care practices, such as toothbrushing and fluoride use, non-nutritional habits, trauma prevention, and growth and development; 3) topical fluoride varnish applied on all tooth surfaces for children considered at high caries risk; and 4) recommendation for dental review visits. Children were scheduled for a dental review visit every 6 mo over 2 y. Those at high caries risk, however, had additional appointments scheduled between their standardized 6-mo visits. Although the key components of the oral health programme were standardized, the individual content of each component was customised to the child's history and clinical findings. Any children with treatment needs were referred for dental care.	KnowledgeSkills	Quasi-experimental study design	Intervention group—90 children Control group—64 children
Medeiros et al (2015)	19	The baby oral health programme (bOHP) provides oral for pregnant woman and their babies. Throughout their pregnancy, mothers were provided with all necessary dental care for free and educated about good oral health habits and caries-avoidance diets, for themselves and their baby. The number of visits varied for each mother due to the level of treatment need. At the last visit before having their baby, mothers were asked to return with their baby when they were 3 mo old. Appointments were then scheduled every 3 mo and focused on the oral health of the baby. Topics covered during the visits included the following: 1) diet—sugar consumption and breast and bottle feeding; 2) oral hygiene—how to clean the mouths of babies and when to start using toothbrush and toothpaste; and 3) non-nutritive sucking habits. Babies had an oral examination and fluoride therapy and/or ART restorations were provided when needed.	Knowledge Skills Environmental context and resources	Quasi-experimental	Group 1 (n = 87 pregnant women)—Received intervention after baby was born and visited the dental clinic at least once a year Group 2 (n = 90 pregnant women)—did not receive intervention after giving birth or visited the dental clinic just once

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
Intervention group – 0-18 mo of age Control group - 24-42 mo	Every 6 mo for a period of 2 y	The primary outcome measure was the presence of Severe Early Childhood Caries (SECC) The secondary outcome measure was the dmfs score, behavioural changes in dietary habits, oral care practices and oral hygiene status	NR	Oral hygiene: Intervention group Good 37.8% Fair 56.7% Poor 5.6% Control group Good 4.7% Fair 81.3% Poor 14.1%($P < .0001$) Fluoride use: Use of fluoridated—Intervention group 94.3% Control group 38.6% ($P < .0001$) Oral hygiene practice: Toothbrushing after last night feed—Intervention group 78.3% Control group 19.6% ($P < .0001$) Difficulty in cleaning child's teeth—Intervention group 25.6% Control group 50% ($P = .002$) Presence of SECC: Intervention group 7.8% Age < 3 y old – 18.2% Age > 3 y old – 4.4% Control group – 31.3% Age < 3 y old – 32.7% > 3 y old – 26.7% Significant difference in the presence of SECC between the intervention and control group ($P < .001$) d3mfs score: group –Median (IQR) 0.0 (0.0)Min, Max 0.0, 23.0 Control group – Median (IQR) 0.0 (0.0)Min, Max 0.0, 75.0($P = .153$) d3mfs score by category: Intervention group –0% - 91.1%1-4 - 6.7% >5 - 2.2% Control group –0% - 84.4%1-4 - 3.1%>5 - 12.5% ($P = .031$)	Children in the intervention group (91.1%) had d3mfs = 0 in comparison t to the control group (84.4%). After adjusting for confounding variables, the odds of children in the control group having SECC were three times higher than children in the intervention group
0-5 y	NR	dmfs	NR	Extraction due to caries Group 1: No 87 Yes 0 Group 2: No 88 Yes2 ($P = .615$) Toothache Group 1: No 87 Yes 0 Group 2: No 63 Yes 27 ($P < .001$) Cavitated dentine lesion Group 1:0 - 8 > 1 - 79 Group 2:0 - 73 > 1 - 17($P < .001$)	The mean dmfs scores for Group 1 (0.25; SD = 0.93) and Group 2 (4.12; SD = 6.56), were significantly different ($P < .01$).

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Vichayanrat et al (2012)[24]	27	Three stage intervention: 1) Oral health education and services at health centres: Various oral health activities made available (dental screening, structured oral health education, fluoride supplements, and toothbrush/ toothpaste provided at vaccination visits every 3 mo); 2) home visits by lay health workers providing social support: Visits made every 3 mo to mothers to follow-up on oral health practices, focussing on providing informational, appraisal, and emotional support; 3) community mobilization process: Members of the Tambon Administrative Organization, day care teachers and village health volunteers were invited to attend meetings throughout the programme. Community members were given education on the problem of ECC and group discussions took place to develop a better understanding ECC and its prevention in community.	Knowledge Social influences Environmental context and resources	Quasi-experimental	114 children and caregivers
Prospective studies (N = 3)					
Borssen et al (1998)	13	Dental health education offered at health centres when children aged 1 y old provided by a dental hygienist. Group sessions of 6-10 parents also included completing a health declaration for the child and age-modified questionnaire about diet and oral hygiene habits	Knowledge	Prospective	491 children
Weber-Gasparoni et al (2013)[25]	24	Intervention group: 15-min video, covering process of tooth caries, oral hygiene practices, dietary habits that affect caries susceptibility, checking the child's teeth for early signs of cavities, and bacterial transmission from mother to child Control group: Same oral health message as intervention group but provided via a pamphlet	Knowledge	Prospective	415 children and mothers (283 intervention, 132 control)

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
6-36 mo	One year	Dental caries, supervised TB and use of FTP	Caries: Control group: 34.7% Intervention group: 47.6% dmft (mean ± SD): Control group: 2.22 ± 4.26 Intervention group: 2.34 ± 3.81 Supervised TB: Control group: 40.4% Intervention group: 50.0% FTP use: Control group: 32.7% Intervention group: 30.6%	Caries: Control group: 63.6% Intervention group: 60.7% dmft (mean ± SD): Control group: 3.49 ± 3.97 Intervention group: 3.04 ± 3.90 Supervised TB: Control group: 85.7% Intervention group: 91.4% FTP use: Control group: 59.6% Intervention group: 85.5%	Dental caries increased in both groups, but the prevalence of caries and dmft score were not significantly different ($P > .05$). No significant differences were found in supervised TB between and within groups. There was a significant difference in FTP use between the groups ($P = .031$) and pre- and post-intervention in the intervention group ($P < .0001$)
2 y old	1 y	Supervised TB and use of FTP	NR	46% brushed once a day with help from parents 48% twice or more with help from parents 6% had irregular or no help with TB 5% did not use FTP	
12-49 mo	1 and 6 mo	Caries and behavioural changes in TB and FTP use	Cavitated ± non-cavitated lesions: Control group: 14% Intervention group: 10% Daily TB: Control group: 68% Intervention group: 74% Bedtime TB: Control group: 77% Intervention group: 77% FTP use: Control group: 63% Intervention group: 53% Pea-sized amount of TP: Control group: 42% Intervention group: 36%	Cavitated ± non-cavitated lesions: NR 1-mo follow-up (shift from baseline): Daily TB: Control group: 84% ($P = .002$) Intervention group: 87% ($P < .001$) Bedtime TB: Control group: 87% ($P = .02$) Intervention group: 88% ($P < .001$) FTP use: Control group: 74% ($P = .003$) Intervention group: 83%($P < .001$) Pea-sized amount of TP: Not investigated at follow-up 6-mo follow-up (shift from baseline): Daily TB: Control group: 79% ($P = .06$) Intervention group: 87% ($P < .001$) Bedtime TB: Control group: 93% ($P = .005$) Intervention group: 86% ($P < .005$) FTP use: Control group: 77% ($P = .006$) Intervention group: 81% ($P < .001$) Pea-sized amount of TP: Control group: 56% ($P = .22$) Intervention group: 69% ($P < .001$)	There was an increase in caries from baseline to 6-mo follow-up, but there was no significant difference between groups in the proportion of children with carious lesions ($P > .17$). At 1-mo follow-up mothers in both groups increased making sure children brushed daily ($P = .002$; $P = .0002$), brushing at bedtime ($P = .02$; $P = .0002$), and using fluoridated toothpaste ($P = .003$, $P < .0001$) from baseline. At 6-mo follow-up, mothers from the intervention group maintained making sure child brushed daily ($P < .0001$), brushing at bedtime ($P = .005$), and use of fluoridated toothpaste ($P < .0001$), whereas control group mother only maintained bedtime brushing ($P = .005$) and the use of fluoridated toothpaste ($P = .006$)

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Wennhall et al (2008)[42]	18	Oral health education (as in Wennhall et al 2005) was provided between ages 2-5 y old. Intervention supplemented by the local Public dental service (PDS). At 3, 4 and 5 y old, all the children received preventive measures and restorative treatment based on their individual needs in connection with regular visits to the PDS	Knowledge Skills Environmental context and resources	Longitudinal study	Intervention group: 651 Control group: 201
Cohort studies (N = 4)					
da Silva et al (2013)[41]	25	Bimonthly lectures to mothers over 6 mo covering oral health and hygiene, including the presentation of posters, macro-models and toothbrushes. Afterwards, mothers were followed up monthly over a year to provide individual instructions on the specific needs of the baby's oral health and reinforce the previous guidance.	Knowledge Skills	Prospective cohort of convenient sample of those participating 'Promotion of Oral health in Early Childhood' project	Total sample of 112 mothers and infants
Nurko et al (2003)[55]	17	Twelve-week Infant Oral Health Educational Program for low-income and uninsured parents of children aged 1-12 mo covering diet counselling, early enamel demineralization detection, appropriate fluoride use, fluoride supplements, and oral hygiene instructions	Knowledge Skills	Retrospective cohort of convenient sample of those attending and not attending programme	Total sample of 120 parents with 41 who participated in the programme
Sgan-Cohen et al (2001)[51]	25	In 'programme' clinics, a large poster with the slogan 'Healthy teeth from the beginning-because the beginning counts!' was displayed, including TB messages concerning the commencement of TB. A leaflet was also distributed to parents covering topics such as 'how to keep your baby's teeth healthy' Oral health education took place during usual visits to the MCH centre during the first 2 y of the child's life. At each visit, nurses spent 10-15 min providing education on daily teeth cleaning with fluoridated toothpaste, commencing TB at the age of tooth eruption (through year 1), and through year 2 a dental examination was conducted by a dentist or hygienist. Nurses were also trained to repeat oral health messages at each visit and mark on a checklist added to the child's existing medical file when this was done. A photograph of ECC and a dental model and toothbrush was sent to all programme centres to allow the demonstration of TB skills. This, however, was not an obligatory component of the programme. The control centres did not receive any health education programme. In addition, parents received toothbrushes and toothpaste on three occasions (baseline, two and 4 mo)	Knowledge Skills Environmental context and resources	Prospective cohort Two programme groups one with TB and TP (programme 1) and one without (programme 2) Two control groups: one with TB and TP (control 1) and one without (control 2)	449 in total

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
2 y old	3 y (5 y old)	Caries, outreach facility attendance and supervised TB	NR	deft: Intervention group: 5.4 ± 4.3 Control group: 6.9 ± 4.3 defs: Intervention group: 8.2 ± 8.1 Control group: 11.2 ± 9.7 Caries free: Intervention group: 14.4% Control group: 6% Cavitated lesions: Intervention group: 44.7% Control group: 66.7% Number of visits to outreach facility: <3:21 4-5:236 6:394 Percentage receiving no parental assistance: Intervention group: 8.4% Control group: 14.4%	Caries outcomes were significantly different between the groups ($P < .001$) Regular attendance to the outreach facility was associate with fewer caries at age 5 ($P < .01$) Mean caries prevalence was higher in children attending the outreach facility less regularly (3 or less sessions) than those attending six sessions ($P < .05$). Significant differences were found between the two groups concerning parental help with TB and fluoride tablet usage ($P < .05$)
0-18 mo	Followed up monthly during 1 y	Frequency of TB and caries	57.3% performed oral hygiene at daytime and night-time for their children. 42.7% performed the hygiene only at daytime Active white spots and caries were seen in 5.6% of dental surfaces	74.7% performed oral hygiene at daytime and night-time for their children 24.1% performed hygiene only at daytime 1.2% performed hygiene exclusively at night-time Active white spots and caries were seen in 0.4% of dental surfaces	Active white spots and caries dropped from 5.6% to 0.4% ($P < .0001$)
1-5 y old 53% female 97% hispanic Low SES	NR	Caries—decayed and filled teeth (dft), decayed and filled surface (dfs) and enamel caries	NR	Intervention group: dft = 0.37, dfs = 1.22 and enamel caries = 1.93 Control group dft = 1.23, dfs = 2.97 and enamel caries = 4.05	Significant difference between the two groups in terms of dft and enamel caries ($P < .05$)
6-12 mo old	6 mo	Supervised TB	Programme 1:16.4% Programme 2:10.9% Control 1:13.3% Control 2:22%	Programme 1:74.9% Programme 2:52.3% Control 1:56.6% Control 2:51.2%	Significant improvements in TB were seen at 6 mo across all the groups ($P < .0001$). No significant differences between P2, C1 and C2

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Wagner et al (2016)[28]		Oral Health programme: (a) All families were visited and counselled on general and oral health by Communal newborn visiting service (CNVS) between 1st and 4th week after birth. This visit included the following: - Importance of breastfeeding - Use of baby bottles and pacifiers - Healthy diet - Importance of screening examinations by a paediatrician - Caries development and its prevention - Start of toothbrushing when first tooth erupts once a day with use of a smear layer of fluoride toothpaste (500 ppm F) - From 2nd birthday toothbrushing twice a day with a pea-sized amount of fluoride toothpaste (500 ppm F) - Establishment of a dental home in first year of life - Regular dental care with biannual dental examinations. Every family received a folder with information, and a toothbrush, fluoride toothpaste (500 ppm F) and a pacifier (b) All families were invited to attend a dental examination of their child in the dental clinic - Families who attended = Intervention group - Families who did not attend = Control group (c) Children in the Prevention group received comprehensive dental care by a paediatric dentist in the dental clinic. This included the following: - First dental visit in first year of life - Caries risk-related continuous dental care from birth to the age 5 y - Re-evaluation of caries risk at each dental appointment - Biannual/quarterly dental examination of the child & maternal counselling Age 0 to 3 y - Children at high caries risk receive 2 fluoride varnish applications per year Age 3 to 5 y - Children at low/moderate caries risk receive 2 fluoride varnish applications per year - Children at high caries risk receive four fluoride varnish applications per year 4) Children in the Control group - Families were personally responsible to establish a dental home with regular dental care 5) Age 3—all families were invited by CNVS to an interim evaluation of the programme in the dental clinic. This included the following: - Dental examination and maternal counselling (daily toothbrushing with fluoride toothpaste, regular dental care)	Knowledge Skills Beliefs about consequences Social influences Environmental context and resources	Cohort study	563 families
Observational studies (N = 3)					
Hatefnia et al (2017)[32]	23	Based on the Theory of Planned Behaviour, three educational classes were held by the researcher lasting 20 min over a duration of 3 wk (1 session per week). The control group received routine education from the healthcare centre and the same booklets/pamphlets as the intervention group.	Knowledge Skills Social influences	Case-control interventional study	80 mothers

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
Mean age of 3.3 ± 0.5 y	5 y	Caries and oral health behaviours, including commencement of toothbrushing and supervised toothbrushing	All children toothless at baseline	Significant differences were found among the start, frequency and supervision of toothbrushing between the intervention and control group ($P < .001$)	Intervention group had significantly lower caries prevalence and experience at the d1-4 and d3-4-level compared to control group ($P < .05$). The Significant Care Index of the intervention group was 0.4 ± 0.9 d3-4mft compared with 4.3 ± 3.2 d3-4mft of the control group ($P < .001$) Statistically significant associations were found between caries experience and start of toothbrushing (OR = 0.06, 95% CI 0.03-0.12, $P < .001$), supervision/ regular second brush by parent (OR = 0.02, 95% CI 0.01-0.05, $P < .001$), and frequency of toothbrushing (0.17, 95% CI 0.08-0.37, $P < .001$)
3-6 y	1 mo	Knowledge, attitudes, subjective norms, intention, perceived behavioural control and toothbrushing behaviour	Knowledge (Mean, SD) Intervention group: 5.57 (2.63) Control group: 6.22 (2.25) Attitude (Mean, SD) Intervention group: 12.25 (2.89) Control group: 12.05 (3.69) Subjective Norms (Mean, SD) Intervention group: 17.27 (4.76) Control group: 15.72 (6.64) Intention (Mean, SD) Intervention group: 1.77 (1.18) Control group: 2.02 (1.65) Perceived behavioural control (Mean, SD) Intervention group: 5.57 (1.50) Control group: 5.67 (2.28) Toothbrushing behaviour (Mean, SD) Intervention group: 2 (1.21) Control group: 1.95 (1.60)	Knowledge (Mean, SD) Intervention group: 8.92 (1.91) Control group: 5.90 (1.90) Attitude (Mean, SD) Intervention group: 16.55 Control group: 11.60 (3.22) Subjective Norms (Mean, SD) Intervention group: 19.97 (3.45) Control group: 15.17 (5.70) Intention (Mean, SD) Intervention group: 3.20 (0.64) Control group: 1.87 (1.41) Perceived behavioural control: (Mean, SD) Intervention group: 1.77 (1.18) Control group: 1.77 (1.18) Toothbrushing behaviour (Mean, SD) Intervention group: 3.32 (0.69) Control group: 1.92 (1.11) There was a significant difference in all mean scores post-intervention for the intervention group compared to the control group ($P < .001$)	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Wagner et al (2014)[53]		Intervention group: Thirty-two qualified dental health educators visited the birth wards of hospitals twice a week to provide new mothers with dental health counselling. Mothers were counselled 2-3 d after giving birth in groups of two to seven in a one-off 30-min course. The course covered topics including the importance of breast feeding, the use of baby bottles and pacifiers, diet, and caries development and its prevention. In addition, practical toothbrush training was provided using a doll. A folder containing educational material related to diet, oral hygiene, fluorides, and dental examination, and a child's toothbrush was also provided. Control group: No intervention at all	Knowledge Skills Environmental context and resources	Case-cohort design	Intervention: 237 Control: 234
Winter et al (2019)	26	The prevention programme focused on extensively enlightening young parents on how to avoid ECC with the aid of repeated personal pulses of information provided by an interdisciplinary team consisting of gynaecologists, midwives, paediatricians, dentists, and the city's social services. During the designated preventive medical check-ups, the paediatricians or dentists conduct examinations, as well as providing instruction and motivation related to the topic of ECC. At each consultation, the parents receive a package of information, including flyers/media with coordinated contents, and a present appropriate to the situation (eg, children's toothpaste, toothbrush, and toothbrushing timer).	Knowledge Skills Environmental context and resources	Observational	Intervention group: 706 Control group: 661 children

Pre/post and cross-sectional studies (N = 4)

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
Intervention at birth Examination at age of 5	5 y	Caries	NR	After matching for age, sex, SES and ethnicity Caries prevalence: Intervention: 33.2% Control: 42.6% ($P < .05$) d3-4mfs: Intervention: 3.2+/_7.4 Control: 5.2 ± 6.4($P < .05$) d3-4mft: Intervention 1.5+/_2.5 Control: 2.4+/_4.1($P < .05$) Care index: Intervention: 14.2% Control: 11%(NS) Significant caries index: Intervention: 3.5 dmft Control: 6.1 dmft ($P < .05$)	Age of TB commencement, supervision of TB or regular rebrushing, use of FTP were significantly related to d3-4mft ($P < .000$). Parents in the intervention group began TB at a younger age, used FTP and fluoride salt, and supervised TB more often than parents in the control group (p-value not reported).
3-4 y olds	6 mo, 12 mo and 2 y	Dental caries	NR	Mean number of front teeth with d1 − 2 (Mean, 95% CI): Control group - 0.19 (0.14-0.24) Intervention group - 0.13 (0.09-0.17)($P = .053$) Mean number of front teeth with d3 − 4 (Mean, 95% CI): Control group - 0.15 (0.10-0.19) Intervention group - 0.07 (0.04-0.09)($P = .003$) Mean number of front teeth with d5 − 6 (Mean, 95% CI): Control group - 0.15 (0.10-0.21) Intervention group - 0.05 (0.02-0.08)($P = .001$) Mean number of posterior teeth with d1 − 2 (Mean, 95% CI): Control group - 0.43 (0.36-0.51) Intervention group - 0.30 (0.24-0.35)($P = .002$) Mean number of posterior teeth with d3 − 4 (Mean, 95% CI): Control group - 0.25 (0.18-0.31) Intervention group - 0.13 (0.09-0.18)($P = .002$) Mean number of posterior teeth with d5 − 6 (Mean, 95% CI): Control group - 0.15 (0.09-0.20) Intervention group - 0.04 (0.02-0.07)($P = .001$) Control group: Sound primary dentition - 78.8% Total (ECC + SECC) - 21.2% SECC – 14.5% Intervention group: Sound primary dentition – 86.3% Total (ECC + SECC) - 13.7% SECC – 7.9% 94.6% of the parents in the intervention group had started brushing their child's teeth in the first year of life compared to 84.3% in the control group ($P < .001$).In both groups, 7% of parents reported that their 3- to 4-year-old children were responsible for brushing their own teeth.	The mean d3 − 6mf-t and mean d5 − 6mf-t in the control group was twice as high as the intervention group. Teeth with extensive caries were three times as high in the control group compared to the intervention group. The total number of carious lesions in the front teeth of the intervention group was half the number of the control group. The percentage of children with SECC in the control group was nearly twice as high as children in the intervention group

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Hoeft et al (2016)[34]	27	The Contra Caries Oral Health Education Program (CCOHEP) is a curriculum based on Social Cognitive Theory for Spanish-speaking parents with children 0-5 y old. It entails 2-hour participatory/ interactive sessions led by lay people trained as community health outreach workers. The intervention aims to increase caregivers' knowledge and skills using a variety of didactic approaches as well as skill-building through diverse activities. There are 4 educational sessions: 1) Caries aetiology and reducing germ sharing; 2) Parent-assisted toothbrushing with fluoride toothpaste, flossing, and child behaviour management during toothbrushing; 3) Reducing sugar intake, snacking, diet, and bottle use; and 4) The tooth decay process, fluoride, and how to initiate and what to expect during dental visits. The sessions are designed to provide an understandable rationale for why toothbrushing and other protective behaviours are important for young children and to improve the quality and quantity of oral hygiene practices.	Knowledge Skills Beliefs about capabilities Beliefs about consequences Motivation and goals Environmental context and resources Social influences Behaviour regulation	Single group, pre-/post-test design	105 caregivers
Huebner et al (2015)[23]	31	Four parent-focussed sessions involving 30 min of refreshments and socialization, 30 min of facilitated parent-to-parent discussion of 'what's working, not working and what to do about it' and a 20- to 30-min educational programme. The educational programme included the following: Session 1: a presentation by a local dentist about dental disease and the benefits of brushing Session 2: activities promoting oral health knowledge, dietary choices and brushing behaviours Session 3: explanation of how toothbrushing is supported in the child's early education programme Session 4: practice brushing their child's teeth At each session, free dental supplies were available including adult- and child-sized toothbrushes, children's and adult fluoridated toothpaste, non-fluoridated toothpaste for infants, 2-min timers, photocards, brochure and song sheets. Each family also received a children's book encouraging toothbrushing.	Knowledge Skills Social influences Environmental context and resources	Pre- to post-non-randomized design	67 parents and children
O'Malley et al (2017)[37]	28	Group 1 (intervention)—received a storybook and DVD ('Kitten's First Tooth') 'Kitten's First Tooth' is a children's story embedded with specific behaviour change techniques. The following behaviour change techniques are written into the script: · Providing general information on the behaviour health link · Providing information on consequences · Providing information about other's approval · Prompting intention formation · Providing general encouragement · Providing instruction · Modelling/ Demonstrating behaviour Providing feedback on performance · Teaching to use prompts/cues · Planning social support/social change As well as a DVD and storybook, the initial pack also included : a fridge magnet and a bookmark. Parents were advised to use the DVD and storybook 3 or more times per week. At the end of the study, parents received a 'Thank you' pack which included the following: a 'Kitten's First Tooth' themed brushing chart with stickers and oral health themed stationary. Group 2 (Control)—no intervention	Knowledge Skills Beliefs about capabilities Beliefs about consequences Motivation and goals Memory, attention and decision processes Social influences Behaviour regulation Nature of behaviours	A controlled before and after/non-randomized comparative study design	149 children

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
0-5 y	Immediately post-intervention and at 3 mo	Oral health knowledge and behaviours	Brush twice a day or more: 0.82 Brush with fluoridated Toothpaste: 86% Brushed child's teeth before bed every day last week: 22% Child does not eat or drink anything after brushing his teeth and before going to bed: 47% Adult assistance with brushing child's teeth every night: 57% Check the child's teeth each month ('lift the lip'): 75% Total knowledge score: 12.8 (1.6)	Brush twice a day or more: Post-test 1 99% ($P < .0001$) Post-test 2 90% ($P = .7815$) Brush with fluoridated Toothpaste: Post-test 1 96% ($P = .008$) Post-test 2 99% ($P = .5637$) Brushed child's teeth before bed every day last week: Post-test 1 82% ($P = .0001$) Post-test 2 81% ($P = .7963$) Child does not eat or drink anything after brushing his teeth and before going to bed: Post-test 1 80% ($P < .0001$) Post-test 2 92% ($P = .0076$) Adult assistance with brushing child's teeth every night: Post-test 1 67% ($P = .2568$) Post-test 2 95% ($P = .0001$) Check the child's teeth each month ('lift the lip'): Post-test 1 99% ($P < .0001$) Post-test 2 95% ($P = .1797$) Total knowledge score: Post-test 1 15.2 (0.7, $P < .0001$) Post-test 2 15.2 (0.6, $P = .2983$)	NR
1-5 y old 34 males, 33 females White non-Hispanic, Other non-Hispanic and Hispanic or Latino	4 to 8 wk post-intervention	Oral health Confidence in TB Knowledge about baby teeth Attitudes towards child TB and caries Choice of dental supplies Satisfaction with the intervention programme	94% believed that twice daily TB of child was realistic 59% brushed their children's teeth twice daily 34% parent brushed, 56% brushed together (parent and child) Mean attitude score towards TB 4.33 Mean Confidence in TB and TB frequency: 8.4 Knowledge score (including home hygiene and dental health): 2.25 (m)	89% brushed their children's teeth twice daily Mean attitude score towards TB 4.60 Mean Confidence in TB and TB frequency: 9.47 Things to know (including home hygiene and dental health):2.62 (m)Attitudes towards TB, confidence in TB and TB frequency, and knowledge were significantly different comparing pre- and post-intervention ($P < .01$)	N/A
3-5 y old	3 mo	Parental self-efficacy, intention and attitudes towards oral health behaviours (toothbrushing, sugar snacking and child dental attendance)	Self-efficacy: Toothbrushing (Mean, SD) Intervention group 4.29 (0.56) Control group 4.25 (0.69) Intention: Brush child's teeth Intervention group 4.19 (0.57) Control group 4.12 (0.61) Attitudes: Prevention (toothbrushing) Intervention group 4.29 (0.63) Control group 4.12 (0.61) Perceived seriousness of tooth decay in children: Intervention group 3.72 (0.75) Control group 3.69 (0.87) Chance control—decay occurs by chance: Intervention group 3.83 (0.55) Control group 3.97 (0.63)	Self-efficacy: Toothbrushing (Mean, SD) Intervention group 4.62 (0.47) Control group 4.29 (0.68)($P < .01$) Intention: Brush child's teeth Intervention group 4.46 (0.58) Control group 4.10 (0.61) ($P < .05$) Attitudes: Prevention (toothbrushing) Intervention group 4.53 (0.52) Control group 4.25 (0.48) ($P < .05$) Perceived seriousness of tooth decay in children: Intervention group 3.81 (0.79) Control group 3.62 (0.85) ($P < .01$) Chance control—decay occurs by chance: Intervention group 3.97 (0.63) Control group 3.95 (0.69) ($P > .05$)	NR

(Continues)

TABLE 1 (Continued)

Paper	Quality of paper	Intervention description	Barrier intervention addresses—as per Theoretical Domains Framework	Study design	Number
Schroth et al (2015)[44]	16	Healthy Smile Happy Child (HSHC) campaign in four communities delivered through existing community resources. Activities included the following: Health fairs—Increase awareness and discuss early childhood caries prevention with caregivers, as well as provide information on dental services and resources within local community Teaching resources—True/False game, Dental Bingo game, So Sweet Bottles table display demonstrating the sugar content of drinks commonly given to children, the 'Think about your Baby's Teeth' poster, and age-specific fact sheets for parents/ caregivers Dental 'anticipatory guidance bags'—developed to correspond with children's immunization schedules provided parents with advice for caring for baby teeth Early dental visits and infant oral health screenings promoted Programme staff encouraged parents/caregivers to regularly check their children's teeth for early signs of caries, by 'lifting the lip'	Knowledge Skills Beliefs about consequences Social influences	Serial cross-sectional study	319 children and primary caregivers

[a]Although other outcome variables related to eating habits, for example, were also reported by several studies; as the focus of this systematic review is home-based toothbrushing, only these data are reported in the table.

publication.[39] Seven studies failed to find significant differences,[20,26,31,33,44,50,61] and two even reported increases in caries experience post-intervention.[24,25]

Ten studies explored changes in the barriers associated with PSB. Nine of the ten found significant improvements in variables such as, knowledge, attitudes, perceived behavioural control, self-efficacy, perceived threat, health literacy, subjective norms, intentions, and oral health fatalism post-intervention.[20,23,27,32-34,36,37,45,47,52] One study found that parental intentions, however, did not significantly change post-intervention.[35]

Finally, only 5 studies undertook process evaluation as part of their evaluation for their intervention.[31,35,36,46,62] This was used to assess the acceptability of the intervention to participants' and how variables of significance changed post-intervention.

4 | SUMMARY

In summary, 42 intervention studies targeting home-based toothbrushing practices were identified for inclusion in the current review. These interventions were predominantly one-to-one sessions (26/42) with a health practitioner in a health setting addressing a small number of barriers to PSB, namely knowledge and skills, with less than half (18/42) being informed by psychological theory. Clear significant improvements in PSB practices were found in 16 studies. Of the studies exploring the impact on caries, improvement in caries was found in 19/29 of the intervention studies. There was a small number of studies failing to find a significant impact of their intervention (7/29) or indeed finding a detrimental impact (2/29).

5 | DISCUSSION

This is the first systematic review to summarize the published research examining interventions promoting home-based toothbrushing practices to reduce dental caries in young children. A total of 42 studies were included in the review identifying their effectiveness in promoting home-based toothbrushing by parents of young children.

The first point to note is that there are relatively few that can be classed as purely promoting home-based toothbrushing by parents, as the vast majority of those included targeted oral health in general, including issues such as healthy eating, with toothbrushing practices forming a small part within the intervention. There were five studies that focussed specifically on targeting the home-based toothbrushing practices of parents with their children.[23,27,40,54,61] Most of the studies shared similar formats with the interventions predominantly addressing knowledge about oral health. These educational programmes tended to be communicated through health professionals, predominantly dental care practitioners, via lectures, counselling/discussion sessions, leaflets, and videos, with further support being provided through follow-up phone calls/text messages and home visits in some instances.[22,24,27,31,34,39,45,56,57] There were some exceptions to this format, for example, several studies employed motivational interviewing to discuss with parents dental outcomes for their children[20,22,28-30,33,36,38]; or interventions included additions to this format, for example, by further enhancing toothbrushing skills through demonstrations/practice of appropriate brushing techniques;[23,31,47,49-51] though this was not always an obligatory element of the intervention.[51] Two studies, however, used completely novel delivery methods for their intervention, with one utilizing a smartphone app ('ToothSense')[35]

Demographics	Follow-up	Outcome measures reported[a]	Pre-intervention	Post-intervention	Caries increment
Children under 71 mo (mean age 38.2 ± 18.6 mo)	5 y	Knowledge, attitudes and behaviour regarding early childhood oral health; and preschool oral health status	Teeth being cleaned or brushed at home (68.2%) Caregivers brushing their child's teeth (53.3%) Child's teeth being brushed more than once per day (37.6%) Brushing child's teeth before 12 mo (26.8%)	Teeth being cleaned or brushed at home (87.7%, $P < .0001$) Caregivers brushing their child's teeth (86.7%, $P < .0001$). Child's teeth being brushed more than once per day (49.3%, $P = .001$). Brushing child's teeth before 12 mo (43.7%, $P < .0001$).	There was no significant difference in early childhood caries prevalence between baseline and follow-up. Age-adjusted logistic regression for SECC, however, showed a significant reduction in prevalence between baseline and follow-up ($P = .021$)

and the other taking the form of a storybook ('Kitten's First Tooth') to be read by parents and children together.[37] Finally, many of these interventions supplemented their educational programmes through the provision of free toothpaste and toothbrushes,[20,24,26,31,33,36,40,42,43,46,47,49-51,53,54,60,61] and in a small number of studies through dental care and fluoride provision, such as fluoride varnish.[24,28,33,38,40,42,43,47,48,52,54,58,59]

Despite the studies being broadly similar in format, there is little to no justification for the intervention components, with only two notable exceptions,[27,37] and there is a distinct lack of theoretical basis for the intervention. Out of the 42 intervention studies included in the review, less than half reported that they had been informed by theory. There, however, does appear to be a recent influx in the number of interventions incorporating theory into their development and evaluation with the majority of the theory-informed interventions being published from 2015 onwards (14/18 studies). This is an encouraging development for oral health interventions; however, there is a clear prevailing theoretical basis for a substantial number of these interventions with 8 of the 18 intervention studies utilizing Motivational Interviewing.[20,22,28-30,33,36,38] Motivational Interviewing targets behaviour change at the level of the individual by engaging in focused and goal-directed counselling that allows individuals to identify their own barriers and solutions.[63] Although, Motivational Interviewing was the most popular theory of choice in the current systematic review, the evidence for its effectiveness was mixed, with six studies yielding significant findings[22,28-30,36,38] and two yielding non-significant findings.[20,33] Although this may not seem initially concerning, it is worth acknowledging that one of the studies producing non-significant findings was the paper marked as having the highest quality in the present review.[20] Furthermore, it raises several questions, which are indeed acknowledged by the authors themselves,[20,33] regarding the optimal target population, training, intervention content, and dose to elicit effective behaviour change, which at present remains unclear. In contrast to the individual level approach, a number of studies considered their interventions within a wider socioecological framework (ie, individual, interpersonal, organizational, and community) and/or used a community-based participatory approach to gain local knowledge about the health problem and design the intervention.[23,24,26,31,34,37] Such community and peer-to-peer support is being increasingly encouraged nationally and internationally as an effective means of delivering oral health improvement.[7,64,65] Nevertheless, only two studies[27,37] mapped appropriate behaviour change techniques to their chosen theory to inform their intervention components and measured subsequent changes in these components, thus providing clear examples of how their interventions content was constructed based on specific behaviour change techniques. The problems with interventions not being based on theory are twofold. Firstly, it means there is no evidence or sound theoretical reason for including individual components within an intervention, and there is no specificity between what is being used in the intervention and what that effectively targets. Secondly, it means there is no understanding of why an intervention is effective or ineffective as the case may be, as the determinants of the behaviour are not clearly defined.

With regard to the effectiveness of the interventions included in the current review, meaningful results for PSB are lacking. Despite 17/42 studies demonstrating improvements in the self-reported toothbrushing practices of parents for their young children, these improvements were seen across intervention and control groups in several studies. Thus, this raises the question of whether only minimal involvement is needed, or the more likely scenario that participants may be providing socially desirable responses. However, in

TABLE 2 Theoretical Domains from the Theoretical Domains Framework addressed by included interventions

Theoretical Domain	Number of studies addressing Theoretical Domain
Knowledge	41
Skills	35
Environmental context and resources	22
Social influences	20
Beliefs about consequences	11
Motivation and goals	10
Behaviour regulation	6
Beliefs about capabilities	5
Memory, attention, and decision processes	4
Nature of behaviour	2

Heilbrunn-Lang, Carpenter, de Silva, Meyenn, Lang, Ridge, Perry, Cole, Hegde,[46] despite reporting significant improvements in parent-assisted toothbrushing and toothpaste use, parents self-reported their child's oral health as poorer post-intervention. Furthermore, due to the lack of theory and consideration of the determinants of behaviour it is unclear what is driving this improvement. All the intervention studies reporting on PSB gained the data through self-reported measures, which are open to bias. Subsequently, should objective measures of toothbrushing become available, future interventions should combine these with self-report measures to yield more comprehensive and accurate results. With regard to caries, the results are more varied with two studies even showing increased prevalence of caries following the interventions.[24,25] This is concerning, and there are numerous reasons why such results could have emerged. Firstly, both studies scored within the middle range in terms of their quality; thus, the results could be due to limitations in methodological rigour. Second, although interventions are developed and implemented with the intention of improving individuals' lives, unintended consequences and even harms can occur as a result of intervening. This is why when developing interventions, it is imperative to take the wider context into account in an attempt to anticipate and avoid causing unintended harm, and in addition, it demonstrates the utility of a thorough process evaluation of interventions. Unfortunately, of those studies that did find significant reductions in caries following their intervention, it is unknown whether this was the result of greater PSB or the result of receiving restorative and preventive dental care as part of the intervention.

Finally, there was a wide range in the quality of the interventions included within the present systematic review. This is in part due to the poor reporting of intervention development, content, and evaluation methods, as without this information it is difficult to understand what the intervention is, its mechanisms of action, what the impact is of the intervention and for whom and in what context. The implications of this are therefore twofold. First, future endeavours must embrace complex intervention development and evaluation methodology, underpinned by appropriate theory. Second, intervention developers should seek to report their interventions and evaluation process in full, including publishing their intervention development procedure. Such an approach will increase the methodological rigour of interventions, which in turn will improve the quality of the research and the intervention itself. Thus, increasing the likelihood of the intervention not only being effective in improving health outcomes, but also being acceptable to the public. Moreover, high-quality research means that appropriate conclusions can be drawn not only in terms of effectiveness, but about what works, for whom, and in what context, and can be used to inform and produce subsequent recommendations.

5.1 | Strengths and limitations

There were several limitations to the current review. First, the original search strategy included papers written in various languages, and although efforts to translate these papers into English were made, resources were not always available. As such, these papers had to be excluded meaning there is the possibility that important findings are missing from the current review. Second, it must be acknowledged that there were several protocol papers for interventions that were identified during our search, but as they have not yet been fully evaluated they had to be excluded. These interventions, however, may offer interesting insights in the future.

The major strength of the current research is that it is the first comprehensive review of the literature regarding interventions promoting parental supervised toothbrushing practices. The current review used the TDF to categorize intervention mechanisms to PSB. This strategy was adopted to ensure consistency in the description of the construct and thus provide a common language that can be understood within a multi-disciplinary field, but it is recognized that in some circumstances our interpretation may have differed from the original authors. The advantage of systematically analysing each paper using the TDF to categorize what theoretical determinants of behaviours the intervention targets, rather than relying on the authors classification is that the process is inherently rigorous. In this instance, three authors independently coded each intervention mechanism (EA, KG-B, and SE), followed by discussion of each coding with support from a fourth coder (PD) where necessary. Due to the limited description of interventions, such a rigorous approach has been invaluable in the attempt to identify the

active components of interventions. Ensuring the scientific quality of the current review has been a key principle from the outset, with a thorough protocol being published on the PROSPERO website prior to its undertaking.

The present systematic review is the first to assess a wide range of papers to comprehensively collate the currently existing evidence on interventions promoting PSB. Furthermore, the current review is unique in its use of the Theoretical Domains Framework to provide a unifying framework to identify what barriers appeared to be targeted by interventions, thus providing an insight into their mechanisms of behaviour change. Such an approach has highlighted that PSB must be considered as a range of behaviours, which is underpinned by several behavioural domains. Yet, this has not been targeted in a meaningful way by interventions to date, and indeed, there is a lack of rigour in intervention development. This has been a key reason for the narrative synthesis of results, as clear effect sizes of interventions are poorly reported. Thus, it is recommended that future interventions consider the wide array of socioecological determinants of PSB, use a guiding theory to aid their development and report caries increment effect sizes in a clear and transparent manner.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

EA, K.V-C., ZM, RM and PD conceived the ideas; EA, K.V-C, S.E and K.G-B collected and analysed the data. E.A and K.G-B led the writing. All authors read and contributed to the final draft of the manuscript.

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APPENDIX 1

Reference list of studies included in systematic review.