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Effect of treating carious teeth on children's and adolescents' anthropometric outcomes: A systematic review of randomised controlled trials

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Objective: To examine the impact of treating carious teeth on children's and adolescents' anthropometric outcomes. ***Basic research design:*** Four electronic databases and four electronic clinical trials registries were searched. Two reviewers independently conducted the screening, data extraction and critical appraisal. The Cochrane Risk of Bias Tool for Randomised Controlled Trials was used to assess the risk of bias in the included studies. ***Results*:** The searches yielded 399 potential studies. Following deduplication and screening of the papers, four were considered eligible for inclusion of which two referred to the same study. None of the included studies was found to have a high risk of bias in any of the domains. However, performance bias was deemed of unclear risk in all studies. One of the studies found that following extraction of pulpally involved teeth, underweight children exhibited a statistically significant improvement in their weight-for-age (change in mean=0.26; $p<0.001$) and BMI-for-age z scores (change in mean=0.52, $p<0.001$) and had a significant weight gain (change in mean=1.2; $p<0.001$). Two studies showed that dental intervention did not have a significant effect on anthropometric outcomes. Treatment of caries significantly improved children's oral health-related quality of life in two studies. ***Conclusions:*** The evidence into the impact of treating carious teeth on children's growth is mixed and inconclusive. However, there is consistent evidence that treatment of severely carious teeth can significantly improve children's oral health-related quality of life. Oral health promotion and strategies to screen for oral health problems and widen dental access should be considered as part of integrated public health programs targeting children.

Keywords: Dental Caries, Dental Care for Children, Child Development, Systematic Review

Introduction

Dental caries is a major public health issue worldwide (Benjamin, 2010; FDI World Dental Federation, 2015; Global Burden of Disease Study 2013 Collaborators, 2015; Marcenes *et al.,* 2013; Petersen *et al.*, 2005) and has been characterised as a 'silent epidemic' (Benjamin, 2010). It is one of the most common infectious diseases in the childhood population (FDI World Dental Federation, 2015) and affects 60-90% school-aged children in many developed countries (Petersen, 2003; Petersen *et al.*, 2005). According to the World Health Organisation, the prevalence of caries is increasing in many developing countries, primarily due to the increased intake of sugars and limited fluoride exposure (Petersen *et al.*, 2005).

The burden of untreated caries is high (Marcenes *et al.*, 2013) and can affect directly the child and their family, the community, as well the healthcare system (Casamassimo *et al.*, 2009). Caries experience has been associated with poorer quality of life for the child, distress for the family, poorer school performance, missed days from school and parent's work, increased treatment cost and risk of hospitalisation (Casamassimo *et al.*, 2009; Colak *et al.*, 2013; Royal College of Surgeons: Faculty of Dental Surgery., 2015; Scarpelli *et al.*, 2013). In the UK, between 2017 and 2018, dental extraction (primarily due to caries) was the most common reason for English children aged 6 to 10 years to be admitted to hospital (Public Health England, 2019).

A number of primary studies and systematic reviews have investigated the association between caries and anthropometric indices, largely because health problems associated with growth and development share common pathways with dental caries through dietary behaviours. Caries experience has been associated with lower body weight, height and body mass index (BMI) (Alkarimi *et al.*, 2014; Benzian *et al.*, 2011; Hooley, 2012). Untreated caries may lead to pain and infection, which could affect a child's eating ability, the uptake of nutrients and their sleep resulting thus in poor growth (Hannaway, 1970; Sheiham, 2006). Chronic infection induced by untreated gross caries, may impair growth hormone secretion as well as increase calorific demands and reduce nutrients absorption, therefore negatively affecting the child's normal development and growth (Alkarimi *et al.*, 2012; Alkarimi *et al.*, 2014; Mohammadi *et al.*, 2009).

Given that after eliminating dental pain and sepsis, children's growth has been shown to improve (Acs *et al.,* 1999), it is important to investigate the impact of treating carious teeth can have on children's growth. There has been no attempt so far to systematically examine the impact of treating dental caries on chilren's growth. Therefore, the present systematic review aimed to address the following question: Does treatment of carious teeth affect children's and adolescents' anthropometric outcomes?

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Method

The review protocol was registered in advance with the international database PROSPERO (registration number: CRD42017081397). PRISMA guidelines were followed to conduct and report the review.

The PICOs framework was used to formulate the focused question and build the search strategy. Subject headings and free text terms were used. The RCT filter developed by Scottish Intercollegiate Guidelines Network was applied (SIGN, 2017). The inclusion criteria were based on PICOs framework and are presented in Table 1.

An information specialist developed the search strategy and conducted the searches. The electronic databases searched included Embase, MEDLINE, CINAHL and CENTRAL. The searches were conducted on 01/08/2017. The Embase (Ovid) search strategy can be found at https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=81397. The same search strategy was adapted for the other electronic databases. In order to locate further trials, we searched the following registries: ClinicalTrials.gov, EU Clinical Trials Register, WHO International Clinical Trials Registry Platform, ISRCTN registry. Finally, we searched EThOS to locate theses. Following screening, the reference lists of included studies were checked for additional studies. Missing and unpublished data were sought from primary authors. There were no date or language limits.

The results were collected and deduplicated in EndNote and the Rayyan systematic review web application was used for screening (Ouzzani *et al.*, 2016). Two reviewers independently screened the papers on title/abstract (MP and AP). The same reviewers conducted the screening of selected papers on full text. A discussion between the reviewers was held to reach a consensus on any disagreements. Interrater agreement was excellent for both the title and abstract stage (k=0.98, 95%CI, 0.97-1.00, $p<0.05$) and the full text stage (k=0.82, 95%CI 0.49-1.00, $p<0.05$).

The Cochrane Collaboration data collection form for RCTs was used to extract details of the included studies following pilot-testing. Two reviewers (MP and AP) independently carried out the data extraction on descriptive characteristics. A third reviewer extracted the statistical data (DP) which were then double checked by MP.

The Cochrane risk assessment tool for RCTs was used to assess the risk of bias (Higgins *et al.*, 2011). In case of disagreement, a discussion was held to reach consensus (MP and AP).

The change in the anthropometric measures was calculated using the mean difference before and after the intervention (DP).

Results

The PRISMA flowchart (Fig 1.) indicates that 332 potentially relevant papers were identified through electronic databases. The grey literature search yielded 67 reports. Following identification of additional records through other sources and deduplication, 190 remained, of which 185 were excluded as their titles or abstracts indicated that they did not meet the inclusion criteria. Thus, five full-text papers were assessed. From these, one was excluded due to the lack of control group (no treatment) (Maserejian *et al.*, 2012). That study compared the effect of composite versus amalgam on children's growth, rather than whether treatment was provided or not (Maserejian *et al.*, 2012). Thus, four papers were included in the review.

The characteristics of the four included publications are detailed in Table 2. Two were part of the same study (Weight Gain Study) (Duijster *et al.*, 2013; Monse *et al.*, 2012). All studies took place in non-European countries (Saudi Arabia, Philippines and Surinam) and in areas with high caries burdens. Saudi is ranked as a very high human development country, Surinam as high and Philippines as medium. The recruited children were up to 7 years of age. The sample sizes of the studies varied from 86 (Alkarimi *et al.*, 2012) to 380 children (Van Gemert-Schriks *et al.*, 2011). Three studies only followed up participants for a short period of 4,6 or 8 months (Alkarimi *et al.*, 2012; Duijster *et al.*, 2013; Monse *et al.*, 2012). Van Gemert-Schriks et al. (2011) followed up the children 1, 2 and 3 years post-treatment.

Caries experience of the participating children was assessed using the dmft and dmfs indices, which count the total number of decayed (d), missing (m) and filled (f) teeth (t) or tooth surfaces (s) (Klein & Palmer, 1940). Two studies additionally used the pufa-index, which indicated the severity of dental caries (Duijster *et al.*, 2013; Monse *et al.*, 2012). Treatment modalities to treat carious teeth included active prevention (silver-diamine-fluoride) (Duijster *et al.*, 2013; Monse *et al.*, 2012), partial caries removal (atraumatic restorative technique) (Van Gemert-Schriks *et al.*, 2011), conventional fillings (Alkarimi *et al.*, 2012), stainless steel crowns (Alkarimi *et al.*, 2012) and tooth extractions (Alkarimi *et al.*, 2012; Duijster *et al.*, 2013; Monse *et al.*, 2012; Van Gemert-Schriks *et al.*, 2011). Across the studies, extractions were carried out for all the symptomatic teeth and the teeth with pulpal related pathology.

Table 1. Inclusion Criteria based on PICOs framework

Population/participants	Children and adolescents younger than 18 years old
Intervention(s), exposure(s)	Treatment (any kind) of carious teeth
Comparator(s)/control	Children/Adolescents who do not receive treatment
Outcomes(s)	Primary outcome(s) Anthropometric variables (e.g. weight, height, Body Mass Index, waist circumference, hip circumference) Secondary outcome(s) Oral Health-Related Quality of Life (where applicable)
Study type	Randomised controlled trials

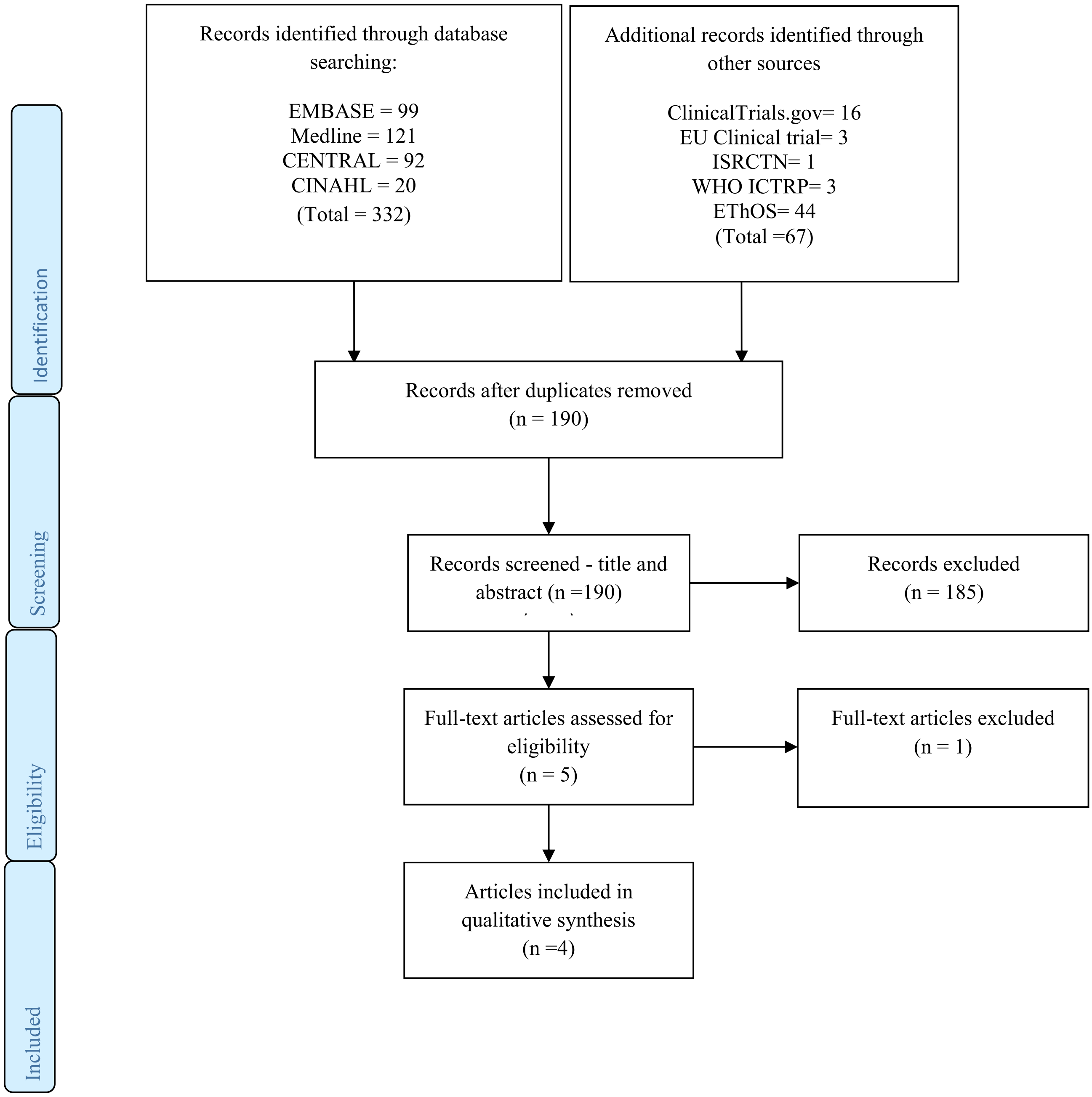

Figure 1. PRISMA Flow Diagram

The results on the risk of bias across the studies are presented in Table 3. Overall, none of the trials was found to have high risk of bias in any of the domains. All domains were assessed as of low risk of bias apart from the performance bias domain which was deemed of unclear risk in all studies and the selection bias which was deemed unclear for the Weight Gain Study (Duijster *et al.*, 2013; Monse *et al.*, 2012). For both domains a judgement of unclear risk was made due to the lack of information.

The small number of studies prevented assessment of heterogeneity and calculation of summary estimates in meta-analysis (Shea *et al.*, 2017). Although meta-analysis can be conducted with three studies, it would be underpowered. In this case, our ability to provide summary estimates for the effect of caries treatment on anthropometric measurements was also restricted by the lack of data needed to compute paired differences in z-scores between baseline and follow-up or between groups. Moreover, two sources presented results from the same study, with some overlap of data (Duijster *et al.*, 2013; Monse *et al.*, 2012).

The Philippines Weight Gain study indicated a significant improvement in underweight children's weight-for-age (mean change =0.26; p<0.001) and BMI-for-age z scores (mean change =0.52, p<0.001) after dental treatment, whereas height-for-age decreased (mean change =0.09; p<0.001) (Duijster *et al.*, 2013; Monse *et al.*, 2012). In particular, extraction of teeth with pulpal involvement led to a significant weight gain (mean change =1.2; p<0.001). In contrast, the results of Alkarimi et al. (2012) and Van Gemert-Schriks et al. (2011), which overall were judged to have lower risk of bias, indicated no significant differences in the above anthropometric outcomes between the treatment and control groups.

Table 2. Table of study characteristics

Author, Year of publication	*Study location (country, city)*	*Study setting*	*Follow up*	*Sample at baseline & follow up*	*Sample characteristics (age, Male/Female)*	*Outcomes*	*Method of treating caries*	*Outcomes (including effect size)-e.g difference in means & CI*	*Comments*
Alkarimi *et al*., 2012	Saudi Arabia, Jeddah	Military primary schools	6m	Baseline: 86 (42 early treatment vs 44 control i.e. normal treatment) Follow up: 86 (42 vs 44)	72-95m Treatment Gp M: 16 (38.1%) F: 26 (61.9%) Control Gp M: 16 (36.4%) F: 28 (63.6%)	WAZ, HAZ, BAZ dmft & pufa index Dental pain, satisfaction, appetite	Extraction of non-restorable teeth & teeth with pathology Stainless steel crowns for extensively carious teeth Pulpotomy & stainless steel crowns for teeth with inflamed coronal pulp Fillings for teeth with small lesions	<u>Primary:</u> Mean differences & 95% CI in treatment group (post vs pre) • WAZ 0.09 (0.23, -0.07) • HAZ 0.07 (0.12, 0.04) • BAZ 0.03 (-0.5, 0.44) Mean differences & 95% CI (adjusted for group type, pre-intervention score, mother's education & child's appetite), 95%CI & p-value (treatment vs control) • WAZ 0.10, (-0.07, 0.27), • HAZ 0.02, (adjusted OR, 95% CI, (treatment vs control) • Pain 0.09, (0.01,0.51) • Satisfaction 9.91 (2.68, 36.51) • Appetite 2.91 (1.24, 6.82)	Dental treatment did not affect outcomes
Duijster *et al*., 2013*	Philippines, Misamis Oriental, Northern Mindanao	Day care centres	4 & 8m	Baseline=179 Follow up =145 Waiting list Control Gp: n=102	48-71m M: 55 (37.9%) F: 90 (62.1%)	Weight, height, BMI (WAZ, HAZ, BAZ), dfmt. pufa	Extraction of pulpally-involved teeth Silver-diamine-fluoride ACT for other teeth	Primary: Mean differences & *p* (post vs pre) WAZ 0.26, <0.001 HAZ -0.09, <0.001 BAZ 0.52, <0.001 <u>Secondary:</u> Mean difference & *p* SOHO-5 -2.7, <0.001 Dental pain –24, <0.001	Differences in WAZ, HAZ & BAZ before & after treatment
Monse *et al*., 2012 *	Philippines, Northern Mindanao	Day care centres	4m & 8m	Baseline: 202 (100 treatment vs 102 control i.e. treatment after 1st follow up) Follow up: 164 (85 vs 79)	59.9±5.0m Treatment Gp : M: 49 (49%) F: 51 (51%) Control Gp M: 36 (35%) F: 66 (65%)	Weight, height, BMI WAZ, HAZ, BAZ dmft/dmfs pufa	Extraction of pulpally-involved teeth silver-diamine-fluoride ACT for other carious teeth	Mean differences in SD & *p* (post vs pre) in treated WAZ 0.3, <0.01 HAZ 0.1, <0.001 BAZ 0.4, <0.001 β, 95% CI (treatment vs control) adjusted for time between baseline & 1st follow-up. WAZ 0.23, (0.11,0.35), HAZ -0.14, (-0.28, 0.00), BAZ 0.49, (0.29, 0.69)	Conditional growth velocity. Children's BAZ increased after treatment but not in untreated children.

table 2 continued overleaf...

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Author, Year of publication	*Study location (country, city)*	*Study setting*	*Follow up*	*Sample at baseline & follow up*	*Sample characteristics (age, Male/Female)*	*Outcomes*	*Method of treating caries*	*Outcomes (including effect size)-e.g difference in means & CI*	*Comments*
Van Gemert-Schriks *et al*., 2011	Interior of Surinam	Schools	6m, 1, 2 & 3y	Baseline: G1 (Full treatment)=96 G2 (Extraction)=91 G3 (Atraumatic restorative treatment ART)=96 G4 (control)=97 Follow up: G1=88 G2=85 G3=89 G4=93	6 years G1 M: 53 (55.2%) F: 43 (44.8%) G2 M: 50 (54.9%) F 41 (45.1%) G3 M: 48 (50%) F: 48(50%) G4 M 41 (42.3%) F:56 (57.7%)	BMI-Standard deviation, Total-dmfs. Total-ds Pulpal inflammation (pulp) was reported had reached pulp &/or if exposure expected on excavation.	Extraction of symptomatic teeth, pulpally-involved teeth & teeth with signs of pathology Atraumatic restorative treatment (ART) for carious teeth with no signs of pulpal inflammation	Only a figure was provided to show change in BMI & SDS_{BMI}	No differences in BMI/ (SDS_{BMI}) between groups.

**Part of the Weight Gain Study*

WAZ: Weight-for-age z-score, HAZ: Height-for-age z-score, BAZ:BMI-for-age z-score, dmft: decayed missing filled teeth index, pufa: records the presence of severely decayed teeth with visible pulpal involvement (p), ulceration caused by dislocated tooth fragments (u), fistula (f) and abscess (a), ACT: Arrest of Caries Technique.

Two studies showed that children who received treatment experienced better oral health-related impacts compared to children in the control groups. In the study by Alkarimi et al. (2012), children in the intervention group experienced significantly less pain (OR 0.09, 95%CI 0.01-0.51), higher satisfaction with their teeth (9.91, 2.68-36.51) and better appetite (2.9, 1.24-6.82) than controls. Similarly, Duijster et al. (2013) demonstrated improved oral health-related quality of life among children after treatment, as indicated by the significantly lower scores in the Scale of Oral Health Outcomes questionnaire (SOHO-5)(mean SOHO-5 score fell from, 4.1 to 1.4, p<0.001). The proportion of children experiencing eating and sleeping impacts, as well as dental pain, also decreased. In particular, 82.5% of children reported at least one impact before treatment, but following treatment only 27.6% did so. Moreover, weight gain after treatment was associated with improvement or no difference in sleeping ability ((no difference: b coefficient 0.36 (0.12, 0.61; p=0.004) and improvement: 0.31 (0.07, 0.55; p=0.01)). However, weight gain was not associated with changes in eating or dental pain.

Discussion

Dental caries is prevalent around the globe and its burden is increasing especially amongst developing countries where the access to dental care may be limited (Petersen *et al.*, 2005). The present systematic review judged that the evidence stemming from randomised controlled trials into the impact of treating caries on children's development is mixed and inconclusive. Although there is evidence that treating carious teeth has a positive impact on children's growth, it is not consistent.

Different explanations may be speculated for the lack of differences between the test and comparison groups in some studies. All except the one from Van Gemert-Schriks at al. (2011), had short follow up periods of, up to 8 months, which may not capture growth changes children aged 4-7 years (Alkarimi *et al.*, 2012; 2014). Furthermore, it may be that it is only the extraction of severely carious teeth (i.e. pulpally-involved and infected teeth) that explains any improvement in anthropometric outcomes. In addition to the severity of caries, whether children are underweight or not may also determine the impact of dental treatment on growth-related parameters. The possibility of failure to grow being attributed to other factors than caries (e.g. other infectious diseases) cannot be excluded, although such factors are likely to be evenly distributed between the group participants after randomisation (Monse *et al.*, 2012).

Eliminating active caries either conservatively or surgically (by extractions of the carious teeth), in turn, has been shown to result in an increase in children's body weight and body mass index (Duijster *et al.*, 2013; Mohammadi, Wright & Kay, 2009). One possible explanation for the increase in weight-gain, could be the re-establishment of children's dietary intake following eradication of active caries, which due to pain had affected children's mastication/chewing ability and consequently growth patterns in the first place (Mohammadi *et al.*, 2009). Secondly, as demonstrated by Alkarimi et al. (2012), treatment of severe carious lesions can improve children's appetite,

Table 3. Risk of bias assessment.

Authors (Date)	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data addressed (attrition bias)	Selective reporting (reporting bias)
Alkarimi et al. (2012)	+	+	?	+	+	+
Duijster et al. (2013)	?	?	?	+	+	+
Monse et al. (2012)	?	?	?	+	+	+
Van Gemert-Schriks et al. (2011)	+	+	?	+	+	+

+	Low Risk
-	High Risk
?	Unclear Risk

and this could be a result of reduced pain and inflammation. Lastly, another possible mechanism for the resulting weight gain after extraction of decayed teeth could be the impact on sleeping. In fact, Duijister et al. (2013) demonstrated that following dental treatment, improvements in sleeping rather than eating were associated with weight gain.

Notwithstanding, two studies showed that children's dental symptoms, appetite and oral health-related quality of life improved post-treatment and these can be viewed as immediate effects of the intervention that will precede any improvement in growth. If treating dental caries, therefore, improves a child's potential to grow and thrive, oral health promotion strategies to prevent dental caries at a community level as well as provision and access to dental treatment could be incorporated in public health programs targeting children. A common risk factor approach to such programs would be advantageous to address multiple conditions rather than disease-specific actions (Sheiham & Watt, 2000; Watt & Sheiham, 2012).

The present study has some limitations. Only a limited number of studies have been identified and this restricted our ability to estimate heterogeneity and provide a summary estimate for the effect of treatment of caries. In addition, two of the studies included refer to the same RCT, and despite the fact that comparisons are different, there is still some overlap.

Across the studies, any infected or symptomatic teeth were removed regardless of the group to which children were allocated. This may have acted as contaminant in the studies and diluted the results. However, it would have been unethical to refuse treatment of symptomatic teeth in the control-group children. Similarly, we believe that ethical considerations explain the limited number of randomised controlled studies identified in the literature. Withholding treatment from a child with dental disease is undoubtedly unethical. This has also an implication on the follow up periods discussed above.

Following up the patients of these studies, would allow determination of long-term effects of dental treatment on growth and development from childhood to adolescence. Future evaluations should adjust for known confounders and explore further the impact of dental care on additional outcomes of quality of life.

Evidently, in recent years there have been more analytic cross-sectional studies examining the association between anthropometric outcomes and caries (Paisi *et al.*, 2019). Taking into consideration the hierarchical level of evidence, and the fact that cross sectional studies do not imply causality, more RCTs are required to provide experimental evidence of the possible link. Novel pathways to conduct such trials in an ethical manner need to be identified.

Conclusions

Although there is some evidence that treating severe carious teeth has a positive impact on children's growth, the evidence is mixed and inconclusive. The impact of treating caries is more pronounced in underweight populations.

A positive association between provision of dental treatment and oral health related quality of life has also been observed. Following a common risk factor approach, oral health promotion and strategies to screen for oral health problems and widen dental access could be incorporated in future public health programs targeting children. Exploring the long-term effect of treatment on children's development and quality of life is warranted.

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Conflicts of interest

No conflicts of interest to declare

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