

# Association between deleterious oral habits and asthma in children: a systematic review and meta-analysis

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**Abstract:** Deleterious oral habits (DOH) have been described as a common finding in pediatric series. Studies have investigated their association with local and systemic health problems. In this study, the association between DOH and asthma was investigated. PubMed, Scopus, Lilacs, Web of Science, Google Scholar, and OpenThesis were accessed to identify observational studies that evaluated the association between DOH (thumb sucking, pacifier use, onychophagia or nail biting, bottle feeding) and asthma in children aged 2–17 years. Information on DOH was obtained from the verbal report of the children's parents. Asthma diagnosis was performed by a physician or using the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire. We used a random-effects model to pool the results. The odds ratio (OR) was used as measure of association between DOH and asthma. The National Institutes of Health Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used to assess risk of bias. The GRADE approach was used to assess the quality of evidence. Five studies were included and data from 18,733 children aged 2 to 13 years were analyzed. We found an association between bottle feeding and asthma (OR = 1.25; 95%CI 1.13–1.38;  $p < 0.001$ ) with moderate level of certainty. Despite the association between pacifier use and asthma (OR = 1.11; 95%CI 1.00–1.24;  $p = 0.05$ ), the quality of evidence was low. Only one study provided data on nail biting and thumb-sucking, and the individual results showed no association between these habits and asthma. This meta-analysis found an association between bottle feeding, pacifier use, and asthma in children.

**Keywords:** Child; Asthma; Habits; Oral Health.

## Introduction

Asthma is a major health problem worldwide with an estimated 2.5 million deaths per year. Asthma is considered a heterogeneous disease characterized by various symptoms such as wheezing, shortness of breath, chest oppression and/or coughing, and restriction of expiratory airflow.<sup>1</sup> The disease has a multicausal nature and is associated with genetic, socioeconomic, emotional, and environmental factors.<sup>2</sup> Exposure to allergens is one of the most investigated environmental factors and its association with asthma is well established.<sup>3</sup>

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Oral habits are customs or practices that have become established through frequent repetition<sup>4</sup> and can be classified as functional and non-functional habits. Typical functional oral habits include chewing, swallowing, breathing, phonation, and less specific habits such as emotional communication and facial expression. Non-functional habits include nail biting, tongue movements, atypical swallowing, and non-nutritive sucking habits such as thumb sucking and pacifier use.<sup>5</sup>

An oral habit becomes harmful when it occurs over a long period of time, unconsciously or not, during normal daily activities and results in damage to the oral or general health of the individual.<sup>6</sup> Deleterious oral habits (DOH) have been described as common findings in pediatric series. In a study of 832 children aged 6 to 12 years conducted in Karad district, India, 51% of the children were found to have at least one DOH, including bottle feeding (10.1%), thumb-sucking (8.7%), nail biting (5.8%), tongue thrusting (4.9%) and mouth breathing (4.3%).<sup>7</sup> In Brazil, a study including 328 children aged 8 to 14 years showed that most (71.3%) had at least one DOH with a significant impact on quality of life.<sup>5</sup> In this study, nail biting and lip biting or sucking were the most common DOH with a prevalence of 43.0% and 27.1%, respectively.<sup>5</sup>

There is an important debate as to whether behavioral factors can be associated with the development of asthma or whether they are concomitant characteristics of the disease. Among behavioral factors, the presence of DOH including thumb-sucking, nail biting, and others may lead to an altered pattern of muscle activity<sup>8</sup> increasing the risk for disorders in swallowing, phonation, and breathing<sup>9-11</sup> as well as changes in dental arches and occlusal parameters, especially in children.<sup>12</sup> In addition, an association between DOH and asthma has been suggested,<sup>13</sup> but there is no evidence synthesis for this association. In this study, we systematically investigated the association between DOH and asthma in children.

## Methods

We conducted a systematic review and meta-analysis according to the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) statement.<sup>14</sup> Institutional review board approval and informed consent are not required for this study design.

## Research question and eligibility criteria

The present study focused on the following question: Is there an association between DOH and asthma in children? The research question was defined using the PECO strategy (population [P], exposure [E], control [C], and outcomes [O]) as follows: P = children aged 2-17 years, E = DOH (thumb-sucking, pacifier use, onychophagia or nail biting, and bottle feeding), C = children without DOH, and O = asthma. The presence of asthma should be assessed using validated questionnaires or the diagnosis confirmed by a specialist.

Observational studies were considered eligible if they provided sufficient raw data to evaluate the association between DOH and asthma. We excluded editorials, comments and opinions, case reports, technical reports, and reviews. Studies that provided data on bruxism were also excluded, as this condition has been defined as a motor behavior with multifactorial etiology and not necessarily a disorder or DOH.<sup>15</sup>

## Search strategy

A systematic search using PubMed, SCOPUS, Lilacs and Web of Science databases was performed to identify studies that evaluated the association between DOH and asthma. A grey-literature search was conducted using Google Scholar and OpenThesis. The first 100 results from Google Scholar were analyzed. The search was initially conducted in May 2020 and updated in April 2021 without language restrictions. Reference lists of all eligible studies and reviews were manually scanned to identify additional studies for inclusion. For articles that were not available in electronic databases or for data that were not available in the articles included in this review, authors were contacted to obtain the necessary information. The following terms were used in the search strategy: pacifier, finger sucking, thumb-sucking, nail biting, onychophagia, bottle feeding, and asthma (Table 1). To expand the number of eligible articles, no filters were used in the search.

## Study selection

The titles and abstracts found in the electronic search were independently screened by two authors (V.T.G.S. and C.S.S.T.). Disagreements were resolved

by consensus between the two reviewers. Relevant studies were read in full and selected according to the eligibility criteria. A flowchart of the study selection was reported according to the PRISMA 2020 statement.<sup>16</sup>

**Data extraction and risk of bias assessment**

Data from the reports were extracted using a predefined spreadsheet program (Microsoft Excel®) and included the following information: authors, year of publication, country, design, population characteristics, setting (school, health unit, community, etc.), asthma and DOH assessment (use of questionnaires or diagnosis confirmed by a specialist), and types of DOH analyzed.

Two authors (V.T.G.S. and B.C.L.A.) evaluated the risk of bias of included studies. The National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (<https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>) was used to grade the quality of the studies. The results of the risk of bias assessment were described qualitatively. Disagreements were resolved through discussion.

**Data analysis**

The odds ratio (OR) was used as a measure of the association between DOH and asthma. To calculate

OR, the number of children with asthma was extracted for each group of comparison according to the oral habits. Statistical heterogeneity was quantified using the I<sup>2</sup> index, which was interpreted as follows: 0%, no between-study heterogeneity; < 50%, low heterogeneity; 50–75%, moderate heterogeneity; > 75%, high heterogeneity.<sup>17</sup> In the meta-analysis, a random-effects model was used to pool the results. Forest plots were used to graphically represent pooled ORs and 95% confidence intervals (CIs). P-values less than 0.05 were considered statistically significant. Analyses were performed using Review Manager software version 5.3 (Cochrane Collaboration, Copenhagen).

**Grading the strength of evidence**

We graded the strength of evidence for the association between DOH and asthma as high, moderate, low, or very-low using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) rating system<sup>18,19</sup>. In the GRADE system, observational studies are initially graded as low-quality evidence but may be graded higher according to the risk of bias assessment, inconsistency, indirectness, imprecision of the results, and publication bias. Certainty is also uprated for estimates with large (OR > 2.0 or OR < 0.5) or very-large (OR > 5.0 or OR < 0.2) magnitude of effect, evidence of dose-response effects, and control for confounding factors.

**Table 1.** Search databases and strategies.

Search databases	Search strategies
PubMed	(Pacifiers [Mesh] OR "Finger Sucking" OR "Sucking, Finger" OR Thumbsucking OR "Thumb Sucking" OR "Sucking, Thumb" OR Fingersucking[Mesh] OR "Biting, Nail" OR Onychophagia OR "Nail Biting"[Mesh] OR "Bottle Feedings" OR "Feeding, Bottle" OR "Feedings, Bottle" OR Bottlefeeding OR "Bottle Feeding"[Mesh]) AND (Asthmas OR "Bronchial Asthma" OR "Asthma, Bronchial" OR Asthma [Mesh])
Scopus	(Pacifiers OR "Finger Sucking" OR Thumbsucking OR "Thumb Sucking" OR Fingersucking OR Onychophagia OR "Nail Biting" OR "Bottle Feedings" OR Bottlefeeding OR "Bottle Feeding") AND (Asthmas OR "Bronchial Asthma" OR Asthma)
Web of Science	(Pacifiers OR "Finger Sucking" OR Thumbsucking OR "Thumb Sucking" OR Fingersucking OR Onychophagia OR "Nail Biting" OR "Bottle Feedings" OR Bottlefeeding OR "Bottle Feeding") AND ("Bronchial Asthma" OR "Asthma, Bronchial" OR Asthma)
OpenThesis	(Pacifiers OR "Finger Sucking" OR Thumbsucking OR "Thumb Sucking" OR Fingersucking OR Onychophagia OR "Nail Biting" OR "Bottle Feedings" OR Bottlefeeding OR "Bottle Feeding") AND ("Bronchial Asthma" OR "Asthma, Bronchial" OR Asthma)
Lilacs	(Pacifiers OR "Finger Sucking" OR Thumbsucking OR "Thumb Sucking" OR Fingersucking OR Onychophagia OR "Nail Biting" OR "Bottle Feedings" OR Bottlefeeding OR "Bottle Feeding") AND ("Bronchial Asthma" OR "Asthma, Bronchial" OR Asthma)
Google Scholar	(Pacifiers OR "Finger Sucking" OR Thumbsucking OR "Thumb Sucking" OR Fingersucking OR Onychophagia OR "Nail Biting" OR "Bottle Feedings" OR Bottlefeeding OR "Bottle Feeding") AND ("Bronchial Asthma" OR "Asthma, Bronchial" OR Asthma)

Although funnel plots may be useful when examining the effects of small studies in meta-analyses, they have limited power to detect such effects when there are few studies<sup>20</sup>. Because we had only a small number of included studies, we did not conduct a funnel plot analysis. However, we reduced the potential for publication bias by planning a comprehensive search that included grey literature without restrictions. In the level of evidence assessment, we analyzed the influence of small trials (< 100 patients per arm) on the pooled estimates.

## Results

### Overview of the included studies

After screening 386 titles and abstracts, 32 full-text articles were assessed for eligibility, and five studies were included in the systematic review.<sup>13,21-24</sup> Figure 1 provides a flowchart depicting the selection process of references at each stage.

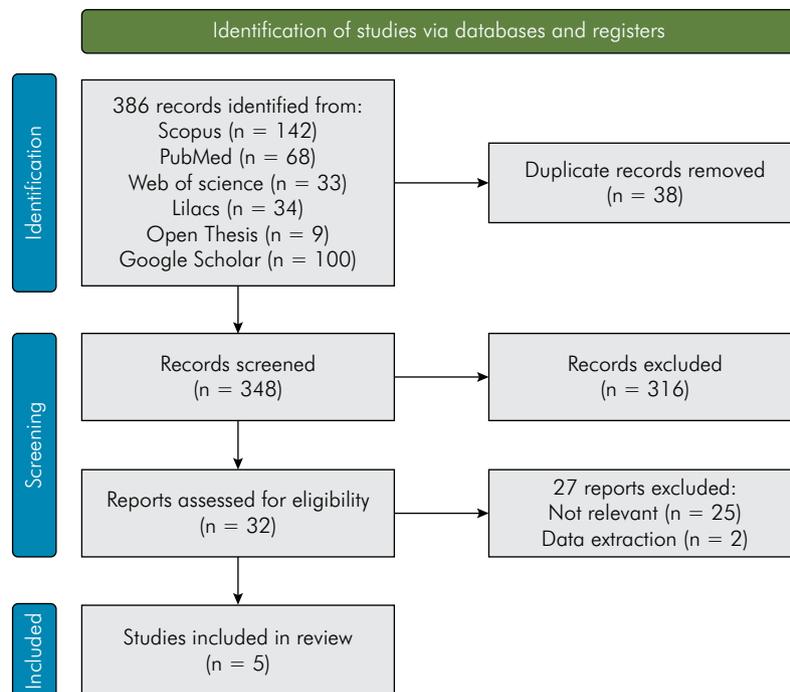
We included three cross-sectional<sup>13,21,24</sup> and two cohorts<sup>22,23</sup> studies. Most studies were conducted in primary health care,<sup>24</sup> schools<sup>13,21</sup> and the community.<sup>22,23</sup> Sample sizes ranged from 448<sup>22</sup> to 14,862 children.<sup>21</sup>

In this systematic review, data from 18,733 children aged 2 to 13 years were analyzed (Table 2).

In all studies, information on DOH were obtained from the verbal report of the children's parents. Asthma diagnosis was performed by a physician or using the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire. In the surveys in which ISAAC questions were used, the questionnaire was distributed to the children's parents by the kindergarten teachers, and the parents returned the completed questionnaires to the researchers.<sup>13,21</sup> Three studies provided data on bottle feeding,<sup>21,22,24</sup> two on pacifier use,<sup>23,21</sup> and one on the association between nail biting and thumb-sucking and asthma.<sup>23</sup>

### Risk of bias assessment

In general, the cohort studies presented a low risk of bias for most items. However, neither study included information on the sample size calculation, the presence of DOH was described by the children's parents, and there was a high risk of performance bias. Moreover, there was an unclear risk of attrition bias in the study performed by Lynch et al.<sup>23</sup>



**Figure 1.** Flow diagram of study selection.

**Table 2.** Characteristics of the included studies.

Study	Country	Study design	Age group (y)	Setting	Definition of oral habits	Asthma definition	Sample size
Celedon, 2002 <sup>22</sup>	United States	Cohort	5	Community	Reported by parents	Diagnosis confirmed by a physician	448
Hsu, 2012 <sup>21</sup>	Taiwan	Cross-sectional	2–7	School	Reported by parents	Parents' report + ISAAC questionnaire	14,862
Lynch, 2016 <sup>23</sup>	New Zealand	Cohort	13	Community	Reported by parents	Diagnosis confirmed by a physician	1,013
Morass, 2008 <sup>13</sup>	Austria	Cross-sectional	5.5 ± 0.8	School	Reported by parents	Diagnosis confirmed by a physician + ISSAC questionnaire	1,761
Ginkel, 2018 <sup>24</sup>	The Netherlands	Cross-sectional	6.3	Primary health care	Reported by parents	Diagnosis confirmed by a physician	649

\*ISAAC, International Study of Asthma and Allergies in Childhood

For the cross-sectional studies, we found a low risk of bias in the studies by Gynkel et al.<sup>24</sup> and Hsu et al.<sup>21</sup> for most of the items analyzed. However, the study by Morass et al.<sup>13</sup> had limitations, including unclear definition of eligibility criteria, lack of sample size calculation, subjective diagnosis of DOH, and a high risk of performance bias (Table 3).

**Evidence synthesis**

**Nail biting and thumb-sucking**

Only the study by Lynch et al.<sup>23</sup> provided data on nail biting and thumb-sucking. The authors investigated the effects of these habits in childhood on the development of atopic sensitization, asthma, and hay fever in a prospective longitudinal population-based birth cohort study. There was no evidence of an association between thumb-sucking

(OR = 1.40; IC 95% 0.80–2.50) or nail biting and asthma at age 13 years (OR = 0.98; IC95% 0.55–1.78).

**Bottle feeding**

Three studies<sup>21,22,24</sup> provided data on the association between bottle feeding and asthma. A total of 7281 children were enrolled, of whom 3480 were bottle fed and 3801 were not bottle fed. The frequency of children with asthma among bottle fed children was 37.2% (n = 1293). Meta-analysis revealed an association between bottle feeding and asthma (OR = 1.25; 95%CI 1.13–1.38; p < 0.001). There was no between-study heterogeneity (I<sup>2</sup> = 0%) (Figure 2).

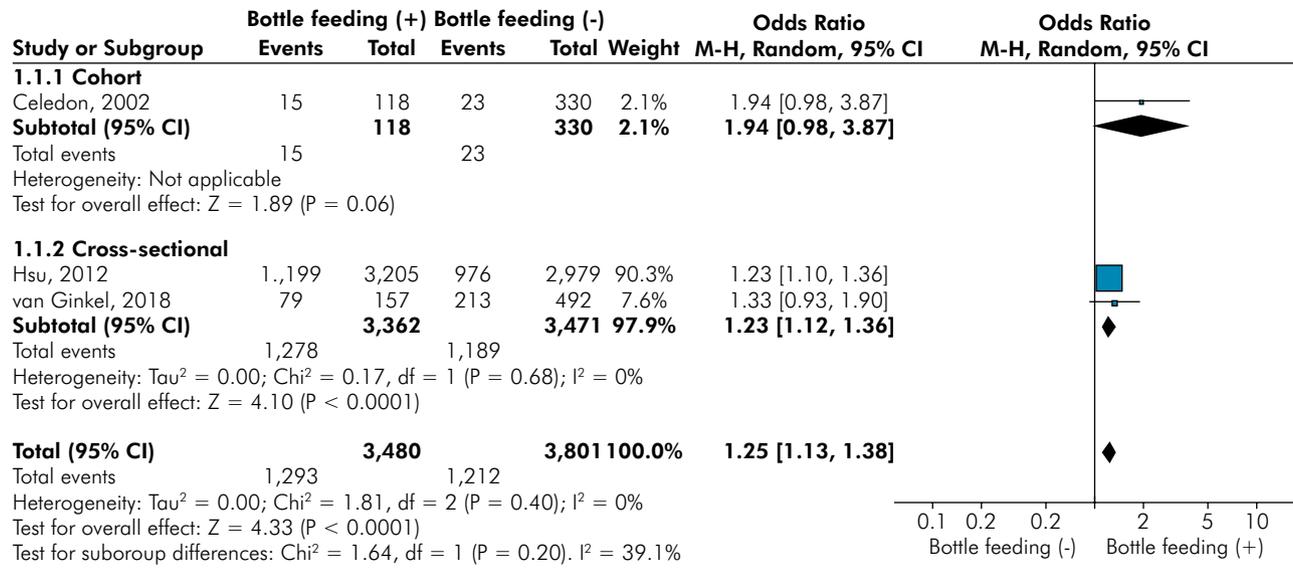
**Pacifier user**

Two studies<sup>13,21</sup> provided data on the association between pacifier use and asthma. A total of 7,640 children were enrolled, 3,700 with pacifier

**Table 3.** Risk of bias assessment.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Study Cohort														
Celedon, 2002 <sup>22</sup>	Y	Y	Y	Y	NR	Y	Y	Y	N	Y	Y	N	Y	Y
Lynch, 2016 <sup>23</sup>	Y	Y	Y	Y	NR	Y	Y	Y	N	Y	Y	N	NR	Y
Cross-sectional														
Hsu, 2012 <sup>21</sup>	Y	Y	Y	Y	NR	NA	NA	Y	N	NA	Y	N	NA	Y
Morass, 2008 <sup>13</sup>	Y	N	N	N	NR	NA	NA	N	N	NA	Y	N	NA	Y
Ginkel, 2018 <sup>24</sup>	Y	Y	Y	Y	Y	NA	NA	Y	N	NA	Y	Y	NA	Y

\*Y: yes; N: no; CD: cannot determine; NA: not applicable; NR: not reported. (1) objective clearly stated; (2) eligibility criteria clearly described; (3) representative sample of clinical population of interest; (4) all eligible participants enrolled; (5) sample size calculation; (6) exposure measured prior to the outcome; (7) sufficient timeframe; (8) examine different levels of the exposure; (9) exposure clearly described; (10) exposure(s) assessed more than once over time; (11) outcome clearly described; (12) outcome assessors blinded to the exposure; (13) loss to follow-up less than 20%; (14) adjusted statistics performed.



**Figure 2.** Forest plot showing the association between bottle feeding and asthma in children.

habit and 3,940 without the habit. The frequency of children with asthma among those using a pacifier was 24.5% (n = 908). Meta-analysis revealed an association between pacifier use and asthma (OR = 1.11; 95%CI 1.00–1.24; p = 0.05). There was no between-study heterogeneity (I<sup>2</sup> = 0%) (Figure 3).

**Strength of evidence**

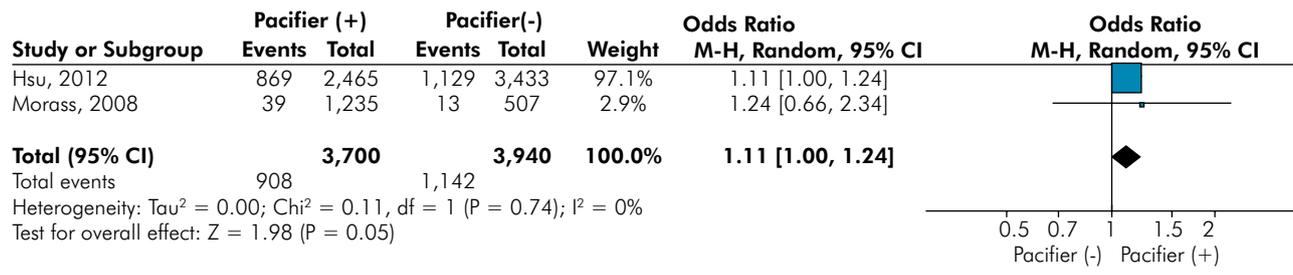
The quality of evidence was rated as moderate for the association between bottle feeding and asthma, and low for the association between pacifier use and asthma (Table 4).

**Discussion**

DOH are common in childhood, and this has led several studies to investigate their association with local and systemic health problems. However, most

studies focused on the association between DOH, malocclusion and dental caries, with conflicting results.<sup>25-29</sup> This systematic review and meta-analysis found an association between bottle feeding, pacifier use, and asthma. These findings are relevant to clinical practice, since clinicians involved with child health care should screen for asthma in children with at least one of these habits.

Data on the association between respiratory health and infant feeding type are lacking, but there is emerging evidence that direct breastfeeding is most protective against the onset of asthma and cough or wheeze compared with breastmilk substitutes or bottle breastmilk,<sup>30,31</sup> which may be related to modulation of the oral and gut microbiota by prebiotic and probiotic components found in breastmilk<sup>32-34</sup>, stimulation of immune system,<sup>35-37</sup> and improvement in lung and airway growth<sup>38</sup>. In this meta-analysis, we found an



**Figure 3.** Forest plot showing the association between pacifier use and asthma in children.

**Table 4.** Strength of evidence on the association between bottle feeding and pacifier use and asthma.

Evidence	OR (95%CI)	I <sup>2</sup>	Risk of bias	Inconsistency	Indirectness	Imprecision	Influence of small trials	Large effect	Plausible confounding*	Potential for dose-response**	Quality of evidence
Bottle-feeding	1.25 (1.13–1.38)	0%	Not serious	Not serious	Not serious	Not serious	Not applicable	No	No	Yes	⊕⊕⊕○
Pacifier use	1.11 (1.00–1.24)	0%	Serious	Not serious	Not serious	Not serious	Not serious	No	No	Yes	⊕⊕○○

Certainty: ⊕ very-low; ⊕⊕ low; ⊕⊕⊕ moderate; ⊕⊕⊕⊕ high; \*In this meta-analysis, we did not rate the influence of all plausible residual confounding; \*\*Individual studies presented a potential for dose-response relationship between oral habit and asthma in children.

association between bottle feeding and asthma in children. However, there is no information on bottle content and the duration of exclusive breastfeeding varies between studies. Although individual studies suggest an association between duration of bottle feeding and the prevalence of asthma, no dose-response meta-analysis could be performed. There is need for targeted research to clarify the role of bottle use in the development of asthma in children, including analyses of content, frequency, and duration.

The use of pacifiers in infants and children is an ancient practice, but the balance between benefits and risks remains uncertain. The mother’s decision to use a pacifier has been associated with its ability to soothe their infant, to help rock them to sleep, and to keep them calm and quiet.<sup>39</sup> In addition, there is evidence that the use of pacifiers in the first six months of life reduces the risk of sudden infant death syndrome.<sup>40</sup> Despite potential benefits, the prolonged and frequent use of pacifiers has been associated with disruption of exclusive breastfeeding,<sup>41,42</sup> otitis media,<sup>43</sup> and dental malocclusions.<sup>44-46</sup>

Recently, pacifiers use at 6 months of age has been associated with the development of food allergies, especially among those who used pacifiers that had been disinfected with antiseptic agents.<sup>47</sup> Pacifiers are considered a potential source of microbial exposure in early life. In a birth cohort of 184 infants in Sweden, it was shown that infants whose parents sucked their pacifier had a lower risk of food sensitization, eczema, and asthma compared with infants whose parents

cleaned their pacifier using other methods.<sup>48</sup> These findings may suggest that the enrichment of the environment for key bacteria and training immune responses in early childhood may play a crucial role on allergy and asthma prevention.<sup>49</sup> Despite our study indicated an association between pacifier use and asthma in children, data on pacifier cleaning practices were not reported and the direction of bias from potential risk factors for asthma could not be analyzed. Moreover, we found limited evidence of an association between thumb-sucking, nail biting, and asthma, which reinforces the need for further studies to clarify the role of non-nutritive sucking habits in shaping immune responses in early childhood and their effects on childhood health outcomes.

Our findings should be interpreted with caution. The included studies had differences regarding population characteristics and differed in design and setting. In addition, data on the frequency and duration of DOH were not available. Despite the moderate evidence for the association between bottle feeding and asthma, evidence from other oral habits is limited. We believe that the effects demonstrated in this meta-analysis could be reduced by adjusting for confounding factors.

In conclusion, this systematic review and meta-analysis found an association between bottle feeding, pacifier use, and asthma in children. Further well-designed prospective studies should be conducted to evaluate whether DOH-asthma associations are confounded or may be modified by extraneous factors.

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