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Breastfeeding Versus Bottle Feeding on Malocclusion in Children: A Meta-Analysis Study

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Abstract

Background: Breastfeeding plays an important role in child health. However, there are doubts about its influence on malocclusions. Systematic reviews have yielded contradictory results.

Research aim: This study aimed to investigate whether the type and duration of breastfeeding are associated with malocclusions in primary teething.

Methods: The review strategy included several electronic databases, lists of references, reviews, dissertation and thesis websites, experts, and other relevant documents. Published and unpublished observational studies (N = 42) were reviewed using the Participants (children), Interventions (breastfeeding), Comparisons (bottle feeding), Outcomes (malocclusion), and Study design (observational) strategy, without restrictions on language or locale. Information about the authors, publication year, country of study, setting, study design, sample size, age, type and duration of exclusive and mixed breastfeeding, and malocclusions was recorded by two blinded evaluators. Quantitative meta-analysis (N = 30) of the studies with available data was performed.

Results: Breastfeeding was a protective factor against malocclusions. The odds of association increased with breastfeeding duration. Irrespective of duration, breastfeeding had a protective association with open bite. For those who were breastfed for up to 6 months, breastfeeding protected against overjet, open bite, posterior crossbite, and crowding. Breastfeeding for 12 months or longer was associated with lower odds of overjet, open bite, and posterior crossbite. Breastfeeding exclusively for 6 months was also a protective factor against malocclusions. However, studies on this subject presented low quality, statistical heterogeneity, and only unadjusted measures of association in most of the cases.

Conclusion: Breastfeeding beneficially affects primary occlusion when practiced for at least 6 months.

Keywords

breastfeeding, breastfeeding duration, epidemiological methods, exclusive breastfeeding, oral motor dysfunction

Background

The World Health Organization (WHO), the United Nations Children's Emergency Fund (UNICEF), and other health organizations advocate for exclusive breastfeeding from birth to 6 months of age (Health Canada, Canadian Paediatric Society, Dietitians of Canada, & Breastfeeding Committee for Canada, 2012; WHO, 2001). Evidence for the importance of exclusive breastfeeding until 6 months of age and complementary until age 2 years exists to combat early malnutrition, reduce infant morbidity and mortality (Horta & Victora, 2013; Sankar et al., 2015; Victora et al., 2016), supply the iron reserves that infants require (Maguire et al., 2013; Victora et al., 2016), and improve cognitive function (Horta, Loret, & Victora, 2015; Nyaradi, Li, Hickling, Foster, & Oddy, 2013; Victora et al., 2016). There is also strong evidence that exclusive breastfeeding provides immunological and emotional benefits to the infant (Bridgman et al., 2016; Rollins et al., 2016).

In oral health, breastfeeding plays a role in the growth and development of the stomatognathic system (Ganesh, Tandon,

& Sajida, 2005; Raymond & Bacon, 2006; Sánchez-Molins, Grau, Lischeid, & Ustrell, 2010), which is the combination of organs, structures, and nerves involved in the functions of sucking, chewing, swallowing, speech, and breathing (Castro, Toro, Sakano, & Ribeiro, 2012). The mother's breast acts as a natural orthodontic device (Page, 2001). When sucking, the infant correctly positions the tongue inside the mouth and performs a true "milking" of the breast (Sakalidis et al., 2013). The arches, cheeks, and tongue move harmoniously, and the neuromuscular functions of the mouth develop in a balanced manner (Rollins et al., 2016). Another possible explanation for the beneficial effects of breastfeeding is that long-term feeding reduces the child's risk of acquiring nonnutritive sucking habits, such as sucking pacifiers and fingers (Narbutytė, Narbutytė, & Linkevičienė, 2013; O'Connor, Tanabe, Siadaty, & Hauck, 2009).

Conversely, insufficient breastfeeding and excessive bottle feeding can lead to an increase in the frequency of these nonnutritive sucking habits, which are associated with a risk for developing malocclusions (MOs; Garde et al., 2014; Narbutytė et al., 2013; O'Connor et al., 2009; Sánchez-Molins et al., 2010; Thomaz, Cangussu, & Assis, 2013; Viggiano, Fasano, Monaco, & Strohmenger, 2004). However, no consensus exists on this association or on its magnitude (Hermont et al., 2015; Howard et al., 2003; Thomaz, Cangussu, & Assis, 2012). How breastfeeding duration, exclusive breastfeeding, and artificial feeding affect the onset of dental MOs is also unclear (Carrascoza, Possobon, Tomita, & de Moraes, 2006; Diouf et al., 2010; Hermont et al., 2015; Peres, Cascaes, Nascimento, & Victora, 2015; Peres, Cascaes, Peres, et al., 2015; Thomaz et al., 2012). Moreover, questions remain regarding the types of MO that are affected by breastfeeding.

Systematic reviews (Abreu, Paiva, Pordeus, & Martins, 2016; Hermont et al., 2015; Narbutytė et al., 2013; Peres, Cascaes, Peres, et al., 2015; Victora et al., 2016) on the subject have yielded contradictory results. Researchers in some studies have found an association between breastfeeding and MO (Narbutytė et al., 2013; Peres, Cascaes, Peres, et al., 2015; Victora et al., 2016), whereas others concluded that there was insufficient evidence to establish such relationships (Abreu et al., 2016; Howard et al., 2003). These differences may be due to methodological differences. Some were restricted to longitudinal observational studies (Hermont et al., 2015; Narbutytė et al., 2013) and English as the primary language (Narbutytė et al., 2013), other authors included studies with mixed (Abreu et al., 2016; Peres, Cascaes, Peres, et al., 2015) and permanent dentitions (Abreu et al., 2016; Hermont et al., 2015; Peres, Cascaes, Peres, et al., 2015), and some did not consider how breastfeeding duration affects MO (Narbutytė et al., 2013). We were able to identify only one meta-analysis that included studies of the primary dentition but did not distinguish how breastfeeding affects each type of dentition (Peres, Cascaes, Peres, et al., 2015).

Key Messages

- Breastfeeding plays an important role in child health by reducing morbidity and mortality. However, there are doubts about its influence on the onset, magnitude, and types of malocclusions in primary teething. Systematic reviews have yielded contradictory results.
- This is the first meta-analysis evaluating whether breastfeeding (exclusive and/or supplementary) and its duration affect the occurrence of different types of malocclusion, exclusively considering deciduous teething.
- Breastfeeding beneficially affects deciduous occlusion. These effects can be observed if breastfeeding is practiced for at least 6 months.

Evidence exists that some MOs in the deciduous dentition will be self-corrected in the permanent dentition (Baccetti, Franchi, McNamara, & Tollaro, 1997; Dimberg, Lennartsson, Arnrup, & Bondemark, 2015; Dimberg, Lennartsson, Söderfeldt, & Bondemark, 2013). However, 30% to 42% of these problems will persist (Dimberg et al., 2013), especially posterior crossbite (Dimberg et al., 2015) and Class II MOs (Baccetti et al., 1997). Therefore, the study of etiological factors of MO in the deciduous dentition may help prevent this problem in the permanent dentition.

Although the importance of breastfeeding to the psychological and physical development of children is well established (Victora et al., 2016), its influence on the development of the maxillofacial system remains controversial (Abreu et al., 2016; Hermont et al., 2015). Given the importance

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of breastfeeding newborns and the fact that there is no consensus on the role of breastfeeding in the development of dental MOs, the purpose of this study was to investigate whether the type and duration of breastfeeding, compared with other forms of feeding, are associated with MO in primary teething in observational studies. The hypothesis was that breastfeeding is a protective factor against MOs in primary teething.

Methods

Design

We performed a systematic review followed by a meta-analysis of observational studies. The article was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for literature reviews (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009) and according to the Meta-analysis Of Observational Study in Epidemiology (MOOSE) guidelines (Stroup et al., 2000), because PRISMA is not specific for meta-analyses of observational studies. The review protocol was not registered because the studies included were not based on randomized clinical trials.

Sample

We used the PICOS (Participants, Interventions, Comparisons, Outcomes, and Study design) strategy (Methley, Campbell, Chew-Graham, McNally, & Cheraghi-Sohi, 2014) to search for studies, substituting intervention (I) with exposure (E). The population of interest consisted of children. Two exposures were considered: breastfeeding and exclusive breastfeeding. The control group consisted of nonbreastfed children and/or those who were bottle fed. The outcomes were dental MOs.

No search restrictions were placed on language, publication status, or publication date. Electronic database searches were supplemented by manual searches of bibliographic data from overall health subjects and dentistry in particular, minimizing selection bias. Published and unpublished studies up to December 2015 were included in the search.

We used the following bibliographic databases: PubMed, MEDLINE, Central Cochrane, Latin American and Caribbean health literature (Literatura Latino-Americana e do Caribe em Ciências da Saúde), Google Scholar, Brazilian Database of Dentistry (Base Brasileira de Odontologia), SciELO, Embase, EBSCOhost Online Research Databases, PsycINFO–American Psychological Association, Dentistry and Oral Sciences Source, Education Resources Information Center, Social Sciences Citation Index, Sociological Abstracts, Web of Science, CidSaude, PAHO, REPIDISCA, DESASTRES, ADOLEC, Base de Dados de Enfermagem, HomeoIndex, MedCarib, WHOLIS, IBECS, Scopus, Index Medicus for the South-East Asian Region, Index Medicus for the Eastern Mediterranean Region, CINAHL, WHO-Afro, Cubana Medicina, Database of Abstracts of Reviews of Effects, and Western Pacific Region Index Medicus. Studies were also identified by searching other data sources, including lists of references, reviews, and dissertation and thesis websites. We also consulted experts and any other relevant documents to identify additional studies. When necessary, the study authors were contacted to clarify their findings and data methodologies. The first data search was performed in April 2015. The search was updated in September 2015 and again in January 2016.

The search keywords were identified according to Medical Subject Headings and Health Sciences Descriptors vocabularies. To broaden the search, synonyms were identified using Google and a thesaurus. The following English keywords were used: (Tooth, Deciduous or Primary teething or Temporary teething or Child or Children or Minors or Only child or Child, Preschool or Preschool) AND (Breast Feeding or Breastfeeding or Milk, Human or Feeding) AND (Breast-Milk Substitutes or Milk Substitutes or Bottle Feeding or Bottlefeeding or Milk) AND (Malocclusion or Teeth or Oral habits or Deleterious oral habits or Habits or Mandibular Advancement or Orthodontics, Corrective or Prognathism or Malocclusion, Angle Class I or Angle Class I or Malocclusion, Angle Class II or Angle Class II or Malocclusion, Angle Class III or Angle Class III or Overbite or Tooth Crowding or Crossbite or Angle's Classification) AND (Cohort Study or Concurrent Studies or Incidence Study or Cross-Sectional Study or Cross Sectional Survey or Prevalence Study or Case-Control Study or Case-Comparison Study). To ensure reproducibility, the searches were documented in detail.

We included all identified studies in which researchers investigated the relationship between the type (artificial feeding or breastfeeding, exclusive or mixed) and duration of feeding and the development of MO. Only studies (N = 42) with an observational analytical design (cohort, case control, or cross-sectional) were taken into consideration (see Figure 1), when, for ethical reasons, it was not possible to evaluate the associations of interest in randomized clinical trials. For the meta-analysis, the included studies (N = 30) provided data enabling the calculation of association measures, such as relative risk (RR), odds ratios (*OR*s), and prevalence ratios (PRs).

Additional sample inclusion criteria were research that included children of both genders ages 0 to 7 years with primary teeth. The sample exclusion criterion was children with syndromes leading to dentofacial deformities (e.g., Down syndrome and Papillon-Lefevre syndrome).

The primary outcome was the presence of any type of MO, such as nonspecific MO, anterior and posterior open bite, anterior and posterior crossbite, overbite, overjet, crowding and molar and canine relationships, or others. All of them were combined and analyzed as one outcome. The secondary outcomes consisted of the most prevalent subtypes of MO reported in the literature. This strategy was necessary due to the wide variety of MO classifications available. All the outcomes were dichotomized as being present or absent.

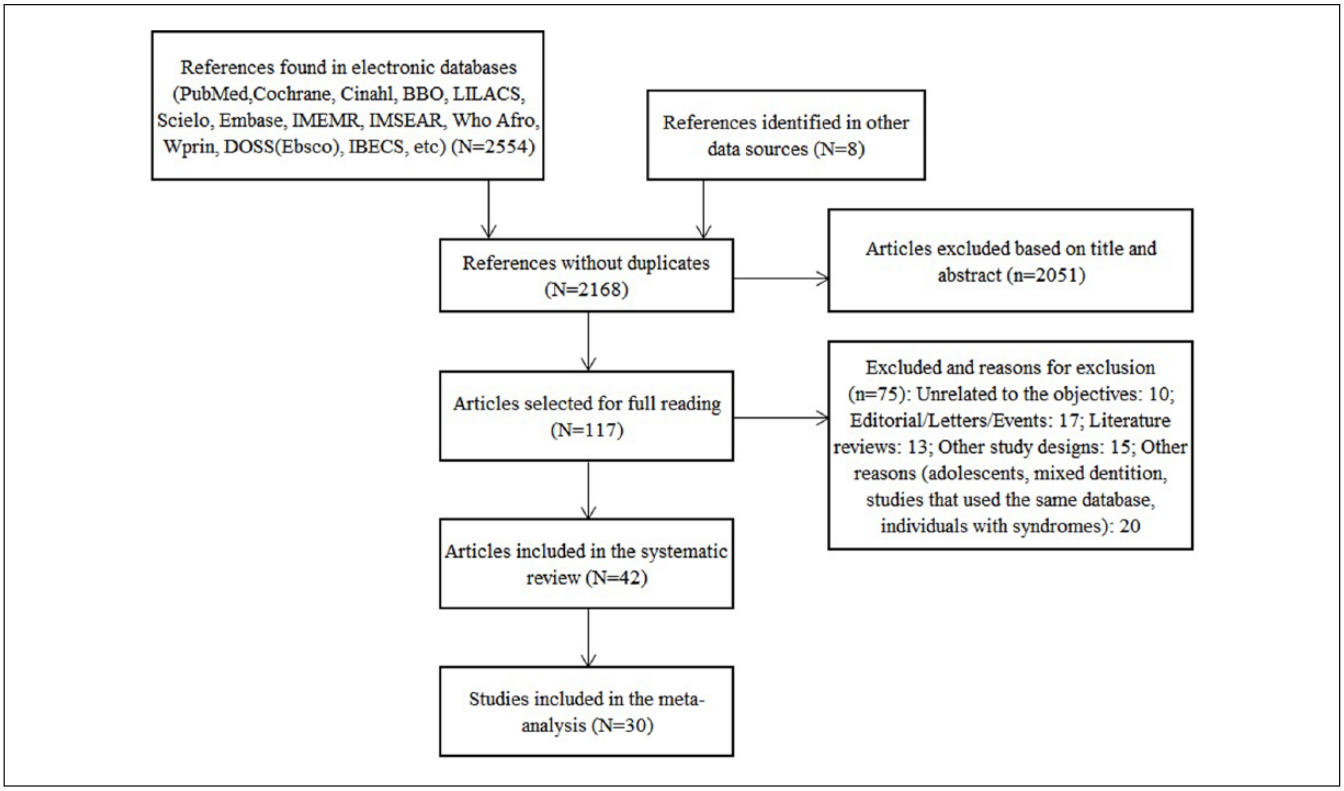

Figure 1. Flowchart of the article selection process.

Data Collection

The research was done by two previously trained, blinded researchers. That is, the searches were done twice, independently. At the end of the searches, the results were compared and all the studies found by both were analyzed.

Studies were initially selected for inclusion based on their titles and abstracts, which were selected and read by two independent assessors. Each assessor independently classified the studies as "included," "excluded," or "unclear" according to the eligibility criteria. Discrepant results were discussed until a consensus was reached, and records of the reasons for any exclusions were kept. Two researchers read all selected manuscripts. They extracted information about the authors, publication year, country of study, setting, study design, sample size, sample age range, exposure and outcome, and the criteria for defining the exposure and outcome. Some of these data were categorical and others numerical. All included studies were available in English, German, Spanish, or Portuguese, and the researchers were fluent in English, Spanish, and Portuguese. The German studies were translated to English by a bilingual professional. Data were recorded on a data form. Disagreements between the two extractors were resolved using the consensus method.

The time of breastfeeding was categorized as (a) having been breastfed, regardless of duration (yes or no); (b) having been breastfed for 6 months or longer (yes or no); (c) having been breastfed for 12 months or longer (yes or no); and (d) having been exclusively breastfed for 6 months or longer (yes or no).

Data Analysis

A systematic review and meta-analysis of the studies were performed using the Review Manager version 5.3.5 (Cochrane Collaboration, 2014).

Assessment of the risk of bias. The risk of bias for each study was assessed using quality assessment tools specific to the observational studies (see Table 1). For each of the 14 items, the response options were as follows: yes (the space was filled with an "X"); and no, cannot determine, not applicable, or not reported (the space was left blank). Studies with a "yes" response to Items 7 through 11 and 14 (considered to be the most important) and those with adequate responses to at least 10 of the 14 items were considered to have a lower risk of bias (National Institutes of Health & National Heart, Lung, and Blood Institute, 2014). Funnel plots and the inclusion of unpublished studies were used as strategies to find potential publication biases (Liu, 2011; Mavridis & Salanti, 2014).

Measuring associations. The MO events in the exposed and unexposed children were recorded to calculate association measures. *OR*s and their respective 95% confidence intervals (CIs) were estimated using the method described by DerSimonian and Laird (1986, 2015). We used a Mantel-Haenszel

Table 1. Quality Assessment Tool (QAT).

1	Was the research question or objective in this paper clearly stated?
2	Was the study population clearly specified and defined? Was the cohort population free of the outcomes of interest at the time of recruitment?
3	Was the participation rate of eligible persons at least 50%?
4	Were all the subjects selected or recruited from the same population or similar populations (including in the same time period)? Were the inclusion and exclusion criteria for study subjects prespecified and applied uniformly to all participants?
5	Were sample size justification, power description, or variance and effect estimates provided?
6	For the analyses in this paper, was the exposure of interest measured prior to the outcome being measured?
7	Was the time frame sufficient so that one could reasonably expect to observe an association between exposure and outcome if it existed?
8	For exposures that may vary in amount or level, did the study examine different levels of exposure as they related to the outcome (trends or dose response)?
9	Were the exposure measures clearly defined, valid, reliable, and implemented consistently across all the study participants?
10	Was exposure assessed more than once over time?
11	Were the outcome measures clearly defined, valid, reliable, and implemented consistently across all the study participants?
12	Were the outcome assessors blinded to the exposure status of the participants?
13	Was loss to follow-up after baseline 20% or less?
14	Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Note. From "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies." by National Institutes of Health and National Heart, Lung, and Blood Institute, 2014 (Available on: https://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort). The original publication is available on https://www.cadth.ca/media/pdf/QAT_final.pdf (Bai A, Shukla VK, Bak G, Wells G. Quality Assessment Tools Project Report. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2012).
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random-effect meta-analysis (implemented in Review Manager), which estimates the amount of between-study variation by comparing each study's result with a Mantel-Haenszel fixed-effect meta-analysis result (Cochrane Collaboration, 2014; Deeks & Higgins, 2010). In addition, the adjusted association measures, together with their respective 95% CIs, were calculated. If adjusted measures were not present, crude measures were calculated from the available data and recorded.

Assessment of heterogeneity. The clinical and methodological heterogeneities were evaluated and took into account any existing disparities. Statistical heterogeneity was evaluated based on the p value estimate of Cochran's Q test and the inconsistency index (I^2). Forest plots and funnel plots were also evaluated. Statistical heterogeneity was noted if $p < .10$ for the Q test, $I^2 \geq 50\%$, 95% CI was not overlapping on the forest plot, and there was asymmetry in the measures of the studies plotted on the funnel plot. Whenever there were significant heterogeneities, subgroup analyses were performed according to the study design and MO type as well as sensitivity analyses, in which we calculated whether the exclusion of the studies with a high probability of bias affects the associations (Higgins, Thompson, Deeks, & Altman, 2003; Langan, Higgins, & Simmonds, 2015).

Results

Characteristics of studies are presented in Table 2. The data showed heterogeneity among the studies. Most studies had a cross-sectional design, and only four cohort studies were identified. The sample size ranged from 38 to 2,186 children, and the MOs were measured in different ways.

Of the 14 items used to evaluate the risk of bias, at least 10 (71.4%) were adequately present in 7 (16.7%) studies that were considered to have a lower risk of bias (see Table 3). The majority of the studies did not provide adjusted estimates for confounders, such as non-nutritive sucking habits. In 12 (28.6%) studies, researchers identified a significant protective association, whereas others found no association (see Table 4). Bueno, Bittar, Vazquez, Meneghim, and Pereira (2013) reported unadjusted estimates; their evidence showed that breastfeeding was a risk factor for overbite-type MOs.

The meta-analysis summary estimation showed a protective association between breastfeeding (considering the four types of breastfeeding evaluated) and MO occurrence. This association increased with the duration of breastfeeding: breastfeeding for any duration (OR = 0.63, 95% CI [0.49, 0.80]), for 6 months or longer (OR = 0.54, 95% CI [0.40, 0.72]), and for 12 months or longer (OR = 0.31, 95% CI [0.20, 0.50]).

Data had high heterogeneity ($I^2 > 50\%$, $p < .10$); thus, subgroup analyses were performed by separating the studies according to study design (see Figures 2-4) and MO type (see Figures 5-7). The subgroup analyses decreased heterogeneity in the cohort studies (see Figures 2 and 4) and the MO-type subgroups (see Figures 5-7).

The protective associations in the subgroup analyses were also significant in both cross-sectional (OR = 0.28, 95% CI [0.14, 0.57]) and cohort (OR = 0.38, 95% CI [0.24, 0.60]) study designs (see Figures 2-4). In the MO-type subgroups,

Table 2. Characteristics of Reviewed Studies (N = 42).

Study	Country	Setting	Study design	N	Age (years)	BF exposure	Outcome
Agarwal et al. (2014)	India	School	Cross-sectional	415	4-6	BF duration (< 6 or ≥ 6 months)	Dental arch transverse diameters, posterior crossbite, and AOB
Aznar, Galán, Marín, & Domínguez (2006)	Spain	School	Cross-sectional	1,297	3-6	BF (yes or no)	Dental arch width (intercanine and intermolar distances)
Bueno, Bittar, Vazquez, Meneghim, & Pereira (2013)	Brazil	Health service	Cross-sectional	138	4-5	BF duration, EBF (≤ 6 or > 6 months)	AOB, overjet, overbite, posterior crossbite, and maxillary deficiency
Caramez da Silva, Justo Giugliani, & Capsi Pires (2012)	Brazil	Population based	Cross-sectional nested cohort	153	3 & 5	BF duration	Distoclusion
Cardoso, de Bello, Vellini-Ferreira, & Santos (2014)	Venezuela and Brazil	School	Cross-sectional	2,186	3-6	BF duration (< 6 or ≥ 6 months)	Open bite
Castelo, Gaviid, Pereira, & Bonjardim (2010)	Brazil	Health service	Cross-sectional	38	3.5-7	BF (exclusive or not)	Crossbite
Charchut, Allred, & Needleman (2003)	United States	Health service	Cross-sectional	126	2-6	Type of feeding (predominantly BF or bottle feeding)	Overbite, overjet, AOB, and terminal plane relationships of the second molar and canine
Chen, Xia, & Ge (2015)	China	Health service	Cross-sectional	734	3-6	BF duration (never, 1-6 months, or > 6 months)	Deep overbite, open bite, anterior crossbite, posterior crossbite, overjet, and terminal plane relationship of canine and molar
Correa-Faria, Ramos-Jorge, Martins, Vieira-Andrade, & Marques (2014)	Brazil	Health service	Cross-sectional	381	3-5	BF (yes or no) and BF duration (≤ 6 or > 6 months)	MO, open bite, crossbite, and crowding
de Campos et al. (2013)	Brazil	Health service	Cross-sectional	441	5	BF duration (< 6 or ≥ 6 months)	MO (according to World Health Organization)
de Morais, Mota, & Amorim (2014)	Brazil	Health service	Cohort	180	3	EBF duration (< 4 or ≥ 4 months)	MO
Diouf et al. (2010)	Senegal	School	Cross-sectional	443	5-6	Type of feeding (BF, bottle feeding, both, or none)	Maxillary intercanine and intermolar length, anterior maxillary arch length, anterior maxillary depth, overjet, overbite
dos Santos Neto, Oliveira, Barbosa, Zandonade, & Oliveira (2012)	Brazil	Health service	Cohort	58	3	BF duration: direct or indirect (< 12 or ≥ 12 months)	MO
Fabac, Legouvić, & Župan (1992)	Croatia	School	Cross-sectional	272	3	BF (< 6 or ≥ 6 months)	Malocclusions (open bite, overbite, crossbite, and Class II)
Furtado & Vedovello (2007)	Brazil	School	Cross-sectional	147	3-6	BF duration (< 6 or ≥ 6 months)	MO
Galan-Gonzalez, Aznar-Martín, Cabrera-Domínguez, & Domínguez-Reyes (2014)	Spain	School	Cross-sectional	298	3-6	BF duration	Terminal plane of molar

(continued)

Table 2. (continued)

Study	Country	Setting	Study design	*N*	Age (years)	BF exposure	Outcome
Ganesh, Tandon, & Sajida (2005)	India	Health service	Cross-sectional	153	3-5	BF (exclusive or mixed)	Canine relationship, molar relationship, overjet, overbite, crossbite, open bite
Gondin et al. (2010)	Brazil	School	Cross-sectional	140	4-5	BF (yes or no) and BF duration (< 6 or ≥ 6 months)	Anterior open bite
Jabbar, Bueno, Silva, Scavone, & Ferreira (2011)	Brazil	School	Cross-sectional	911	3-6	BF (yes or no) and EBF ≤ 6 months	Overjet, anterior crossbite, Class II canine relationship
Karjalainen, Rönning, Lapinleimu, & Simell (1999)	Finland	—	Cohort in a randomized clinical trial	148	3	BF (exclusive or not)	Posterior crossbite and AOB
Kobayashi, Scavone, Ferreira, & Garib (2010)	Brazil	School	Cross-sectional	1377	3-6	BF duration (never, < 6 months, 6-12 months, or > 12 months)	Crossbite
Legovic & Ostric (1991)	Croatia	School	Cross-sectional	214	3	BF duration (never, ≤ 3 months, or > 3 months)	Canine relationship, diastemas, overbite, overjet, and AOB
Leite-Cavalcanti, Medeiros-Bezerra, & Moura (2007)	Brazil	School	Cross-sectional	342	3-5	BF duration (up to 6, 7-18, or > 18 months)	MO
Lescano de Ferrer & Varela de Villalba (2006)	Argentina	—	Cohort	147	5	EBF ≤ 4 months and BF ≤ 1 year	MO, overbite, open bite, (anterior and posterior) crossbite, and arch shape
López del Valle, Singh, Feliciano, & del Carmen Machuca (2006)	Puerto Rico	—	Cross-sectional	540	0.5-5	BF (yes or no)	Open bite, crossbite, space deficiency, and canine and molar relationship
Magallanes, Rios, & Marino (2005)	Peru	Health service	Cross-sectional	64	3	BF (yes or no)	Terminal plane, canine relationship, overjet, and overbite
Massuia & Carvalho (2012)	Brazil	Population based	Cross-sectional	374	3-5	EBF duration (never, < 6 months, or ≥ 6 months)	MO
Melink, Vagner, Hocevar-Boltezar, & Ovsenik (2010)	Slovenia	School	Cross-sectional	60	3-7	BF duration (never, < 6 months, 6-12 months, or > 12 months)	Canine and molar relationships, anterior and posterior crossbites, and midline deviations
Moimaz et al. (2014)	Brazil	Population based	Cohort	80	2.5	BF (yes or no)	Overjet, open bite
Moimaz, Rocha, Garbin, & Saliba (2013)	Brazil	School	Cross-sectional	306	3-6	EBF (yes or no) and total BF duration: complementary and predominant (< 6 or ≥ 6 months)	MO, anterior and posterior crossbites, AOB

(continued)

Table 2. (continued)

Study	Country	Setting	Study design	*N*	Age (years)	BF exposure	Outcome
Nahás-Scocate et al. (2011)	Brazil	School	Cross-sectional	485	3-6	BF duration (never, < 3 months, 3-6 months, 6-9 months, 9-12 months, or > 12 months)	Terminal relationships of the primary second molars: classified as vertical plane, mesial step, and distal step
Pereira, Bussadori, Zanetti, Hõfling, & Bueno (2003)	Brazil	School	Cross-sectional	85	3-5	BF duration (never, ≤ 1 month, ≤ 2 months, ≤ 3 months, ≤ 4 months, ≤ 5 months, ≤ 6 months, ≤ 12 months, ≤ 24 months, or > 24 months)	MO (overbite, overjet, posterior crossbite, and crowding)
Peres, Barros, Peres, & Victora (2007)	Brazil	Population based	Cross-sectional nested cohort	1,270	6	BF duration	AOB and posterior crossbite
Peres, Cascaes, Peres, et al. (2015)	Brazil	Population based	Cross-sectional nested cohort	1,303	5	Predominant and exclusive BF duration (birth, ≤ 3 months, ≤ 12 months, or ≤ 24 months)	MO, open bite, crossbite, overjet
Raftowicz-Wojcik, Matthews-Brzozowska, Kawala, & Antoszewska (2011)	Poland	School	Cross-sectional	243	3-5	BF duration	Open bite, crossbite, overjet, overbite, and molar mesial occlusion
Rodriguez González & Martínez Brito (2011)	Cuba	Health service	Cross-sectional	156	2-5	BF duration (never, ≤ 6 months, or > 6 months)	Transversal micrognathism
Romero, Scavone-Junior, Garib, Cotrim-Ferreira, & Ferreira (2011)	Brazil	School	Cross-sectional	1,377	3-6	BF (exclusive, predominant, or complementary)	Vertical MO (normal, negative [anterior open bite], and increased [deep bite])
Sousa, Lima, Florêncio Filho, Lima, & Diógenes (2007)	Brazil	School	Cross-sectional	366	5	BF duration; EBF	Open bite
Terrado, Botiel, Mazo, Aguirre, & Ochoa (2014)	Cuba	Health service	Cross-sectional	106	5-6	BF (exclusive or mixed)	MO
Vasconcelos et al. (2011)	Brazil	Health service	Cross-sectional	1,308	2.5-5	Type of feeding (BF, bottle feeding, both, or none)	AOB
Viggiano, Fasano, Monaco, & Strohmenger (2004)	Italy	School	Cross-sectional nested cohort	1,099	3-5	EBF (at least the first 3 months)	MO, AOB, and posterior crossbite
Warren & Bishara (2002)	United States	Health service	Cohort	372	4.5-5	BF duration (never, < 6 months, 6-12 months, or > 12 months)	Canine relationship, anterior and posterior crossbites, AOB

Note. BF = breastfeeding; AOB = anterior open bite; EBF = exclusive breastfeeding; MO = malocclusion; — = not reported.

Table 3. Quality Assessment of the Reviewed Studies and Risk of Bias.

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Agarwal et al. (2014)	X		X	X		X		X		X	X	X		X	9
Aznar, Galán, Marín, & Domínguez (2006)	X			X		X				X	X				5[a]
Bueno, Bittar, Vazquez, Meneghim, & Pereira (2013)	X			X		X				X	X				5
Caramez da Silva, Justo Giugliani, & Capsi Pires (2012)	**X**		**X**	**X**		**X**		**X**	**X**	**X**	**X**	**X**		**X**	**10**
Cardoso, de Bello, Vellini-Ferreira, & Santos (2014)	**X**	**X**	**X**	**X**		**X**	**X**	**X**		**X**	**X**			**X**	**10**
Castelo, Gaviid, Pereira, & Bonjardim (2010)	X			X		X		X		X	X				6
Charchut, Allred, & Needleman (2003)	X			X				X		X	X				5[a]
Chen, Xia, & Ge (2015)	X	X	X		X	X		X		X	X	X			9
Correa-Faria, Ramos-Jorge, Martins, Vieira-Andrade, & Marques (2014)	X	X	X	X	X	X				X	X				8
de Campos et al. (2013)	X		X	X		X				X					5
de Morais, Mota, & Amorim (2014)	**X**			**X**	**X**	**X**		**X**	**X**	**X**	**X**		**X**	**X**	**10**
Diouf et al. (2010)	X		X	X		X				X	X				6[a]
dos Santos Neto, Oliveira, Barbosa, Zandonade, & Oliveira (2012)	X			X	X	X		X	X	X	X				8[a]
Fabac, Legouvić, & Župan (1992)	X		X	X		X	X		X						6
Furtado & Vedovello (2007)				X		X	X			X	X				6
Galan-Gonzalez, Aznar-Martín, Cabrera-Domínguez, & Domínguez-Reyes (2014)	X			X		X	X			X					5
Ganesh, Tandon, & Sajida (2005)	X		X	X		X				X	X				6[a]
Gondin et al. (2010)				X	X	X				X	X				5
Jabbar, Bueno, Silva, Scavone, & Ferreira (2011)	X			X		X		X		X	X				6
Karjalainen, Rönning, Lapinleimu, & Simell (1999)	X		X			X	X	X	X	X	X				8[a]
Kobayashi, Scavone, Ferreira, & Garib (2010)	X			X		X	X	X		X	X				7
Legovic & Ostric (1991)	X			X		X		X		X					5
Leite-Cavalcanti, Medeiros-Bezerra, & Moura (2007)				X		X	X			X					4
Lescano de Ferrer & Varela de Villalba (2006)	X					X		X		X					4
López del Valle, Singh, Feliciano, & del Carmen Machuca (2006)	X									X					2[a]
Magallanes, Rios, & Marino (2005)	X			X		X				X	X				5
Massuia & Carvalho (2012)	X	X		X		X	X			X	X				7
Melink, Vagner, Hocevar-Boltezar, & Ovsenik (2010)				X		X	X	X		X					5[a]
Moimaz et al. (2014)	**X**		**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		**X**		**10**
Moimaz, Rocha, Garbin, & Saliba (2013)	X		X	X	X	X				X	X				7
Nahás-Scocate et al. (2011)	X			X		X	X			X	X				6[a]
Pereira, Bussadori, Zanetti, Hõfling, & Bueno (2003)	X		X	X		X	X			X	X				7
Peres, Barros, Peres, & Victora (2007)	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**			**X**	**10**
Peres, Cascaes, Peres, et al. (2015)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**			**X**	**12[a]**
Raftowicz-Wojcik, Matthews-Brzozowska, Kawala, & Antoszewska (2011)	X			X		X	X	X		X	X				7
Rodriguez González & Martínez Brito (2011)	X					X	X			X	X				5[a]
Romero, Scavone-Junior, Garib, Cotrim-Ferreira, & Ferreira (2011)	X		X		X	X	X	X		X	X	X			9
Sousa, Lima, Florêncio Filho, Lima, & Diógenes (2007)	X	X	X	X		X				X	X				7
Terrado, Botiel, Mazo, Aguirre, & Ochoa (2014)	X			X		X				X					4[a]
Vasconcelos et al. (2011)	X	X		X	X	X				X	X				7
Viggiano, Fasano, Monaco, & Strohmenger (2004)	X		X	X		X		X		X	X				7
Warren & Bishara (2002)	**X**	**X**	**X**	**X**		**X**		**X**	**X**	**X**	**X**	**X**			**10**

Note. X = yes. Studies with a lower risk of bias (≥ 70% of adequate items) are in bold.
[a]Not included in the quantitative synthesis due to a lack of raw data.

breastfeeding of any duration remained statistically associated only with a reduction in the occurrence of anterior open bite (*OR* = 0.58, 95% CI [0.45, 0.75]; see Figure 5). Breastfeeding for 6 months or longer was associated with protective factors for overjet (*OR* = 0.68, 95% CI [0.52, 0.89]), open bite (*OR* = 0.55, 95% CI [0.41, 0.74]), posterior crossbite (*OR* = 0.31, 95% CI [0.16, 0.59]), and dental crowding (*OR* = 0.63, 95% CI [0.47, 0.84]) but was a risk factor for overbite (*OR* = 2.26, 95% CI [1.33, 3.86]; see Figure 6). Due to sparse data, it was impossible to get a summary measure of the Angle Class III MOs. Breastfeeding for 12 months or longer was associated with overjet (*OR* = 0.30, 95% CI [0.16, 0.57]) and overbite (*OR* = 2.67, 95% CI [1.46, 4.86]) but not with anterior and posterior crossbite (see Figure 7). A lack of adequate studies prevented the estimation of summary measures for associations with other types of MOs.

Table 4. Measures of Association Between the Presence of BF and Malocclusion.

Study	MO/exposed (%)	MO/not exposed (%)	Measure of association	Association [crude] [95% CI]	Exposure vs. MO
Agarwal et al. (2014)	5/257 (1.9)	20/158 (12.7)	Prevalence ratio	0.15 [0.06, 0.40]	BF (< 6 or ≥ 6 months) × crossbite (yes or no)
Aznar, Galán, Marín, & Domínguez (2006)	—	—	—	—	—
Bueno, Bittar, Vazquez, Meneghim, & Pereira (2013)	17/61 (28.3)	8/77 (10.4)	Odds ratio	2.78 [1.07, 7.25]	BF (> 6 and ≥ 6 months) × overbite (yes or no)
Caramez da Silva, Justo Giugliani, & Capsi Pires (2012)	23/72 (31.9)	50/81 (61.7)	Prevalence ratio	0.44 [0.23, 0.82][a]	BF (< 12 or ≥ 12 months) × distoclusion (yes or no)
Cardoso, de Bello, Vellini-Ferreira, & Santos (2014)	33/582 (5.7)	38/227 (16.7)	Odds ratio	0.48 [0.27, 0.81][a]	BF (yes or no) × AOB (yes or no)
Castelo, Gaviid, Pereira, & Bonjardim (2010)	7/22 (31.8)	12/16 (75.0)	Odds ratio	0.15 [0.04, 0.64]	BF duration × crossbite (yes or no)
Charchut, Allred, & Needleman (2003)	—	—	—	—	—
Chen, Xia, & Ge (2015)	135/434 (31.1)	92/300 (30.7)	Odds ratio	0.94 [0.68, 1.31][a]	BF (< 6 or ≥ 6 months) × Class II canine (yes or no)
Correa-Faria, Ramos-Jorge, Martins, Vieira-Andrade, & Marques (2014)	107/345 (31.0)	17/31 (54.8)	Prevalence ratio	0.56 [0.40, 0.81]	BF (yes or no) × MO (yes or no)
de Campos et al. (2013)	80/226 (35.4)	101/211 (47.9)	Prevalence ratio	0.74 [0.59, 0.92]	BF (< 6 or ≥ 6 months) × MO (yes or no)
de Morais, Mota, & Amorim (2014)	86/158 (54.4)	18/22 (81.8)	Prevalence ratio	1.39 [0.88, 2.18][a]	Exclusive BF (< 4 or ≥ 4 months) × MO (yes or no)
Diouf et al. (2010)	—	—	—	—	—
dos Santos Neto, Oliveira, Barbosa, Zandonade, & Oliveira (2012)	—	—	—	—	—
Fabac, Legouvić, & Župan (1992)	30/154 (19.5)	42/114 (36.8)	Prevalence ratio	0.53 [0.35, 0.79]	BF (< 6 or ≥ 6 months) × Class II canine (yes or no)
Furtado & Vedovello (2007)	58/71 (81.7)	40/75 (53.3)	Prevalence ratio	0.65 [0.51, 0.83]	BF (yes or no) × MO (yes or no)
Galan-Gonzalez, Aznar-Martín, Cabrera-Domínguez, & Domínguez-Reyes (2014)	6/109 (5.5)	6/189 (3.2)	Prevalence ratio	1.73 [0.57, 5.24]	BF (< 6 or > 6 months) × distal plane of molar (yes or no)
Ganesh, Tandon, & Sajida (2005)	—	—	—	—	—
Gondin et al. (2010)	34/129 (26.4)	5/11 (45.5)	Odds ratio	0.43 [0.13, 1.41]	BF (< 6 or ≥ 6 months) × AOB (yes or no)
Jabbar, Bueno, Silva, Scavone, & Ferreira (2011)	328/825 (39.8)	42/86 (48.8)	Prevalence ratio	0.81 [0.64, 1.03]	BF (yes or no) × Class II canine (yes or no)
Karjalainen, Rönning, Lapinleimu, & Simell (1999)	—	—	—	—	—
Kobayashi, Scavone, Ferreira, & Garib (2010)	192/1,258 (15.3)	37/119 (31.1)	Prevalence ratio	0.90 [0.85, 0.96]	BF (< 6 or ≥ 6 months) × posterior crossbite (yes or no)
Legovic & Ostric (1991)	38/134 (28.4)	32/76 (42.1)	Odds ratio	0.54 [0.30, 0.98]	BF (yes or no) × overjet (yes or no)
Leite-Cavalcanti, Medeiros-Bezerra, & Moura (2007)	68/120 (56.7)	140/170 (82.4)	Odds ratio	0.39 [0.14, 0.93]	BF (< 6 or > 6 months) × MO (yes or no)
Lescano de Ferrer & Varela de Villalba (2006)	17/56 (30.4)	39/91 (42.9)	Relative risk	0.66 [0.42, 1.04]	Exclusive BF ≤ 4 months and BF ≤ 1 year (yes or no) × open bite (yes or no)
López del Valle, Singh, Feliciano, & del Carmen Machuca (2006)	—	—	—	—	—
Magallanes, Rios, & Marino (2005)	31/42 (73.8)	14/22 (63.6)	Odds ratio	1.61 [0.53, 4.88]	BF (yes or no) × overjet (yes or no)

(continued)

Table 4. (continued)

Study	MO/exposed (%)	MO/not exposed (%)	Measure of association	Association [crude] [95% CI]	Exposure vs. MO
Massuia & Carvalho (2012)	174/332 (52.4)	26/42 (61.9)	Prevalence ratio	0.85 [0.65, 1.09]	BF (yes or no) × MO (yes or no)
Melink, Vagner, Hocevar-Boltezar, & Ovsenik (2010)	—	—	—	—	—
Moimaz et al. (2014)	2/10 (20.0)	44/70 (62.9)	Prevalence ratio	0.32 [0.09, 1.11]	BF (yes or no) × overjet (yes or no)
Moimaz, Rocha, Garbin, & Saliba (2013)	86/182 (47.2)	78/124 (62.9)	Odds ratio	0.53 [0.32, 0.86]	Exclusive BF (< 6 or ≥ 6 months) × MO (yes or no)
Nahás-Scocate et al. (2011)	—	—	—	—	—
Pereira, Bussadori, Zanetti, Hõfling, & Bueno (2003)	50/75 (66.7)	7/7 (100.0)	Prevalence ratio	0.67 [0.57, 0.78]	BF (yes or no) × MO (yes or no)
Peres, Barros, Peres, & Victora (2007)	137/295 (46.4)	33/71 (46.5)	Odds ratio	1.0 [0.59, 1.67]	BF (< 1 or ≥ 1 month) × AOB (yes or no)
Peres, Cascaes, Peres, et al. (2015)	—	—	Prevalence ratio	0.53 [0.27, 1.02][a]	BF (< 6 or ≥ 6 months) × moderate or severe MO (yes or no)
Raftowicz-Wojcik, Matthews-Brzozowska, Kawala, & Antoszewska (2011)	89/225 (39.6)	8/18 (44.4)	Prevalence ratio	0.89 [0.52, 1.53]	BF (never or yes) × MO (yes or no)
Rodriguez González & Martínez Brito (2011)	—	—	—	—	—
Romero, Scavone-Junior, Garib, Cotrim-Ferreira, & Ferreira (2011)	271/1,258 (21.5)	38/119 (31.9)	Odds ratio	0.58 [0.38, 0.91]	BF (yes or no) × AOB (yes or no)
Sousa, Lima, Florêncio Filho, Lima, & Diógenes (2007)	37/139 (26.6)	16/59 (27.1)	Prevalence ratio	0.98 [0.58, 1.66]	BF (< 6 or ≥ 6 months) × AOB (yes or no)
Terrado, Botiel, Mazo, Aguirre, & Ochoa (2014)	—	—	—	—	—
Vasconcelos et al. (2011)	48/242 (19.8)	371/1,066 (34.8)	Odds ratio	0.46 [0.32, 0.66]	BF (yes or no) × AOB (yes or no)
Viggiano, Fasano, Monaco, & Strohmenger (2004)	80/640 (12.5)	64/459 (13.9)	Odds ratio	1.28 [0.99, 1.66][a]	BF (yes or no) × AOB (yes or no)
Warren & Bishara (2002)	57/190 (30.0)	17/48 (35.4)	Prevalence ratio	0.97 [0.66, 1.43]	BF (yes or no) × MO (yes or no)

Note. MO = malocclusion; CI = confidence interval; BF = breastfeeding; — = not reported; AOB = anterior open bite.
[a] Adjusted association.

Exclusive breastfeeding for 6 months was also associated with a reduced chance of occurrence of MO ($OR = 0.49$, 95% CI [0.31, 0.77]; see Figure 8). The small number of studies available for this duration of exposure precluded further analysis.

In the sensitivity analysis, after removing the studies with a relatively high risk of bias, the results remained similar regarding the association of dental MOs with breastfeeding of any duration ($OR = 0.62$, 95% CI [0.46, 0.85]; $I^2 = 82\%$), breastfeeding for 6 months or longer ($OR = 0.53$, 95% CI [0.37, 0.77]; $I^2 = 84\%$), and breastfeeding for 12 months or longer ($OR = 0.29$, 95% CI [0.17, 0.49]; $I^2 = 72\%$). The heterogeneity of the studies with a relatively low risk of bias was similar to the heterogeneity of all the studies taken together.

Overall, the funnel plots show a concentration of the dots in the top of the plot (larger studies) that were somewhat more symmetrically distributed than were the smaller studies at the bottom. This suggests possible publication bias favoring studies with significant results (see Figures S9-S15 in the Supplementary Material available online).

Discussion

Our pioneering meta-analysis of observational studies, in which we evaluated the relationship between the type and duration of breastfeeding and different forms of MOs, showed that the longer the duration of breastfeeding, the lower the odds for the occurrence of MOs, particularly for overjet, anterior open bite, and posterior crossbite. However, a risk of overbite was found. The associations were consistent among the cohort and cross-sectional studies.

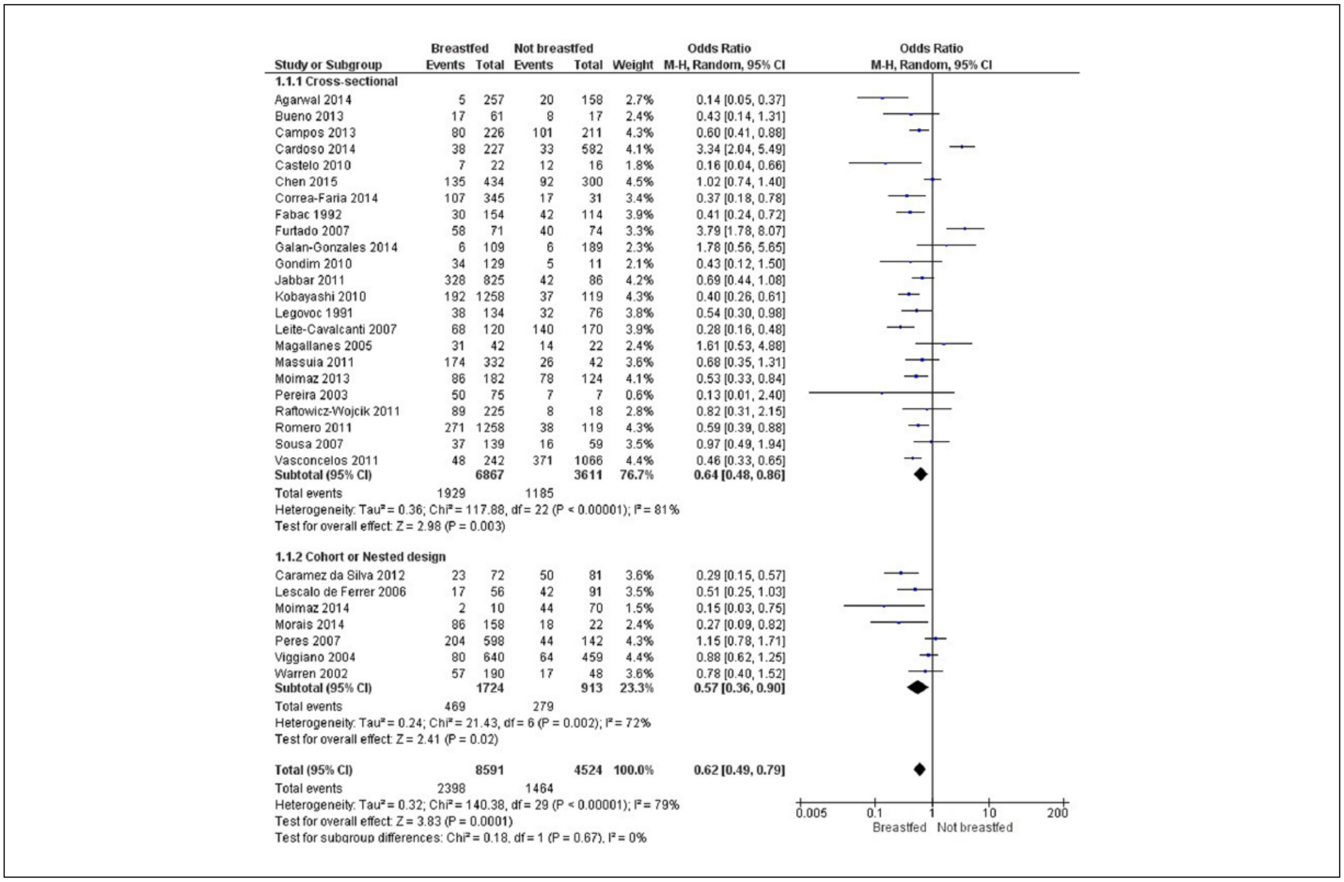

Figure 2. Breastfeeding (any duration) and malocclusion: a subgroup analysis according to study design. M-H = Mantel-Haenszel; CI = confidence interval.

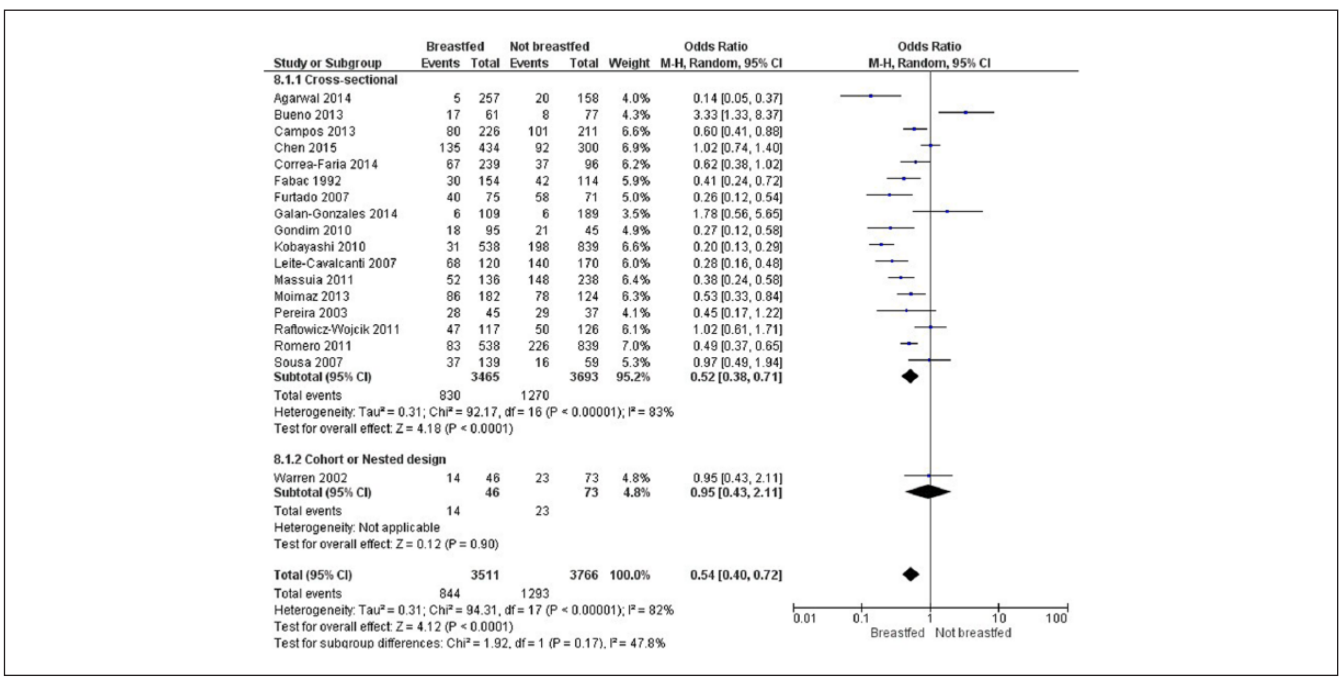

Figure 3. Breastfeeding (≥ 6 months) and malocclusion: a subgroup analysis according to study design. M-H = Mantel-Haenszel; CI = confidence interval.

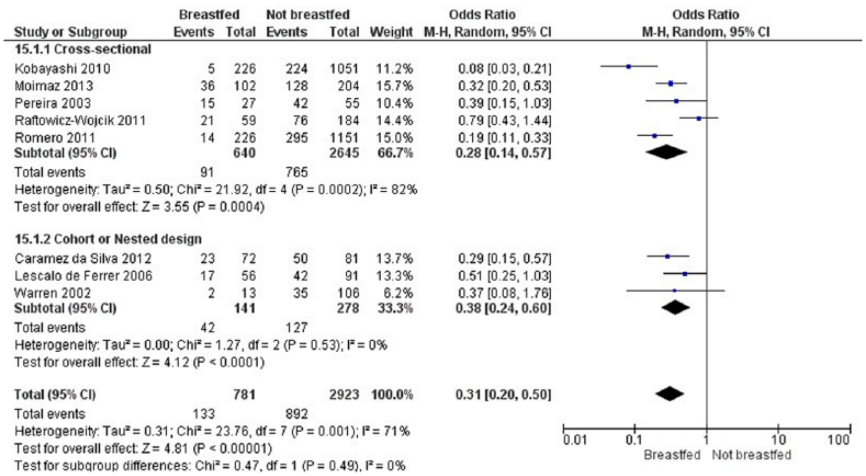

Figure 4. Association between breastfeeding (≥ 12 months) and malocclusion: a subgroup analysis according to study design. M-H = Mantel-Haenszel; CI = confidence interval.

Our results are unprecedented in the literature; however, they reveal an association that was expected. Certain explanations have been put forward to support the plausibility of the association between breastfeeding and specific types of MOs.

First, relatively short breastfeeding duration is potentially associated with the formation of deleterious sucking habits (pacifier and finger; Callaghan et al., 2005; Cardoso, de Bello, Vellini-Ferreira, & Santos, 2014), which are important risk factors for the onset of MOs, particularly anterior open bite (Feştilă, Ghergie, Muntean, Matiz, & Şerbănescu, 2014; Wagner & Heinrich-Weltzien, 2015). Artificial nipples (pacifiers and bottles) have a different shape, texture, and consistency from breast tissue (Lima et al., 2016). These characteristics lead to nonphysiological pressure in the oral cavity, which can restrict normal vertical and transverse palatal growth and cause improper alignment of the teeth, subsequently increasing the chance for posterior crossbite development (Narbutytė et al., 2013; Peres, Barros, Peres, & Victora, 2007; Viggiano et al., 2004).

Second, the muscular forces involved in sucking from a mother's breast differ from those used when sucking from a bottle. Thus, they may have a different effect on the development of the maxillofacial system due to the uneven functional load placed on the facial muscles involved in specific feeding processes (Sánchez-Molins et al., 2010). There are indications that sucking and swallowing, as well as other oral functions, may affect maxillofacial growth patterns and the positioning of teeth (Lescano de Ferrer & Varela de Villalba, 2006; Melink, Vagner, Hocevar-Boltezar, & Ovsenik, 2010).

Breastfeeding generates a greater demand on the infant's perioral muscles. The infant's constant and intensive, repetitive effort promotes the correct development of this musculature (Feştilă et al., 2014; Lescano de Ferrer & Varela de Villalba, 2006; Sakalidis et al., 2013), increasing its tone and ensuring that oral functions are correctly established (Moss, 1997; Stevenson & Allaire, 1991). This process stimulates adequate lip sealing and the correct positioning of the tongue (Carrascoza et al., 2006; Melink et al., 2010; Romero, Scavone-Junior, Garib, Cotrim-Ferreira, & Ferreira, 2011; Stevenson & Allaire, 1991), putting pressure on bones, which generates neuromuscular stimuli, modeling them and stimulating their proper growth and development (Moss, 1997). According to Moss (1997), bone and cartilage grow in response to the intrinsic growth of structures known as functional matrices. Inadequate muscle tonicity and incorrect positioning of the tongue disturb the dynamic balance of orofacial structures, leading to maxillary development (Carrascoza et al., 2006; Melink et al., 2010; Narbutytė et al., 2013; Page, 2001; Raymond & Bacon, 2006; Sakalidis et al., 2013).

Although the association between breastfeeding and MO is plausible, the results of the studies are controversial. The results of two previous systematic reviews also showed discrepancies (Hermont et al., 2015; Narbutytė et al., 2013). Narbutytė et al. (2013) concluded that breastfeeding may affect dentoalveolar MOs (particularly posterior crossbite), and this association increases with breastfeeding duration. Hermont et al. (2015) in turn argued that the available scientific evidence does not confirm that any specific type of MO is associated with type of feeding, nor does it identify a sufficient duration of breastfeeding required for children to achieve a protective benefit against MOs. Therefore, although the importance of breastfeeding to the psychological and physical development of children is well established, its influence on the development of the maxillofacial system remains controversial (Narbutytė et al., 2013).

These divergences may be partially explained by the difference in the quality of the reported studies. None of

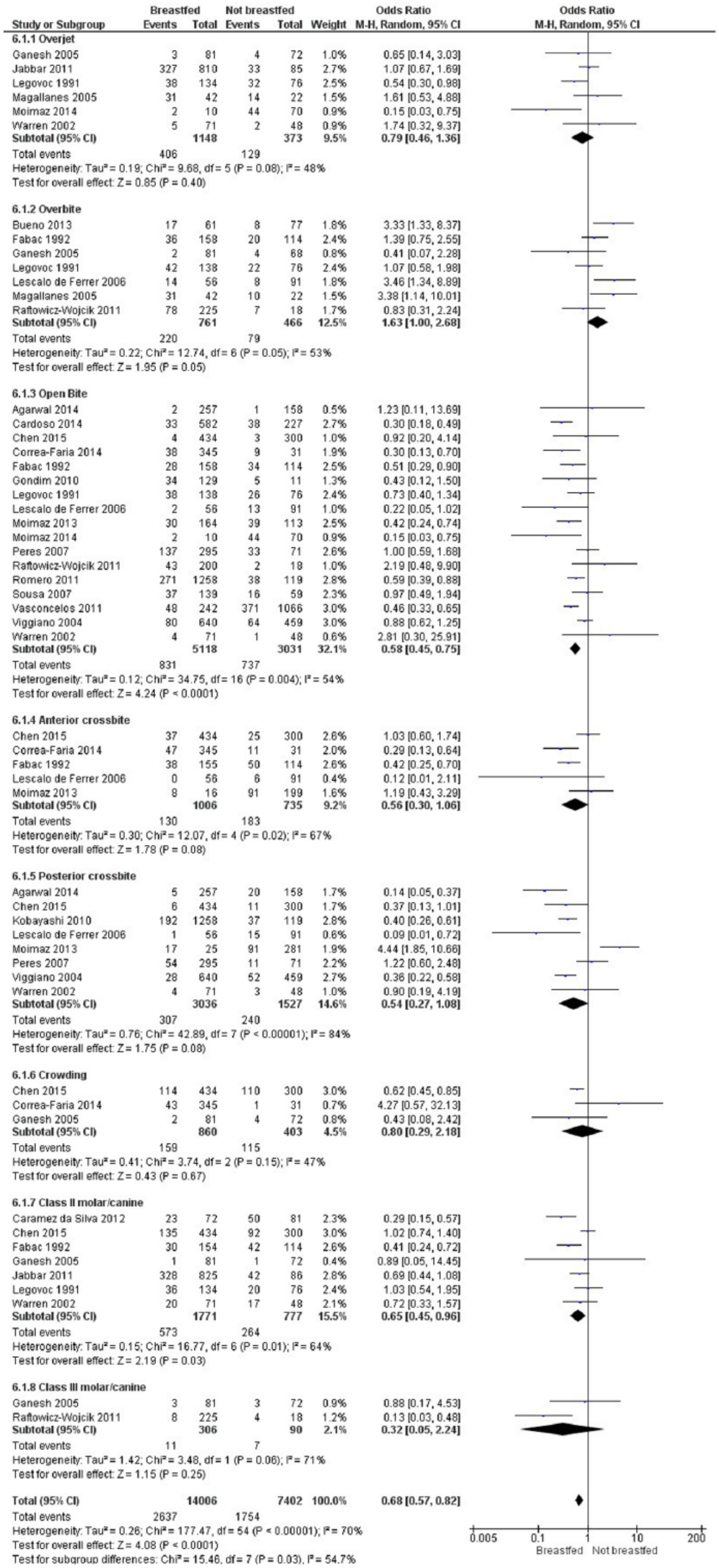

Figure 5. Breastfeeding (any duration) and malocclusion: a subgroup analysis according to type of malocclusion. M-H = Mantel-Haenszel; CI = confidence interval.

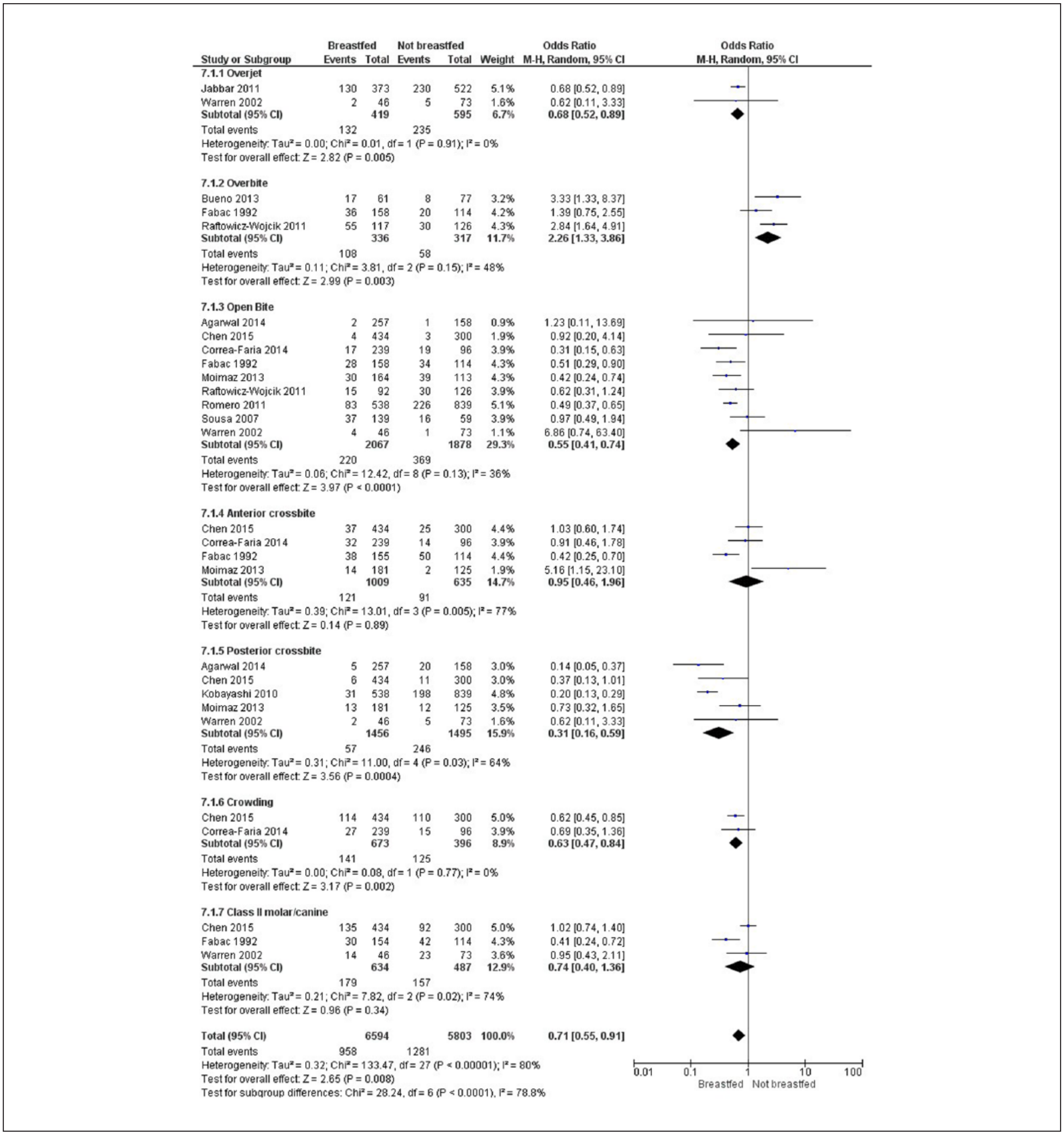

Figure 6. Breastfeeding (≥ 6 months) and malocclusion: a subgroup analysis according to type of malocclusion. M-H = Mantel-Haenszel; CI = confidence interval.

the 42 studies were considered adequate across all 14 quality assessment tool items or for the 6 most important items. The least adequate items in the identified studies were as follows: Item 12, "assessors blinded to the exposure status of participants" (11.9%); Item 14, "adjusting for confounding variables" (14.3%); Item 2, "description of the population" (19.1%); and Item 9, "clearly defined exposure measures" (21.4%). These results indicate that additional cohort studies with larger sample sizes and more detailed methods are needed to confirm this evidence. This was also advocated by Hermont et al. (2015) and Narbutytė et al. (2013).

In this study, only anterior open bite was associated with breastfeeding, regardless of duration. The lowest occurrence

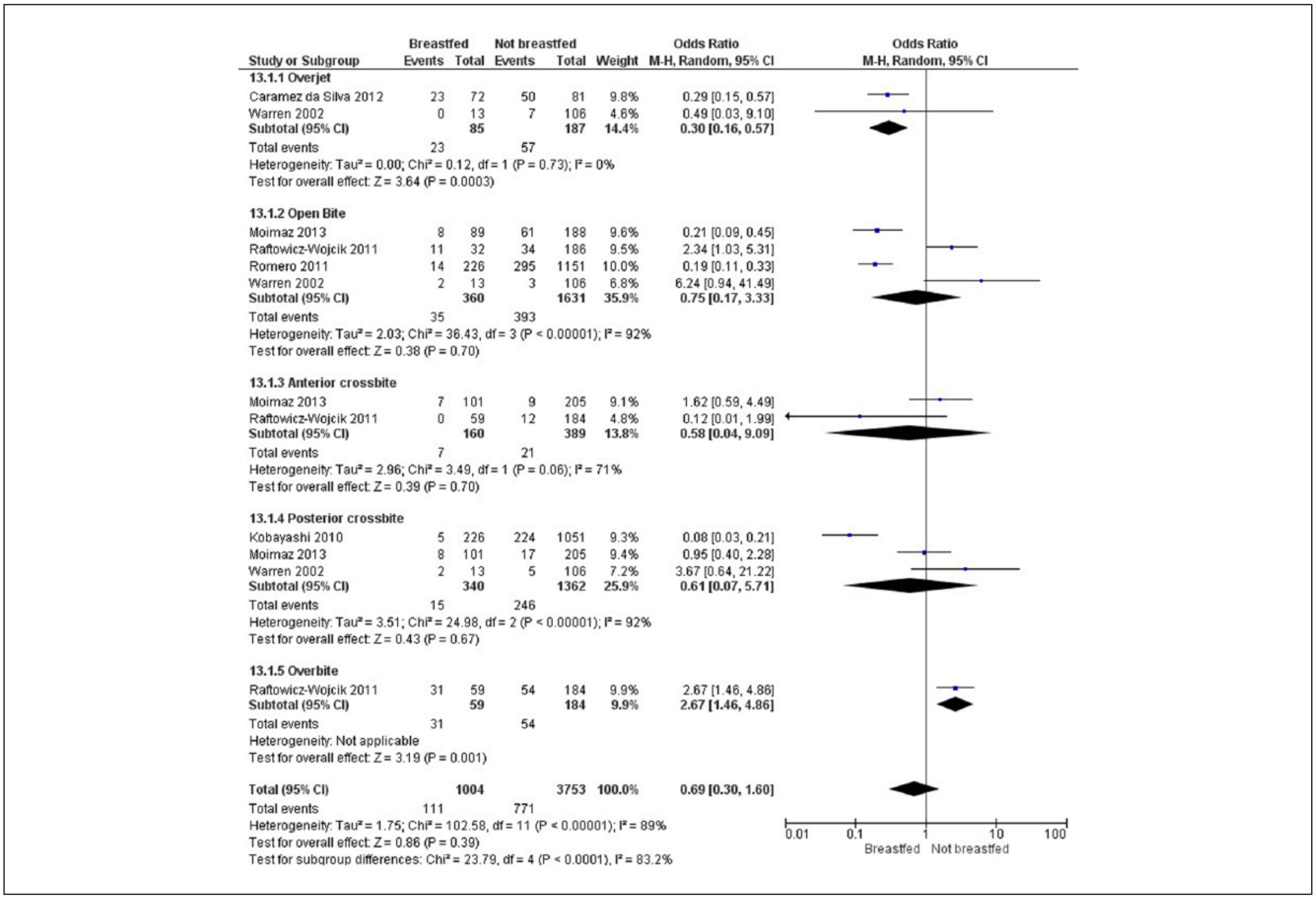

Figure 7. Breastfeeding (≥ 12 months) and malocclusion: a subgroup analysis according to type of malocclusion. M-H = Mantel-Haenszel; CI = confidence interval.

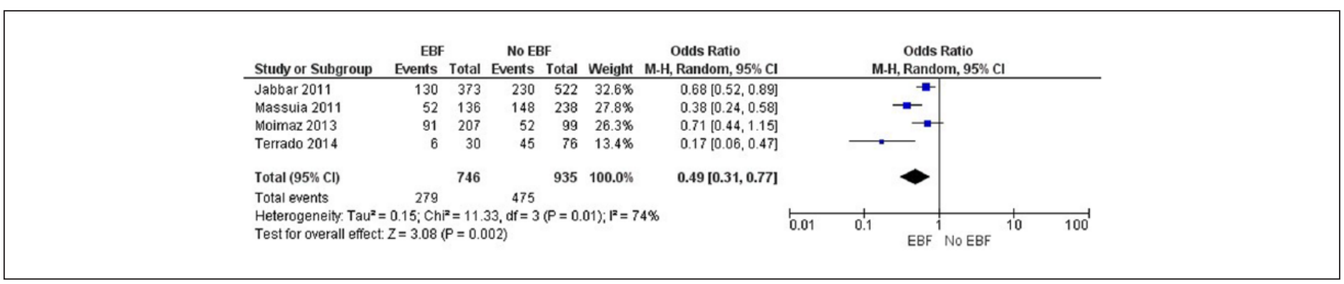

Figure 8. Association between exclusive breastfeeding for 6 months and malocclusion. EBF = exclusive breastfeeding; M-H = Mantel-Haenszel; CI = confidence interval.

of other MOs among breastfed children emerged only with longer exposure times. Warren and Bishara (2002) hypothesized that only prolonged breastfeeding, likely for 24 months or longer, may prevent MOs. Kobayashi, Scavone, Ferreira, and Garib (2010) concluded that children who are breastfed for 12 months or longer had a 20 times lower risk of posterior crossbite than those who were bottle fed. The present meta-analysis revealed that 6 months of breastfeeding was associated with a lower probability of overjet, anterior open bite, posterior crossbite, and crowding occurrence. Breastfeeding for 12 months or longer was associated with a lower incidence of overjet; however, there was no association with crossbite.

There is evidence that anterior crossbite has a strong genetic component (da Fontoura et al., 2015; Uribe, Vela, Kummet, Dawson, & Southard, 2013). Thus, environmental factors such as the type and duration of breastfeeding cannot prevent this problem. Studies show that breastfeeding stimulates anteroposterior mandibular growth (Aznar, Galán, Marín, & Domínguez, 2006; Fabac, Legouvić, & Župan, 1992), thereby reducing the occurrence of overjet (Caramez da Silva, Justo Giugliani, & Capsi Pires, 2012; Jabbar, Bueno, Silva, Scavone, & Ferreira, 2011; Moimaz et al., 2014). However, this growth appears to be limited and does not appear to be a risk factor for increased occurrence of anterior crossbite. Further research should be done to clarify this issue.

Of the MOs evaluated in this meta-analysis, overjet, anterior open bite, and posterior crossbite were most consistently associated with a short duration of breastfeeding, which corroborates the findings of Narbutytė and colleagues' (2013) systematic review, which pointed to the greater protective association of prolonged breastfeeding on the development of posterior crossbite and anterior open bite. Researchers in observational studies have also suggested that relatively longer durations of breastfeeding are associated with decreased occlusal abnormalities and functional disorders (Ganesh et al., 2005; Peres, Cascaes, Peres, et al., 2015; Raftowicz-Wojcik, Matthews-Brzozowska, Kawala, & Antoszewska, 2011; Thomaz et al., 2012; Warren & Bishara, 2002). These results indicate that breastfed children have adequate growth of the maxillary and mandibular bone bases in frontal (antero-posterior axis), transverse (longitudinal axis), and sagittal (lateral-lateral axis) planes.

Children exclusively breastfed in the first 6 months of life had a 51% lower chance of developing MO in the temporary dentition compared with the other children. However, we were able to identify only four studies on these subjects, and the outcomes included different types of MO (i.e., overbite, overjet, crossbite, terminal relationship of the primary second molars, transverse relationship, and crowding), showing heterogeneities in the data. Yet, they were all transversal studies. Thus, we recommend further longitudinal and population-based studies analyzing the association between exclusive breastfeeding and MO because these designs are more appropriate to adequately measure breastfeeding time and reduce information bias.

Birth cohorts analyzing dental outcomes are expensive and difficult to develop; exclusive breastfeeding until 6 months of age and complementary until age 2 years are not common practices worldwide (Cai, Wardlaw, & Brown, 2012; Victora et al., 2016), and dental MO examination is time consuming and costly.

A relatively longer duration of breastfeeding was associated with a greater frequency of overbite in primary teeth. These findings are supported by Bueno et al. (2013), Lescano de Ferrer and Varela de Villalba (2006), Magallanes, Rios, and Marino (2005), and Raftowicz-Wojcik et al. (2011). Because breastfeeding stimulates proper transverse maxillary growth (Galan-Gonzalez, Aznar-Martín, Cabrera-Domínguez, & Domínguez-Reyes, 2014; Sánchez-Molins et al., 2010) and reduces the occurrence of posterior crossbite, a greater overlap of the upper arch on the lower is expected, which increases overbite. Therefore, it is plausible that a higher frequency of overbite, as well as increased spacing between the teeth, is a physiological mechanism in primary teeth that compensates for the excessive vertical growth that occurs in puberty. As such, a reduction in overbite is expected with the emergence of permanent teeth. Proper growth of facial alveolar bone structures in children who are breastfed for an adequate period also helps to explain the association between breastfeeding for 6 months or longer and a lower incidence of crowding, as identified in this meta-analysis.

For ethical reasons, it is not possible to develop experimental studies to analyze the etiology of MOs. Therefore, this meta-analysis included only observational studies, which have lower evidence levels than randomized clinical trials (Burns, Rohrich, & Chung, 2011; GRADE Working Group, 2004). Only a few cohort studies (de Morais, Mota, & Amorim, 2014; dos Santos Neto, Oliveira, Barbosa, Zandonade, & Oliveira, 2012; Karjalainen, Rönning, Lapinleimu, & Simell, 1999; Lescano de Ferrer & Varela de Villalba, 2006; Moimaz et al., 2014; Warren & Bishara, 2002) and study designs nested within cohorts (Caramez da Silva et al., 2012; Peres et al., 2007; Peres, Cascaes, Peres, et al., 2015; Viggiano et al., 2004), which are considered more robust than cross-sectional studies, were identified (Burns et al., 2011; GRADE Working Group, 2004). Furthermore, three such studies were not included in our quantitative synthesis due to a lack of raw data (dos Santos Neto et al., 2012; Karjalainen et al., 1999; Peres, Cascaes, Peres, et al., 2015). As such, the evidence of this meta-analysis was primarily obtained from cross-sectional studies. Nevertheless, the analyzed exposure (breastfeeding) was known to precede the outcome, thus eliminating the possibility of spurious findings due to reverse causality. Furthermore, our study design subgroup analyses showed consistent results, suggesting that breastfeeding significantly affects MOs.

Limitations

Potential classification error due to recall bias based on breastfeeding duration may have affected the estimates of the selected studies. However, the categorization of duration into large intervals and the short amount of time since the end of exposure (children were approximately 5 to 6 years old) at the time of the outcome evaluations reduce the possibility of bias (Huttly, Victora, Barros, Beria, & Vaughan, 1990; Promislow, Gladen, & Sandler, 2005).

High statistical heterogeneity was observed among the studies. However, restricting the studies to research on primary teeth reduced methodological differences. Subgroup and sensitivity analyses were conducted with respect to study design, MO type, and risk of bias. Because the results remained constant, a meta-regression was not performed.

In this evaluation, unadjusted measures of association were estimated for non-nutritive sucking habits; however, this is hardly a limitation because from a theoretical point of view, these deleterious habits may take part in a causal pathway for a possible association between breastfeeding and MO. Thus, they should not be adjusted as confounders but rather understood as mediators (Rothman, Greenland, & Lash, 2008).

Conclusion

The existing evidence allows us to conclude that breastfeeding has a beneficial effect on dental occlusion, and this effect may be greater if breastfeeding lasts for at least 6 months. The analysis corroborates the recommendation of 6 months of exclusive breastfeeding supplemented by mixed feeding for at least 12 months to reduce the occurrence of orthodontic problems. However, more research is needed because the quality of the existing studies is low.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Supplementary Material

Supplementary Material may be found in the "Supplemental material" tab in the online version of this article. To access any underlying research materials related to this article, please contact the corresponding author.

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