

Malocclusions – from infancy to adulthood. What is the influence of infant behaviours on their occurrence and what are the long-term outcomes of orthodontic treatment?

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## DEDICATION

My mother, Ibtisam Dođramacı, who always believed in me and prayed for me, and for constantly encouraging me to pursue my dreams.

My husband, Professor Giampiero Rossi-Fedele, who suggested I complete a PhD as, “*Any serious academic must have a PhD*”, and gave sincere feedback throughout.

My children, Dora and Basil, currently in the middle and early mixed-dentition, respectively. For a great part of your lives I have been working on this PhD that has also been part of your learning journey, since you often share your observations and insights about the dental presentations and oral habits of your peers. Dora, you taught me the importance of having a growth mindset; I particularly valued this during all the statistical analyses. Basil, your comment a couple of years ago, “*How can a baby have crooked teeth from sucking a dummy if they are born without teeth?*” showed me your deep reflection. Keep up your open and growth mindset. Never stop reading or learning!

My late grandfather, Professor Adil Dođramacı, Professor of Internal Medicine - University of Baghdad, who inspired me when I was 10-years-old to follow an academic career path. My late uncle, Professor Ihsan Dođramacı, Professor of Paediatrics, signatory of the World Health Organization (WHO) constitution, former chair of the executive board - UNICEF, former president and executive director - International Pediatric Association, higher education reformer, founder of Hacettepe and Bilkent Universities, and philanthropist, who supported me in many ways during my sabbatical and thereafter, and who was the perfect example that you can achieve anything that you set your mind to.

## PREFACE

Prior to commencing on this PhD learning journey, I was asked by a parent, who knew I was an orthodontist, whether breastfeeding prevents “crooked teeth” (malocclusions). I found this question puzzling. At the time, I had recently qualified as a specialist in orthodontics and was also a mother to two very young children both under the age of five; one was continuing breastfeeding after having been introduced to a solid diet a couple of months earlier, while the other had completed breastfeeding, both fed according to the World Health Organization’s Global Strategy for Infant and Young Child Feeding (2003).<sup>1</sup>

During my specialist orthodontic studies, I learned that malocclusions have multifactorial aetiology, there being genetic and environmental determinants. Moreover, rather than malocclusions being a single homogenous trait, they can present as single or multiple entities with skeletal, soft tissue, and/or dentoalveolar components. Modern, comprehensive orthodontic treatment aims to resolve multiple malocclusion features simultaneously. How can the prescription of breastfeeding avert future orthodontic treatment? I wondered whether such benefits of breastfeeding were limited to infants and young children, in spite of earlier work including adult participants. Despite the well-known merits of breastfeeding for mothers and children, mothers may not want to or are physically unable to. Breastfeeding is impossible for mothers with double mastectomies while those working distant to their child find it difficult to nurse optimally. Breastfeeding is also a matter of choice, *“mothers [have] a right to choose whether or not they want to breast-feed;...provided [they are] properly informed about the facts.”*<sup>2</sup> These were the initial ideas that motivated me to pursue further research, through a PhD.

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<sup>1</sup> Global Strategy for Infant and Young Child Feeding. Geneva, Switzerland: World Health Organization; 2003.

<sup>2</sup> Doğramacı I. Thirty-fourth World Health Assembly, Geneva, 4-22 May 1981: summary records of committees. Geneva, Switzerland: World Health Organization; 1981:194.

As a result of the research I conducted during this PhD, I increased my understanding about malocclusions, their causes and consequences, as well as the longer-term dental and psychological outcomes in relation to orthodontic treatment, or its absence.

The research is presented as a thesis by publication, comprising one research protocol and six research articles, all published in peer-reviewed journals. Each article is preceded by a contextual statement.

My hope for this research is to benefit not only academia, but also have a positive impact on society through attitudinal changes towards oral habits and orthodontic treatment, as well as by influencing public health and dental policies.

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## FULL CITATION LISTING OF INCLUDED PUBLICATIONS

1. **Doğramacı EJ**, Peres MA, Peres KG. *Breastfeeding and malocclusions: The quality and level of evidence on the Internet for the public.* J Am Dent Assoc. 2016;147(10):817-825.
2. **Doğramacı EJ**, Rossi-Fedele G. *Establishing the association between non-nutritive sucking behaviour and malocclusions: A systematic review and meta-analysis.* J Am Dent Assoc. 2016;147(12):926-934.
3. **Doğramacı EJ**, Rossi-Fedele G, Dreyer CW. *Effect of breastfeeding on different features of malocclusions in the primary dentition: a systematic review protocol.* JBI Database System Rev Implement Rep. 2017;15(7):1856-1866.
4. **Doğramacı EJ**, Rossi-Fedele G, Dreyer CW. *Malocclusions in young children: Does breastfeeding really reduce the risk? A systematic review and meta-analysis.* J Am Dent Assoc. 2017;148(8):566-574.
5. **Doğramacı EJ**, Brennan DS. *The influence of orthodontic treatment on dental caries: An Australian cohort study.* Community Dent Oral Epidemiol. 2019;47(3):210-216.
6. **Doğramacı EJ**, Brennan DS. *The long-term influence of orthodontic treatment on adults' psychosocial outcomes: An Australian cohort study.* Orthod Craniofac Res. 2019;22(4):312-320.
7. **Doğramacı EJ**, Naini FB, Brennan DS. *The long-term influence of orthodontic treatment on dental knowledge and behaviour: An Australian cohort study.* J Dent. 2020;100:103345.



## **ABSTRACT**

Malocclusions, defined as deviations in the intra- and/or inter-maxillary relationships of teeth from normal, can hamper the attainment of oral health if they adversely impact on physiological functions such as speech and mastication, or psychologically linked capabilities like smiling. Malocclusions have multifactorial aetiology; one's phenotype is a result of their genotype's interaction with the environment. While genetic factors presently cannot be altered, environmental factors such as nutritive or non-nutritive habits, are modifiable. Where malocclusions can be prevented from developing, this should be promoted as orthodontic treatment presents economic consequences, amongst others, for the individual, their carer/families, health service providers and the broader population. If a decision is made between the dental healthcare practitioner and the patient (or carers/parents) to treat malocclusions, this may be relatively short in duration and limited to intercepting a few features during the mixed dentition, or longer and comprehensive, dealing with multiple features simultaneously in the secondary dentition. Although patients may have certain expectations, these need to be carefully moderated, particularly if they seem unreasonable or unattainable, by relying on the best-available evidence during the process of informed consent. Orthodontic treatment, like any medical or surgical intervention, carries benefits, risks and limitations.

The overarching aims of this research were twofold: 1. To examine the association of environmental factors during infancy and childhood on the development of malocclusions, and, 2. To discern the long-term outcomes, in adulthood, of orthodontic treatment. These aims were achieved through the following objectives: 1. To assess the quality of information available on the Internet to the lay public concerning breastfeeding and malocclusions, 2. To produce estimates of the risk of malocclusion development associated with non-nutritive sucking behaviours and sub-optimal breastfeeding, 3. To determine whether any long-term differences exist in the level of dental caries experience,

psychosocial outcomes, dental knowledge and dental behaviour between adults based upon receipt of fixed orthodontic treatment.

One research protocol and six original research articles addressed these objectives. A dynamic cross-sectional analysis of Internet content gauged the quality of information targeting the lay public about breastfeeding and malocclusions. The Joanna Briggs Institute methodology for conducting systematic reviews of association (etiology) was used to synthesise evidence and generate estimates of effect for the association of non-nutritive sucking behaviours and breastfeeding on the development of different malocclusion features in the primary and mixed dentitions. Statistical analyses including modelling were applied to data from the *Oral Health of Adults Entering their Fourth Decade* study, a population-based prospective, observational investigation that followed children (aged 13 years) in South Australia in 1988-89 to early adulthood (aged 30 years) in 2005-06.

Internet information on breastfeeding and malocclusions was of moderate quality, with supportive references ranging between moderate and very low-level evidence. Although children who breastfed sub-optimally had increased risk of developing malocclusions, the risk from non-nutritive sucking behaviours was greater. Orthodontically treated participants had slightly better dental knowledge, though no difference existed in dental behaviours, dental health or psychosocial outcomes, regardless of initial malocclusion, based upon previous receipt of orthodontic treatment.

## THESIS DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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I give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time. I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Esma J. Dođramacı

Date: 10 November 2020

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I value the internal review of manuscripts by colleagues at the Australian Research Centre for Population Oral Health prior to their submission.

I acknowledge the assistance of The University of Adelaide Media Team that facilitated dissemination of the research findings to the lay public and the profession.

I am also indebted to my family for their humour, encouragement and love.

# RESEARCH PUBLICATION 1

## ***Breastfeeding and malocclusions: The quality and level of evidence on the Internet for the public.***

Doğramacı EJ, Peres MA, Peres KG.

Journal of the American Dental Association. 2016;147(10):817-825.

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PMID: 27353080

### **Contextual statement**

Breastfeeding has been reported as preventing the development of malocclusions in the deciduous dentition.<sup>3</sup> Presently, such research outcomes may be used by different organisations to support and promote their work. This is often achieved through the Internet as it is a medium that can be easily accessed and interacted with using different types of devices for private and professional purposes. Accessibility and the possibility of using the Internet almost anonymously are some of the reasons why the Internet is often used by the lay public and patients to obtain or verify consumer health information. A seminal study in Missouri, United States, found that the lay public prefer Bing above other search engines for its usefulness, followed by Yahoo!, Google, and Ask.com.<sup>4</sup> Most individuals explore the first few websites retrieved; just over 50% look at the second or following pages of a search and nearly a third click on a website displayed on one of these pages.<sup>4,5</sup> However, the lay public and patients may not always be able to discriminate between good quality information and spurious claims, or be aware if information is

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<sup>3</sup> Peres KG, Cascaes AM, Peres MA, Demarco FF, Santos IS, Matijasevich A, Barros AJD. Exclusive breastfeeding and risk of dental malocclusion. *Pediatrics*. 2015; 136: e60-e67.

<sup>4</sup> Wang L, Wang J, Wang M, Li Y, Liang Y, Xu D. Using Internet search engines to obtain medical information: a comparative study. *J Med Internet Res*. 2012; 14: e74.

<sup>5</sup> Eysenbach G, Köhler C. How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. *Br Med J*. 2002; 324: 573-577.

incorrect, biased or out-of-date. They may infer that health information available online can be trusted as the Internet is taken as an “authoritative source”;<sup>6</sup> this belief is further influenced by websites having a professional looking layout and appearance, avoidance of medical jargon, details about the source of information, and presence of a “quality seal”; that the content has been checked and approved by a third party.<sup>4</sup>

Search engine rankings currently rely on a mixture of algorithms, search engine optimisation, linked-content, payments for promotion and advertisements. This means that highly ranked websites that the lay public may identify and click on are likely to be the more popular ones but not necessarily the most factual.<sup>7</sup> Reliance on content that is inaccurate or false can lead to the development and perpetuation of myths, which could have dangerous consequences. Although the public are lately being encouraged to fact-check content that might appear to be overstated, this is yet to be taken up broadly within the general population.<sup>8</sup>

In a clinical setting, it is important for a clinician to be aware and up-to-date about the highest-level scientific evidence in their field of work. Although academic peer-reviewed research often helps to synthesise vast information into manageable portions, notably through systematic review articles, there is no similar process for analysing trending health topics on the Internet, which patients may question a clinician about in practice.

The aim of this study was to assess the quality of information on websites identified on the Internet that target the lay public about the relationship between breastfeeding and malocclusions, and to determine the level of evidence of any scientific articles cited in the

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<sup>6</sup> Allam A, Schulz PJ, Nakamoto K. The impact of search engine selection and sorting criteria on vaccination beliefs and attitudes: two experiments manipulating Google output. *J Med Internet Res*. 2014; 16: e100.

<sup>7</sup> Hodson H. Google wants to rank websites based on facts not links. *NewScientist*. Published 25 February 2015. Available at: <https://www.newscientist.com/article/mg22530102-600-google-wants-to-rank-websites-based-on-facts-not-links/?ignored=irrelevant#.VPR2DvnF98H>

<sup>8</sup> Brandtzaeg PB, Følstad A, Chaparro Dominguez MA. How journalists and social media users perceive online fact-checking and verification services. *Journalism Practice*. 2018; 12: 1109-1129.

identified websites; a topic that had not previously been investigated. This research was performed as a dynamic cross-sectional study using a blend of previously published methodologies.

### ***Key findings***

1. There is scant Internet content targeting the lay public regarding breastfeeding and malocclusions.
2. The content identified had an overall moderate level of quality.
3. Few websites cited peer-reviewed literature to support their content. Those that did relied on moderate to very low-level evidence.

### ***Implications***

1. There is limited knowledge translation of research into the relationship of breastfeeding and malocclusions to the lay public via the Internet; wider engagement by professionals, possibly with the media, may improve this.
2. Publication of high-quality systematic reviews and meta-analyses can address high-level gaps in the hierarchy of evidence about environmental components of malocclusions, thus producing higher-level evidence that websites could cite in lieu of the lower-level evidence observed on some of the identified websites.
3. It was postulated that the reported protection that breastfeeding might be affording against malocclusions was actually a result of this feeding method preventing the acquisition of deleterious oral habits such as pacifier or digit sucking, otherwise known as non-nutritive sucking behaviours (NNSBs). It was thereafter decided to explore the association of NNSB and breastfeeding on malocclusions through systematic reviews.

## Statement of authorship

**Statement of authors' responsibilities regarding the below publication that resulted from the Higher Degree Research work:**

Doğramacı EJ, Peres MA, Peres KG  
Breast-feeding and malocclusions: The quality and level of evidence on the Internet for the public.  
Journal of the American Dental Association  
2016; 147(10): 817-825.

Esma J. Doğramacı conceptualized and designed the study protocol, carried out data collection, analysis and interpretation of the data, drafted the initial manuscript, revised and approved the final manuscript as submitted.

Marco A. Peres and Karen G. Peres approved the study protocol, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

Esma J Doğramacı

Date: 20 December 2016

Marco A Peres

Date: 21 December 2016

Karen G/Peres

Date: 21 DECEMBER 2016

Principal author (candidate): Esma J. Doğramacı

Overall percentage contribution: 85%

Certification:

This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in the thesis. I am the primary author of this paper.





# Breast-feeding and malocclusions

## The quality and level of evidence on the Internet for the public

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**H**ealth care professionals have long espoused the many benefits of breast milk and breast-feeding because of the positive affect on the nutritional, immunologic, developmental, cognitive, and emotional well-being of the child.<sup>1</sup> To protect, promote, and support appropriate feeding for infants and young children, “exclusive breast-feeding for 6 months and continued breast-feeding up to 2 years of age or beyond” forms part of the global strategy of the World Health Organization.<sup>2</sup> Investigators have confirmed the dual health promotion and disease prevention effects of breast-feeding and breast milk on children in a series of systematic reviews and meta-analyses<sup>3-9</sup>; 1 set of investigators<sup>7</sup> found breast-feeding to have a protective effect against the development of malocclusions. A malocclusion is “[a] deviation in intramaxillary and/or intermaxillary relations of teeth from normal occlusion.”<sup>10</sup> Overall, study participants who were breast-fed were 70% less likely to develop a malocclusion compared with those who were never breast-fed or were breast-fed for short periods.<sup>7</sup> These effects may result from the specific use of orofacial musculature and the avoidance of factors that can cause malocclusions, such as nonnutritive sucking.<sup>11-16</sup> The presence of malocclusions may provoke unfavorable social responses.<sup>17</sup> In addition, orthodontic treatment of children carries economic implications for patients, their caretakers and families, health service providers, and society as a whole.<sup>18</sup> Prevention or interception of harmful behaviors may prevent the development of malocclusions, minimize their psychosocial affect, and reduce the demand for

### ABSTRACT

**Background.** The authors sought to assess the quality of information on the Internet for laypeople regarding the effect of breast-feeding on malocclusions and to determine the levels of evidence of the articles cited to support the information.

**Methods.** The first author (E.J.D.) entered a key word term, “breast-feeding and crooked teeth,” and a natural language term, “does breast-feeding protect against crooked teeth,” into 4 search engines. The author performed consecutive sampling of every Web site until 5 Web sites were identified that fulfilled the inclusion criteria per search engine, per search term, producing 40 Web sites for evaluation. The author assessed quality using the LIDA instrument and determined the levels of evidence of the cited articles according to the Joanna Briggs Institute Levels of Evidence.

**Results.** The author determined that the quality of the Web sites was moderate, represented by a median overall LIDA score of 73%. The author identified only 2 high-quality Web sites. Nearly one-half of the Web sites cited a combined total of 10 scientific articles to support their content, and these ranged from moderate to very low levels of evidence.

**Conclusions.** The authors found the quality of freely available information on the Internet for laypeople about the protective effect of breast-feeding against malocclusions to be moderate and that the evidence base cited to support the content ranged from moderate to very low levels of evidence.

**Practical Implications.** Increasingly, patients are seeking health information online, although not all information is credible. Dental health care practitioners should regularly review their practices’ Web sites to ensure that they are accessible and that the content is usable, reliable, and up-to-date, particularly as new, higher-level evidence becomes available.

**Key Words.** Breast-feeding; consumer health information; Internet; malocclusion; orthodontics; search engine.  
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<http://dx.doi.org/10.1016/j.adaj.2016.04.018>

orthodontic treatment and the associated economic burden. Factors positively influencing breast-feeding decisions include a woman's own history of having been breast-fed as an infant<sup>19</sup> as well as the accuracy and timing of information she receives.<sup>20,21</sup> People traditionally obtain information from their social network; health care professionals; prenatal course instructors; written information provided in health care settings, libraries, or bookshops; and telephone helplines.<sup>22</sup> Conflicting and incorrect advice can cause confusion<sup>23</sup> and can negatively affect breast-feeding.<sup>24</sup>

With the cost of acquiring computer hardware becoming more affordable for the general public, coupled with the rapid rate of development of digital technology, the popular uptake of the Internet ensued, beginning in the mid-1990s. People access the Internet for a variety of reasons, including to address a lack of patient-centered communication or dissatisfaction with medical care,<sup>25</sup> to fill a knowledge gap,<sup>26,27</sup> to verify existing personal knowledge,<sup>26</sup> to get reassurance, to obtain alternative opinions, and to avoid professional consultations for "trivial" matters.<sup>27</sup> Reliable, accurate, and high-quality health-related information and resources are available from vetted Web sites of professional organizations that laypeople may consult to better understand the medical conditions that have been diagnosed in them or someone they know. On the other hand, incalculable Web sites offer false, inaccurate, and incomplete information that, if relied on for the purposes of self-diagnosis and subsequent self-treatment, may not necessarily be correct, and, importantly, can be detrimental.<sup>28</sup>

Over 50% of first-time mothers have used general Internet searches to seek information about breast-feeding.<sup>29</sup> In November 2015, 46% of the world's population were Internet users; regionally, this amounted to 88% of the North American population and 78% of the Australian population.<sup>30</sup> Seventy-two percent of adult Internet users have looked online for health information, and over three-quarters of these "online health seekers" had used a search engine.<sup>31</sup> Content on the Internet is unregulated; anyone can write and upload content that may not necessarily be reliable. The quality of consumer health information on the Internet about breast-feeding and its protective effect against the development of malocclusions remains unclear and, to our knowledge, had not previously been investigated. In this study, we aimed to assess the quality of information on the Internet targeting laypeople concerning the relationship between breast-feeding and malocclusions and to determine the level of evidence of the cited scientific articles on Web sites for laypeople.

## METHODS

**Search strategy.** The first author (E.J.D.) deemed a key word term, "breast-feeding and crooked teeth," and a natural language term, "does breast-feeding protect

against crooked teeth," to be appropriate after screening the Web sites related to the URLs generated in a pilot study using these search terms. The most popular search engines include Google, Yahoo!, Bing, and Ask.com,<sup>32</sup> and the author used these 4 search engines in this order. A single author (E.J.D.) entered both search terms alternatively into each search engine using a computer connected to the Internet in Australia, without modifying the default settings of any of the search engines; investigators have used this methodology in previous research studies.<sup>33</sup>

**Inclusion and exclusion criteria.** The sole inclusion criteria were free access to the Web site and English-language content. The author (E.J.D.) excluded videos, advertisements, professional or scientific literature, professional forums or blogs for health care professionals, and public discussion forums. The author also excluded Web sites that discussed breast-feeding but not malocclusions, and vice versa, as these would not be relevant for the purposes of this study. The author omitted the internal and external duplicates of Web sites from reassessment that she had identified already.

**Identification of Web sites.** The first author (E.J.D.) performed consecutive sampling of every Web site that met the inclusion criteria from October 19, 2015, through October 22, 2015, until she identified 5 Web sites within each search engine per search term. The author used the key word term first across all search engines, followed by the natural language term. The author identified 20 Web sites per search term, thus producing 40 different Web sites for evaluation.

**Analysis of the quality of Web site content.** The first author (E.J.D.) used the LIDA instrument (Version 1.2)<sup>34</sup> to perform quality analysis; this author is calibrated in its use.<sup>35</sup> The LIDA instrument is a set of free validation tools developed by Minervation, a commercial health care consultancy firm, to assess whether a health Web site provides information that is accessible, relevant, and of high quality ([www.minervation.com](http://www.minervation.com)). The LIDA instrument measures 3 areas: level 1, accessibility (whether the Web site meets legal standards and users can access the information); level 2, usability (whether users can find the information they need); and level 3, reliability (whether the Web site provides comprehensive, relevant, and unbiased information).<sup>35</sup> To determine a measurement for level 1, the assessor enters the URL of the Web site of interest into the LIDA instrument site (<http://lida.minervation.com/>), and the online software automatically generates a score for accessibility. To determine measurements for levels 2 and 3, each question was scored on a scale of 0 to 3 (0 = never, 1 = sometimes, 2 = mostly, 3 = always), which produces summative scores for usability and reliability; scores for each level contribute to

**ABBREVIATION KEY.** JBI: Joanna Briggs Institute.



the overall score of the Web site. The individual and overall scores are graded as being high (> 90%), moderate (50-90%), or low (< 50%).<sup>35</sup>

The author performed quality analysis on completion of each search to avoid encountering “dead” links, or altered or deleted information on the Web sites, which may occur if analysis was deferred.

**Assessment of article type, level of evidence, and citations on Web sites.** The first author (E.J.D.) obtained and characterized each scientific article that was cited on the assessed Web sites according to article type and level of evidence, using the Joanna Briggs Institute (JBI) Levels of Evidence,<sup>36</sup> after being trained at the JBI (Adelaide, Australia). The JBI Levels of Evidence permit the determination of the level of evidence of publications related to effectiveness, diagnosis, prognosis, cost, and meaningfulness. Evidence is ranked into 1 of 5 levels.<sup>37</sup> The author assigned the following terms to each level: level 1, very high; level 2, high; level 3, moderate; level 4, low; level 5, very low. On November 18, 2015, the author identified the number of citations of each article in peer-reviewed journals by using the Scopus database (Elsevier).

## RESULTS

**Global origin, currency, and ownership of assessed Web sites.** The search generated over one-half million URLs across 3 of the search engines; Ask.com did not provide the specific number of results generated (Figure 1). The author (E.J.D.) viewed varying numbers of Web sites in each of the different search engines until she identified the first 5 Web sites that met the inclusion criteria within each search engine, per search term. The author identified and assessed 40 Web sites from 508 URLs (Figure 1). Twenty-five Web sites originated from the United States, 6 from Australia, and 3 from the United Kingdom. Canada, Ireland, Israel, and New Zealand each contributed 1 Web site (Table 1). The origin of 1 Web site was unknown, and 1 Web site had authors from across the world. The author determined the currency of information from the date of posting of the content on the Web site or, if this was not available, from the copyright date. Sixteen (40%) Web sites were updated in 2015, 4 Web sites were updated over a decade ago, and 4 Web sites did not specify any date (Table 1). The author analyzed the Web sites’ ownership and divided them into 9 groups. Commercial Web sites was the largest category represented (n = 9). Private institutions, comprising not-for-profit, nongovernmental, and charitable or research organizations, owned one-fifth of the Web sites. Private individuals owned 7 Web sites, and digital news organizations owned 6 Web sites. Public institutions and private dental practices owned 3 Web sites each, and there were 2 private medical practice Web sites. The author also identified the Web sites of 1 private orthodontic practice and 1 self-help group (Table 1).

## Quality analysis of Web sites using the LIDA

**instrument.** Figures 2 and 3 show the distribution of the component and overall LIDA scores for all 40 Web sites and the distribution of the component and overall LIDA scores according to the category of ownership of Web sites, respectively. Overall, the Web sites had good scores for accessibility, with nearly symmetrical distribution. Six Web sites achieved high accessibility scores (> 90%); these Web sites represented 3 digital news organizations, 1 private institution, 1 commercial organization, and 1 self-help group. There was more variability in the scores for usability, although the median value (83%) was identical to that for Web site accessibility. Nearly one-half of the Web sites (n = 18) scored high (> 90%) for usability, and 7 of these Web sites (2 private medical practices, 2 dental practices, 1 digital news organization, 1 private institution, and 1 commercial organization) scored 100%. Reliability, although moderate and with a nearly symmetrical distribution, had the greatest variability and the lowest median score of all components. The interquartile range for reliability (45%) was 3 times greater than that for accessibility (15%). Two private institutions’ Web sites and 1 private dental practice’s Web site achieved high scores (> 90%) for the reliability component. Although the quality of content on the Web sites was variable, in general, the author found that they could be considered to be of moderate quality, represented by the median overall LIDA score (73%). The author identified only 2 high-quality Web sites (1 from a private institution and 1 from a private dental practice) both of which originated from the United States and achieved high (> 90%) overall LIDA scores.

**Scientific articles cited on assessed Web sites.** Nearly one-half (n = 18) of the Web sites cited a total of 10 scientific articles to support their content,<sup>14,16,38-45</sup> which comprised 4 research, 2 review, and 4 editorial or opinion articles. Two Web sites (from private dental practices) cited multiple articles. The 2 most commonly cited articles on the Web sites also had the highest number of citations in peer-reviewed journals (Table 2). Using the JBI Levels of Evidence, the author classified 1 article as level 3,<sup>45</sup> 3 as level 4,<sup>16,38,39</sup> and the remainder as level 5.<sup>14,40-44</sup> All levels of evidence were cited among the different categories of Web sites assessed (Figure 4). Private dental practices, a private institution, and a digital news organization were the only categories that cited articles with level 3 evidence. Of the remaining Web sites, 17 did not cite any references, and 5 Web sites provided or related personal opinion.

## DISCUSSION

In this cross-sectional study, one of the authors assessed the quality of information on the Internet for laypeople regarding breast-feeding and malocclusions, as well as the level of evidence of cited articles. The author assessed

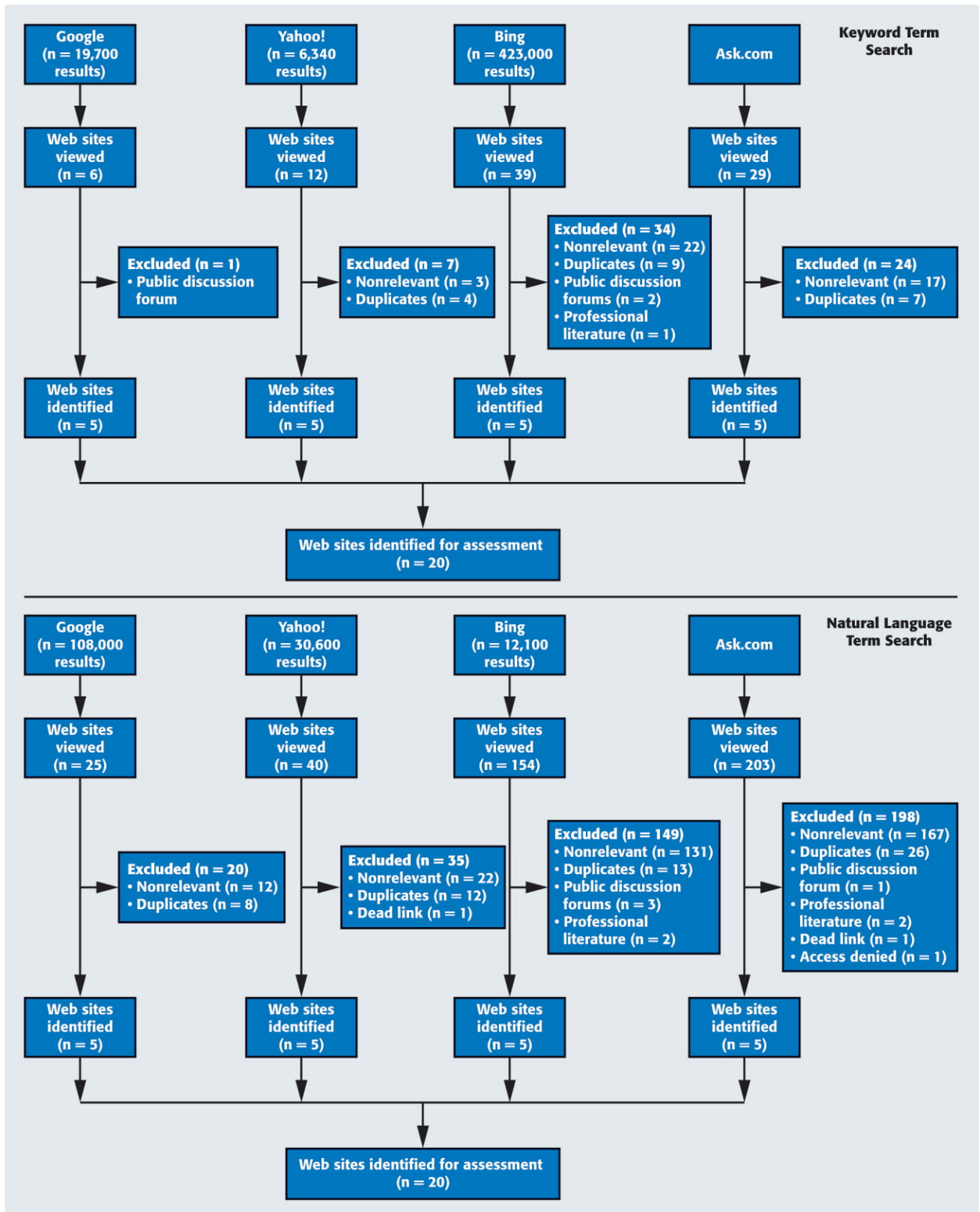


Figure 1. Flow diagram of the identification of assessed Web sites.



only 8% of the URLs retrieved, which is a reflection of the scarce amount of information that has translated to laypeople via the Internet on this subject.

The Web sites were of moderate reliability. This is a result of the content not being up-to-date, the date that the content was posted not being available, and sources of information not always being cited; these issues can introduce bias that may or may not be intentional. Although the author could ascertain the ownership of all but 1 of the Web sites, it was not always evident whether subject experts, an independent expert, or a panel wrote or reviewed the Web site's content. All these elements are assessed within the reliability component of the LIDA instrument, but their importance was originally proposed by the authors of a seminal article published nearly 20 years ago, who suggested that "core standards" could be adopted voluntarily by authors of Web sites to help both health consumers and health care professionals differentiate between the "credible" and the "suspect."<sup>46</sup>

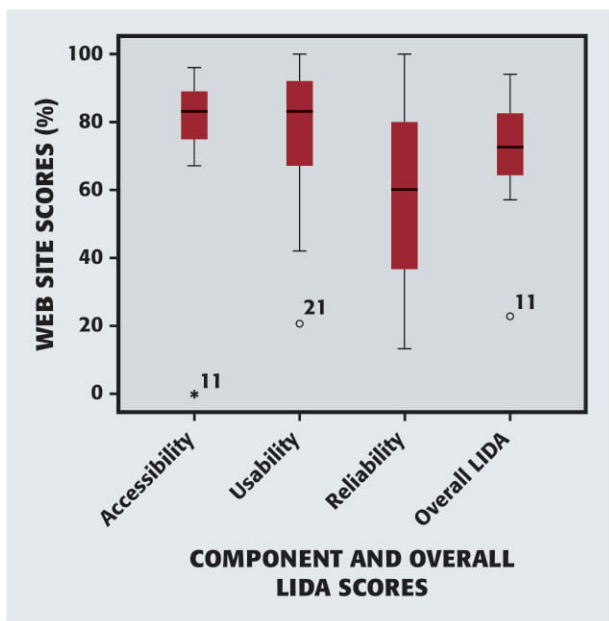
The level of evidence cited on Web sites that target laypeople is relatively low. Only 22% of commercial organizations, the category comprising the most Web sites, cited articles, but these articles were very low level evidence. All private dental practice Web sites cited scientific articles; however, they ranged from moderate to very low level evidence. Although general dental health care practitioners traditionally are not involved in imparting breast-feeding advice, they are usually the first point of contact for a patient to discuss the presence and management of a malocclusion. It could be expected that only the highest level of available evidence would be cited on these Web sites, because dental professionals are expected to apply up-to-date and high-level scientific and evidence-based knowledge and skills to their clinical practice, and as a corollary, their practice Web sites would emulate this. This is an area that can be improved. "The lay public and patients may not always be able to discriminate between good quality information from spurious claims, or be aware if information is incorrect, biased or out-of-date."<sup>33</sup> If the evidence, reliability, and quality of accessed Web sites are low, the public is consequently at risk of acquiring inaccurate information that could potentially be harmful. Mistrust also may result if the information sourced is at odds with professional advice.<sup>33</sup>

Laypeople purposefully seeking health information on the Internet usually explore the first few Web sites they retrieve on the first page of a search engine; just over 50%

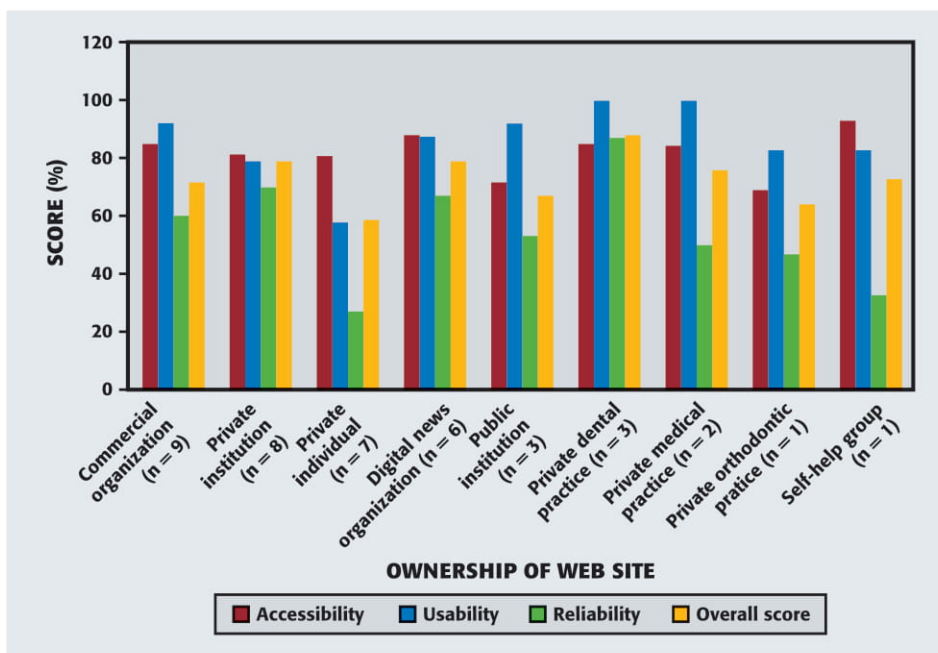
of people will look at the second or following pages of a search, and nearly one-third will click on a Web site displayed on 1 of these pages.<sup>47,48</sup> As it is not possible to predetermine the sample size owing to the dynamic nature of the Internet, the author specified a set number of Web sites for assessment before undertaking consecutive sampling, a method used in previous research.<sup>33</sup> This method differs from those that specify that the first

TABLE 1

<b>Details of assessed Web sites.</b>			
<b>WEB SITE IDENTIFICATION NO.</b>	<b>YEAR OF LAST UPDATE</b>	<b>COUNTRY OF GLOBAL ORIGIN</b>	<b>OWNERSHIP</b>
1	2011	United States	Self-help group
2	2004	United Kingdom	Digital news organization
3	2014	United Kingdom	Private institution
4	2009	Australia	Private individual
5	2015	Australia	Private dental practice
6	2012	Unknown	Private individual
7	Not specified	United States	Public institution
8	Not specified	Ireland	Commercial organization
9	Not specified	International	Private institution
10	2004	United States	Digital news organization
11	2013	Australia	Commercial organization
12	2011	Australia	Commercial organization
13	2015	United States	Digital news organization
14	2015	United States	Digital news organization
15	2015	United States	Commercial organization
16	2009	United States	Private individual
17	2015	Canada	Private institution
18	2015	United States	Private institution
19	2011	Australia	Digital news organization
20	2011	United States	Private institution
21	2012	United States	Private individual
22	2004	United States	Private institution
23	2015	United States	Digital news organization
24	2008	Israel	Private institution
25	2013	United States	Commercial organization
26	2015	United States	Commercial organization
27	2008	New Zealand	Commercial organization
28	2015	United States	Private individual
29	2012	United Kingdom	Public institution
30	2006	Australia	Private medical practice
31	2015	United States	Commercial organization
32	2014	United States	Private medical practice
33	2015	United States	Public institution
34	2000	United States	Private individual
35	Not specified	United States	Private orthodontic practice
36	2015	United States	Private individual
37	2015	United States	Private dental practice
38	2015	United States	Commercial organization
39	2015	United States	Private dental practice
40	2015	United States	Private institution



**Figure 2.** Box plot of the distribution of the component and overall LIDA scores. \*11, °21, and °11 denote the Web site identification number of the outlier values.



**Figure 3.** Distribution of median LIDA scores according to the category of ownership of the Web sites.

list. Investigators have advocated the use of multiple search engines, instead of a single search engine, when looking for medical and health information on the Internet because “the various search engines have different focuses on their search content.”<sup>46</sup> In addition, some people “use different search engines for the same keyword search.”<sup>48</sup> Therefore, our study protocol stipulated that both search terms be used across multiple search engines to mimic the behavior of laypeople on the Internet.

Health advice on the Internet should not be promoted “...without ensuring that reliable empirical research evidence has shown that [the health advice is] more likely to help than to harm....”<sup>28</sup> The author obtained scientific articles cited on the Web sites evaluated in this study and assessed their level of evidence. We do not generally expect laypeople to access scientific articles, as normally a fee is involved; only 2% of “online health seekers” pay, after prompting, to view health information.<sup>31</sup> The JBI Levels of Evidence differ from evidence or hierarchical pyramids, as it allows stratification of studies that digress from traditional research methods, owing to the “broader view of what constitutes research evidence for practice.”<sup>37</sup> This approach allows for evaluation of the literature on

the basis of the study design, the methodological quality, and the rigor of the evidence, and these are not necessarily related to the strength of the findings.<sup>37</sup> Citation of articles rated as lower level evidence on Web sites that target laypeople would have been wholly appropriate, at the time of their publication. However, higher-level evidence has been published that corroborates the editorial and opinion articles, for instance. It would therefore be responsible to review specific Web site content and update this as new evidence becomes available.<sup>33</sup>

The results of this study have established both the extent of

50 or 100 Web sites in a search be captured,<sup>35</sup> which could equate to capturing all of the Web sites that are listed on the first 5 to 10 pages of a search engine’s result

research dissemination as well as the quality of knowledge translation to laypeople via the Internet regarding breast-feeding and malocclusions. Translational research



plays a role in narrowing the knowledge gap between health care professionals and patients. Knowledge translation, stemming from scientific research, to the populations and the communities with whom and within which dental health care practitioners work and live, will ensure that people are made aware of all options, as well as the associated benefits and the potential risks, to make fully informed decisions. The prevalent use of the Internet for sourcing health-related information underscores the importance of updating Web site content with the highest quality information possible, as soon as this knowledge becomes available.

If laypeople choose to use a general search engine to find information on breast-feeding and malocclusion, there is only a slim chance that they will retrieve information from dental practice Web sites in their search. If general dental health care practitioners wish to have information from their practices' Web sites be retrieved prominently via such searches, they could undertake search engine optimization that would help raise the rank of their Web site on the basis of the algorithm used by the particular search engine. This strategy, in turn, can increase traffic to their Web site. Briefly, optimization is related to the site's content (that is, providing a clear design and layout with readable, accurate information within a well-structured and engaging screen presentation), the degree of optimization performed (that is, choosing a good domain name, having a unique title tag for each web page, using key words in the subpages and subdomains, having subpages with a descriptive title, and using descriptions and Meta tags), and the popularity of the Web site. The Web site should consist of high-quality and reliable information based on the highest level of evidence possible, disclose the source of information used to compile the content, ideally provide references, and update information when new evidence becomes available; the date of the last update, review, or both also should be included on the relevant Web page.<sup>33</sup> Alternatively, practitioners could identify and direct their

patients toward resources with adequate content that also would be understandable to them<sup>35</sup>; for example, the practice's Web site could provide a list of relevant hyperlinks or URLs.

Watt<sup>49</sup> has promulgated the adoption of a common risk approach in public health policies as potentially bringing about significant "oral health gains" in low, middle, and high income countries compared with offering isolated clinical prevention and dental health education alone.<sup>49</sup> Although the orthodontic benefits of breast-feeding have been reported, health care professionals should keep in mind the multifactorial etiology of malocclusions. Health care professionals can attempt to modify behaviors that contribute to the development of malocclusions (such as nonnutritive sucking) to some extent through the general promotion of breast-feeding; however, this strategy in itself will not eliminate the occurrence of malocclusions in the population as a

TABLE 2

**Number of citations of scientific articles found in assessed Web sites and in peer-reviewed journals.**

STUDY	NO. OF CITATIONS FOUND IN ASSESSED WEB SITES	NO. OF CITATIONS FOUND IN PEER-REVIEWED JOURNALS
Labbok and Hendershot, <sup>38</sup> 1987	5	38
Legović and Oštrić, <sup>39</sup> 1991	1	28
Drane, <sup>14</sup> 1996	1	0
Palmer, <sup>40</sup> 1998	1	31
McVeagh, <sup>41</sup> 2002	1	4
Page, <sup>42</sup> 2003	1	4
Viggianno and Colleagues, <sup>16</sup> 2004	5	66
Salone and Colleagues, <sup>43</sup> 2013	1	17
Lawrence, <sup>44</sup> 2014	1	1
Peres and Colleagues, <sup>45</sup> 2015	4	0

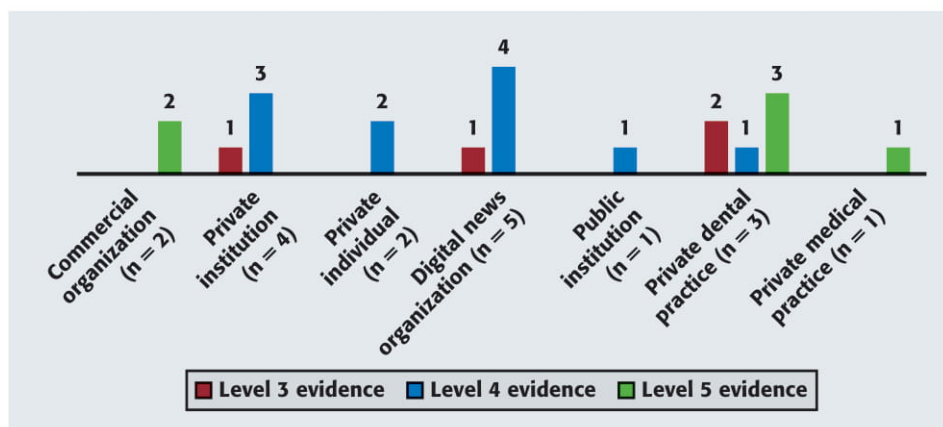


Figure 4. Number of citations of articles on Web sites, according to level of evidence.



whole. Despite the extent of the benefits of breast-feeding for infants and nursing women being well recognized, Dođramacı acknowledged that “mothers [have] a right to choose whether or not they want to breast-feed; ...provided [they are] properly informed about the facts.”<sup>50</sup> The collective responsibility of health care professionals is to ensure that the information they provide to those in their care is objective, evidence-based, and consistent. The level of evidence that they use to support their advice always should be the highest possible.

## CONCLUSIONS

There is scant freely available information on the Internet for laypeople about the protective effect of breast-feeding against the development of malocclusions. The limited information available is of moderate quality; fewer than one-half of the Web sites the author assessed cited scientific articles, and those articles ranged from moderate to very low levels of evidence. As people increasingly rely on the Internet to source information, it is important that Web site owners regularly review the content of their Web sites and update them as soon as new, higher-level evidence becomes available. This helps to ensure accurate, reliable, and timely knowledge translation from professionals to laypeople in a medium they are familiar with, which can be accessed whenever and wherever they desire. ■

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## RESEARCH PUBLICATION 2

### ***Establishing the association between non-nutritive sucking behaviour and malocclusions: A systematic review and meta-analysis.***

Doğramacı EJ, Rossi-Fedele G.

Journal of the American Dental Association. 2016;147(12):926-934.

DOI: [10.1016/j.adaj.2016.08.018](https://doi.org/10.1016/j.adaj.2016.08.018)

PMID: 27692622

### **Contextual statement**

NNSBs are a type of comfort habit that can bring about sensations of security and calmness.<sup>9</sup> Additionally, their use is effective in acutely painful procedures in pre-term infants, neonates and older infants,<sup>10</sup> while pacifier use reduces the incidence of sudden infant death syndrome.<sup>11</sup> Harmful effects of NNSBs, specifically pacifiers, include their association with otitis media and a shorter duration of breastfeeding.<sup>11,12</sup> While acknowledging the multifactorial aetiology of malocclusions, NNSBs have been linked with a multitude of malocclusion features that include posterior crossbite, increased overjet, anterior open bite, reduced overbite and Class II buccal

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relationships.<sup>13,14,15,16,17,18,19,20,21,22,23,24</sup> Despite there being an immense body of literature inferring a causal relationship, a literature search was unable to identify any systematic review or meta-analysis on this topic.

The aim of this study was to assess the association between NNSB and malocclusions, through a systematic review and meta-analysis. The methodology developed by The Joanna Briggs Institute (JBI), which is based at The University of Adelaide, was adopted as it provides a “broader definition of what constitutes research evidence for practice”<sup>25</sup> and is not restricted to considering only a specific type of study design as a source of evidence. Furthermore, this approach also supports limiting inclusion of component studies only to those determined as having high methodological quality.

By identifying the strength of the relationship of different types of NNSB on malocclusions, the results could be compared with the results of the next study that was also a systematic review and meta-analysis, on breastfeeding and malocclusions. Furthermore, the results of this study would also help provide clinically translatable findings, useful when

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<sup>21</sup> Vázquez-Nava F, Quezada-Castillo JA, Oviedo-Treviño S, Saldivar-González AH, Sánchez-Nuncio HR, Beltrán-Guzmán FJ, Vázquez-Rodríguez EM, Vázquez Rodríguez CF. Association between allergic rhinitis, bottle feeding, non-nutritive sucking habits, and malocclusion in the primary dentition. *Arch Dis Child*. 2006; 91: 836-840.

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<sup>24</sup> Mistry P, Moles DR, O'Neill J, Noar J. The occlusal effect of digit sucking habits amongst school children in Northamptonshire (UK). *J Orthod*. 2010; 37: 87-92.

<sup>25</sup> The Joanna Briggs Institute. The University of Adelaide, School of Translational Health Science. The Joanna Briggs Institute Levels of Evidence and Grades of recommendation Working Party. Supporting Document for the Joanna Briggs Institute Levels of Evidence and Grade of Recommendation. 2014.

counselling patients (or their parents/carers) about the causes of malocclusions and the steps that can be taken to avoid them.

### ***Key findings***

1. Increased overjet was more likely to develop in digit rather than pacifier suckers.
2. Pacifier sucking was strongly associated with a posterior crossbite in the primary dentition, with all results having statistical significance, and one meta-analysis (pacifier versus digit sucking) having nil heterogeneity.
3. Anterior open bite was associated with any type of NNSB.

### ***Implications***

1. This study now provides the highest level of evidence into the association of NNSB and malocclusions, with a focus on the primary and mixed dentitions, which did not previously exist.
2. Although component studies of only high methodological quality were included, the meta-analyses had moderate to high-level heterogeneity. Nonetheless, the overall direction of effect of most of the meta-analyses clearly indicates the higher risk of malocclusion in those who perform NNSBs. Heterogeneity is likely the result of across-study differences related to participant characteristics, clinical definitions, and classification of outcome measures. Future research studies would benefit by allocating study participants to exposure-specific groups, adopting uniform, standard and widely accepted definitions and classifications, and collecting and reporting data on core outcome measures.<sup>26</sup>
3. Overjet had a highly variable definition across studies, which might be relevant when assessing risk for dental trauma. Consequently, a study separate to the body

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<sup>26</sup> Tsihlaki A, O'Brien K, Johal A, Marshman Z, Benson P, Colonio Salazar FB, Fleming PS. Development of a core outcome set for orthodontic trials using a mixed-methods approach: protocol for a multicentre study. *Trials*. 2017; 18: 366.

of work in this PhD was conducted to investigate the threshold at which an overjet could be considered increased and at risk of experiencing traumatic dental injury.<sup>27</sup>

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Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
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## Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

- i. the candidate's stated contribution to the publication is accurate (as detailed above);
- ii. permission is granted for the candidate to include the publication in the thesis; and
- iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Giampiero Rossi-Fedele		
Contribution to the Paper	Carried out assessment of methodological quality, data extraction, critically reviewed and revised, and approved the final manuscript as submitted.		
Signature		Date	30 June 2016



## COVER STORY

# Establishing the association between nonnutritive sucking behavior and malocclusions

## A systematic review and meta-analysis

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Infants and young children may engage in nonnutritive sucking behavior (NNSB), that is, habitual sucking of digits, pacifiers, or other objects without deriving any nourishment from them. NNSB is a type of “comfort habit,”<sup>1</sup> affording the child a sense of security and calmness. Researchers have suggested the use of



This article has an accompanying online continuing education activity available at: <http://jada.ada.org/ce/home>.

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### ABSTRACT

**Background.** The authors studied the effects of nonnutritive sucking behavior (NNSB) on malocclusions through a systematic review of association (etiology).

**Types of Studies Reviewed.** The authors performed a 3-step search strategy, including electronic searches. Studies of healthy participants with a history of active or previous NNSB, for whom specific malocclusion outcomes had been assessed, were eligible for inclusion. The authors considered before-and-after studies, prospective and retrospective (longitudinal) studies, case-control studies, and analytical cross-sectional studies. They excluded reviews, text-and opinion-based articles, conference abstracts, case reports, case-series, and descriptive cross-sectional studies. The authors, using standardized instruments, independently assessed methodological quality and extracted data from the included studies. In situations for which there were sufficient studies, the authors conducted meta-analyses using the random-effects model, supplemented with the fixed-effects model in situations for which statistical heterogeneity was less than 50%, which the authors assessed using the  $I^2$  statistic.

**Results.** The authors included 15 identified studies. They found that NNSB was associated with varying risks of developing malocclusions. Pacifier suckers are less likely to develop an increased overjet compared with digit suckers, although the results of a meta-analysis of 7 studies whose investigators had assessed posterior crossbite in the primary dentition demonstrated a significant association with pacifier sucking over digit sucking ( $n = 5,560$ ; risk ratio, 1.42; 95% confidence interval, 1.18-1.70;  $P = .0001$ ). Longer duration of NNSB was associated with an increased risk of developing malocclusions. Cross-study heterogeneity likely resulted from methodological and sample size differences.

**Conclusions.** The authors of this study have confirmed the association between NNSB and the development of malocclusions. This study provides the highest level of evidence on this topic. Pacifiers were associated with a higher risk of developing most malocclusion features when compared with digit sucking.

**Practical Implications.** Though malocclusions are of multifactorial etiology, clinicians should inform parents and caregivers about the dental risks of NNSB, an environmental factor that is modifiable. NNSB should be discouraged in order to avoid the development of malocclusions. Future studies should adopt standardized, universally agreed and accepted definitions and classifications when measuring and reporting orthodontic outcome measures. This will help achieve across-study homogeneity.

**Key Words.** Evidence-based dentistry; finger sucking; malocclusion; meta-analysis; orthodontics; pacifiers; pediatric dentistry; sucking behavior; sucking habits; systematic review. JADA 2016;147(12):926-934

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NNSB as a nonpharmacological intervention in the management of acutely painful procedures in preterm infants, neonates, and older infants,<sup>2</sup> and pacifier sucking is related to the reduced incidence of sudden infant death syndrome.<sup>3</sup> However, pacifier use also has been associated with shorter duration of breast-feeding<sup>3,4</sup> and otitis media.<sup>5</sup> Malocclusion, defined as “a deviation in intramaxillary and/or intermaxillary relations of teeth from normal



Supplemental material is available online.

occlusion [contact between teeth],”<sup>6</sup> is another recognized outcome related to NNSB.<sup>7</sup> NNSBs are said to contribute specifically to the development of increased overjet (“horizontal projection of maxillary teeth beyond the mandibular anterior teeth”<sup>6</sup>), posterior crossbite (“an abnormal relationship of a tooth or teeth to the opposing teeth, in which normal buccolingual or labiolingual relationships are reversed”<sup>6</sup>), anterior open bite (“lack of [anterior] tooth contact in an occluding position”<sup>6</sup>), and incorrect sagittal relationship of teeth.<sup>7</sup>

Clinicians should not interpret the presence of a malocclusion as always needing treatment, as the spectrum of malocclusions ranges from those that are associated with minimal or no functional, dental health-related, or esthetic impairment, to those that are severe and can predispose a patient to traumatic dental injury<sup>8,9</sup> or impaction resorption,<sup>10</sup> both of which can cause tooth loss, as well as those that can elicit unfavorable social responses.<sup>11</sup> Clinicians may use reliable and validated indexes, such as the Index of Orthodontic Treatment Need,<sup>12</sup> to stratify patients’ need for orthodontic treatment according to the severity of their malocclusions.

Malocclusions also have multifactorial etiology; they are determined by a complex interaction of both genetics and environment. Whether malocclusions can be corrected by “therapeutic environmental intervention” may be determined by correctly diagnosing the extent to which genetics and the environment play a part in the expression of the phenotype.<sup>13</sup> If the features of a patient’s malocclusion have limited genetic origin, a clinician may suggest that the patient’s parents attempt to modify environmental factors that can induce malocclusion during the patient’s growth and development.<sup>14</sup> The clinician may suggest withdrawing pacifiers from the infant, or the clinician may advise interceptive orthodontic devices for digit suckers.<sup>15</sup> In patients who have ceased NNSB but for whom features of malocclusion have persisted and are severe, the clinician may encourage orthodontic intervention.

Orthodontic treatment carries significant implications for patients and their caregivers or families with respect to absenteeism from school or work and travel to attend appointments, pressure on health service providers to rationalize the use of limited resources, and society as a whole. “Prevention or interception of

harmful behaviors may prevent the development of malocclusions, minimize their psychosocial impact, and reduce the demand for orthodontic treatment and the associated economic burden.”<sup>16</sup> Although a large body of literature exists, largely composed of retrospective cohort studies, case reports, case series, and opinion or review articles whose authors have reported on the relationship between NNSB and malocclusions, to our knowledge, no investigators previously have undertaken a study to reveal high-level evidence, in the form of a systematic review of association (etiology). We conducted this review with the objective of assessing the association between NNSB and malocclusions.

## METHODS

We registered the title of this review and prospectively archived the protocol with the Joanna Briggs Institute (JBI) before commencing the review; we followed the JBI methodology for systematic reviews of association (etiology).<sup>17</sup>

**Review questions.** The objective of this review was to identify the relationship of NNSB on the development of malocclusions. We addressed the following specific review questions:

- What is the risk of developing malocclusions in participants with NNSB compared to those without NNSB?
- What is the risk of developing malocclusions between participants with different types of NNSB?
- What is the risk of developing malocclusions in participants with longer duration of NNSB compared with those having a shorter duration of NNSB?

**Inclusion criteria.** The usual population, intervention, comparator, and outcome approach to generate review questions for systematic reviews does not align with reviews related to etiology. Therefore, we used the population, exposure, and outcome approach to generate the review questions.<sup>17</sup>

**Population.** We conducted a search for studies of healthy participants with a history of active or previous NNSB and no previous orthodontic or surgical treatment. We set no restrictions on the basis of participants’ ages or sex. We excluded studies of participants who had a cleft lip, palate, or both; other craniofacial deformities; any syndrome; or a history of maxillofacial trauma.

**Exposures of interest.** We considered for inclusion studies whose investigators had evaluated the orthodontic impact of pacifier and digit sucking.

**ABBREVIATION KEY.** AOB: Anterior open bite. CINAHL: Cumulative Index to Nursing and Allied Health Literature. CR: Canine relationship. JBI: Joanna Briggs Institute. MR: Molar relationship. NNSB: Nonnutritive sucking behavior. OJ: Overjet. X-bite: Posterior crossbite.



**Types of outcomes.** We assessed the following outcomes: increased overjet, sagittal relationship, posterior crossbite, and anterior open bite.

**Types of studies.** In this review, we considered for inclusion before-and-after studies, prospective and retrospective cohort (longitudinal) studies, case-control studies, and analytical cross-sectional studies. We excluded reviews, text- and opinion-based articles, conference abstracts, case reports, case-series, and descriptive cross-sectional studies.

**Search strategy for the identification of studies.** We used a 3-step search strategy. We conducted an initial limited search of MEDLINE and Scopus, followed by an analysis of the text words contained in the titles and abstracts and the index terms used to describe the articles. Next, we conducted a search using all identified key words and index terms across MEDLINE (Ovid), Embase (Ovid), Scopus, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO) from the inception date of each database up to the end of May 2016 (eTable, available online at the end of this article). After we removed duplicate records, we screened, independently and in duplicate, the title and abstract (or summary, where available) and the descriptor or Medical Subject Headings terms of the identified records to identify potentially relevant articles for full-text assessment. Finally, we performed a citation search of the reference lists of all included articles. We placed no restrictions on the language or the year of publication.

**Assessment of methodological quality.** As JBI-trained reviewers, we both independently assessed the methodological quality of the full-text articles by means of using standardized critical appraisal instruments from JBI SUMARI.<sup>18</sup> This process aims to identify sources of bias by means of using criteria that the reviewer can score as being met, not met, unclear, or not applicable to the particular study.<sup>19</sup> An a priori decision stated that a cutoff for the inclusion of a study would be a score of 8 (maximum score = 10). We resolved any disagreements that arose through discussion until we reached a decision by consensus.

**Data extraction.** Using standardized data extraction tools from JBI SUMARI,<sup>18</sup> we independently extracted data from studies included in the review. The data extracted included authors' names, year of publication, study setting, study design, population details, exposures, and outcomes of significance to the review questions. We contacted authors for clarification or to request further information as required.

**Data analysis and synthesis.** In situations for which there was a sufficient number of studies whose authors had reported comparable exposures and outcomes, we performed a meta-analysis. We used the random-effects model, which we supplemented by using the fixed-effects model in situations for which statistical heterogeneity was low ( $\leq 50\%$ ); we assessed this by using the  $I^2$

statistic, as a means of sensitivity analysis. We calculated risk ratios (RR) with 95% confidence intervals (CI) for each study, as well as for the pooled results of all component studies. We performed all analyses using Review Manager (RevMan), Version 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).

## RESULTS

**Search strategy results.** We identified 569 records through electronic database searches; 268 were duplicates. Of the remaining 301 records, we discarded 228 records after screening the titles and abstracts or summaries. A full-text assessment for methodological quality of the remaining 73 articles eliminated 48 articles. We excluded 1 article because some of the study participants had received orthodontic treatment. We noted that data from 1 study whose authors had published repeated and different outcomes were identified in 2 articles; we included only the more comprehensive article. We contacted the authors of 8 articles to clarify data, provide additional information relevant to the review that was not apparent in the identified article, or both. One author replied that the data were no longer accessible, the authors of 2 articles had not collected the information we sought, 1 author did not return with clarification of data published in 4 articles, and the authors of 1 other study did not reply. Therefore, we excluded those articles. We included 15 studies in the systematic review (Figure). A citation search of the included articles did not reveal additional records.

**Included studies.** Table 1 shows the main characteristics of the 15 studies,<sup>20-34</sup> all of which were published in English.

**Characteristics of the study settings.** Investigators conducted 7 of the included studies in Brazil,<sup>25-28,30,33,34</sup> 2 each in Finland,<sup>21,23</sup> Italy,<sup>24,32</sup> and Sweden,<sup>20,29</sup> and 1 each in Saudi Arabia<sup>22</sup> and the United Kingdom.<sup>31</sup>

**Characteristics of the participants.** The investigators of all of the studies had investigated children; the investigators of 13 examined the primary dentition,<sup>20-30,33,34</sup> the investigators of 1 examined the mixed dentition,<sup>32</sup> and the investigators of another examined the mixed and secondary dentitions.<sup>31</sup>

**Characteristics of the exposures.** The investigators of 9 studies looked at both pacifier and digit sucking,<sup>20,22,25,26,28,29,32-34</sup> the authors of 1 study investigated only digit sucking,<sup>31</sup> and the investigators of 6 studies examined the combined effect of all types of NNSB as a single exposure.<sup>21,23,24,27,29,30</sup>

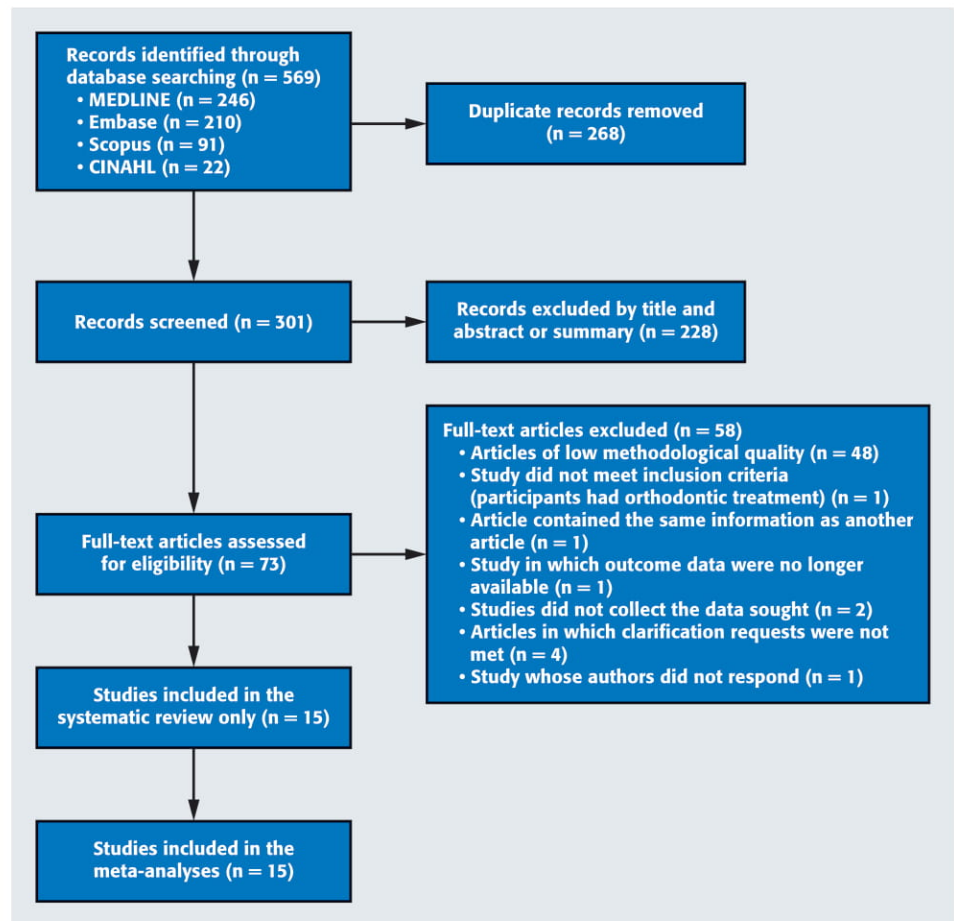
**Characteristics of the outcomes.** With the available data, it was possible to perform meta-analyses on 4 malocclusion outcomes in the primary dentition and 3 in the mixed dentition. eFigures 1 and 2<sup>20-34</sup> (available online at the end of this article) show forest plots of all of the meta-analyses.

*Primary dentition: NNSB versus no NNSB.* Children with NNSB were at risk of developing a class II canine relationship, posterior crossbite, anterior open bite, or a combination of these (Table 2, eFigure 1A [available online at the end of this article]).

*Primary dentition: pacifier sucking versus digit sucking.* Children with a pacifier sucking habit were 32% less likely to develop an increased overjet, although they were at risk of developing a class II canine relationship. The results of a meta-analysis of 7 studies whose investigators had assessed posterior crossbite demonstrated a significant association with pacifier sucking ( $n = 5,560$ ;  $RR = 1.42$ ; 95% CI, 1.18-1.70;  $P = .0001$ ). Both random-effects and fixed-effects models gave similar results. The results related to anterior open bite were inconclusive (Table 2, eFigure 1B [available online at the end of this article]).

*Primary dentition: pacifier sucking versus no pacifier sucking habit, and digit sucking versus no digit sucking habit.* We found an association between pacifier sucking and the development of posterior crossbite and anterior open bite. We could not establish a difference in the risk of developing posterior crossbite with digit sucking, although digit suckers were more likely to develop an anterior open bite (Table 2, eFigure 1C and D [available online at the end of this article]). These results should be viewed with caution, as there was evidence of a moderate to high level of heterogeneity, meaning the effect sizes may not be accurate. In addition, the investigators of the component studies included in these meta-analyses conducted the studies in a single country. Therefore, the generalizability of the findings may be limited only to the populations studied.

*Mixed dentition: digit sucking versus no sucking habit.* We found that no overall difference was demonstrated in the development of a class II molar relationship,



**Figure.** Flowchart of the screening and study selection process. CINAHL: Cumulative Index to Nursing and Allied Health Literature.

although an association existed between digit sucking and posterior crossbite. There was a significant association between digit sucking and anterior open bite; the results were not significantly heterogeneous (Table 2, eFigure 2 [available online at the end of this article]).

*Secondary dentition.* It was not possible to provide narrative syntheses into the outcomes in this dentition owing to the relatively few participants in the single identified study.<sup>31</sup> A lack of other studies with results related to secondary dentition precluded meta-analyses.

*Longer- versus shorter-duration NNSB.* Longer duration of pacifier sucking was associated with anterior open bite<sup>25</sup> and a class II canine relationship<sup>33</sup> in the primary dentition. Longer duration of NNSBs was associated with anterior open bite in the primary dentition.<sup>27</sup>

## DISCUSSION

To our knowledge, we are the first to conduct a systematic review that examined the association between NNSB and malocclusions. The results of our review



TABLE 1

<b>Characteristics of the included studies.</b>							
STUDY	COUNTRY	STUDY DESIGN	SAMPLE SIZE	AGE OF PARTICIPANTS	DENTITION	EXPOSURE(S)	OUTCOME MEASURES
Larsson, <sup>20</sup> 1975	Sweden	Prospective cohort	3,214	4 y	Primary	Pacifier Digit sucking	X-bite* AOB†
Paunio and Colleagues, <sup>21</sup> 1993	Finland	Cross-sectional nested within a cohort	938	3 y	Primary	NNSB‡	X-bite AOB
Farsi and Salama, <sup>22</sup> 1997	Saudi Arabia	Cross-sectional	583	3-5 y	Primary	Pacifier Digit sucking	OJ§ CR¶ X-bite AOB
Karjalainen and Colleagues, <sup>23</sup> 1999	Finland	Cross-sectional nested within a cohort	148	3 y	Primary	NNSB	OJ X-bite AOB
Viggiano and Colleagues, <sup>24</sup> 2004	Italy	Cross-sectional	1,130	3-5 y	Primary	NNSB	X-bite AOB
Peres and Colleagues, <sup>25</sup> 2007	Brazil	Cross-sectional nested within a cohort	359	6 y	Primary	Pacifier Digit sucking	X-bite AOB
Hebling and Colleagues, <sup>26</sup> 2008	Brazil	Cross-sectional	728	5 y	Primary	Pacifier Digit sucking	X-bite AOB
Heimer and Colleagues, <sup>27</sup> 2008	Brazil	Prospective cohort	287	4-6 y	Primary	NNSB	X-bite AOB
Macena and Colleagues, <sup>28</sup> 2009	Brazil	Cross-sectional	2,750	18-59 mo	Primary	Pacifier Digit sucking	X-bite
Dimberg and Colleagues, <sup>29</sup> 2010	Sweden	Cross-sectional	457	3 y	Primary	Pacifier Digit sucking NNSB	OJ CR X-bite AOB
Mistry and Colleagues, <sup>31</sup> 2010	United Kingdom	Cross-sectional	75	7-13 y	Mixed secondary	Digit sucking	OJ MR# X-bite AOB
Jabbar and Colleagues, <sup>30</sup> 2011	Brazil	Cross-sectional	911	3-6 y	Primary	NNSB	OJ CR
Montaldo and Colleagues, <sup>32</sup> 2011	Italy	Cross-sectional	1,451	7-11 y	Mixed	Pacifier Digit sucking	MR X-bite AOB
Caramex da Silva and Colleagues, <sup>33</sup> 2012	Brazil	Cross-sectional nested within a cohort	153	3-5 y	Primary	Pacifier Digit sucking	CR
dos Santos and Colleagues, <sup>34</sup> 2012	Brazil	Cross-sectional	1,385	5-6 y	Primary	Pacifier Digit sucking	OJ CR X-bite AOB

\* X-bite: Posterior crossbite.  
 † AOB: Anterior open bite.  
 ‡ NNSB: Nonnutritive sucking behavior.  
 § OJ: Overjet.  
 ¶ CR: Canine relationship.  
 # MR: Molar relationship.

provide the highest level of evidence on this topic, confirming the important role of NNSB in the development of specific features of malocclusions, which has been shown previously in the literature.<sup>20-34</sup> The nature of a systematic review allows investigators to pool the results of studies, which, with the increased sample sizes of the populations and the number of “events” within them, provide the best possible estimates of effect, compared with results of individual studies viewed in isolation. This contributes to clinicians’ ability to have greater confidence in the results of meta-analyses, for instance, when

compared with reflecting on the results of individual studies, for which clinicians also need to consider whether the results are generalizable to the population with which they work and whether they can draw any meaningful and practical implications from the results. In this study, we did not aim to report on the appropriate management of malocclusions induced by NNSB, nor on the effectiveness of interventions, as these topics already had been addressed by the authors of a different systematic review and meta-analysis.<sup>15</sup> Our findings of increased risk of developing a class II canine relationship,

posterior crossbite, and anterior open bite related to pacifier sucking versus digit sucking in the primary dentition are consistent with the findings of a longitudinal study whose investigators examined sucking habits in childhood,<sup>35</sup> which suggested that digit sucking is "... a preferable habit to dummy sucking..." However, because of a patient's greater risk of developing an increased overjet that we identified with digit sucking, we are unable to support this statement.

The JBI methodology has a "broader definition of what constitutes research evidence for practice"<sup>36</sup> and is not restricted to considering only a specific type of study design as a source of evidence. This approach allows for evaluation of the literature on the basis of the study design, the methodological quality, and the rigor of evidence, and these are not necessarily related to the strength of the findings.<sup>36</sup> Another important feature of reviews whose investigators use JBI methodology is distinguishing the included studies according to methodological quality. Only high-quality studies are included, as they provide scientifically sound and clinically relevant results in relation to the review question. This in turn gives strength and reliability to the results and, therefore, validity to the meta-analysis.<sup>37</sup> The JBI methodology accounts for different types of study designs by means of using study-specific and standardized critical appraisal and data extraction tools.<sup>18</sup> In this way, the variability in design of the component studies, and their observed effect estimates, are unlikely to contribute to unrealistic or inaccurate estimates of effect. It may be argued that the exclusion of poorly designed studies goes against the spirit of inclusiveness of meta-analysis. Furthermore, analyses of studies that were associated with lower quality methodology could be undertaken and reported separately. However, results emanating from such studies may be questionable and perhaps invalid, owing to bias in their design, conduct, analysis, or a combination of these.<sup>19</sup> Therefore, reporting the results of meta-analyses that include poorly designed studies may be considered problematic, and the usefulness of the results for informing health care providers, researchers, and policy makers is doubtful.

During the course of the review, we encountered across-study heterogeneity in participant characteristics, clinical definitions, and classification of outcome measures. Many of the studies we included were substudies with participant characteristics that had been determined by the broader aims and objectives of a parent study. The World Health Organization recommends the index ages of 5 and 12 years for population oral health surveys<sup>38</sup>; however, not all study investigators adopt these recommendations. To circumvent age-related heterogeneity, we investigated the different exposures and outcomes with respect to the dentition that was present.

Investigators have varying definitions of increased overjet. Two studies defined this as greater than 2

millimeters,<sup>30,34</sup> another considered values greater than 3 mm,<sup>23</sup> whereas others accepted 4 mm as the critical value.<sup>22,29</sup> Those study investigators who adopted a lower threshold may have overestimated the prevalence compared with the study investigators who adopted a higher threshold, and vice versa. Given the variability, we were able to perform only a single meta-analysis on this outcome, prioritizing studies whose investigators had reported the highest threshold. Orthodontic treatment, in the context of where it is rationed or subsidized by the state, is offered to those whose overjet is stratified as being severe and, therefore, in great or very great need for treatment.<sup>12</sup> Heterogeneity of this particular clinical definition likely stems from differences in identifying when an overjet should be considered to be "increased." Authors of an internationally respected orthodontic textbook stated that normal overjet was 2 to 3 mm,<sup>7</sup> leading to the inference that values greater than 3 mm were increased. The Index of Orthodontic Treatment Need,<sup>12</sup> used extensively in the United Kingdom as well as in other countries, distinguishes any overjet greater than 3.5 mm as being increased.<sup>12</sup> Study investigators who adopted 2 mm as being the "increased" reference point cited an article published in 1969<sup>39</sup> about a nested study whose investigators used a sample that was admittedly not representative of the target population and in which the outcomes of only "white" children were preferentially reported.<sup>30,34</sup>

We also found differences in the classification of outcome measures, specifically sagittal relationships. Most study investigators used the classification by Foster and Hamilton.<sup>39</sup> With a single exception, all studies using this classification were Brazilian, with most authors having a dental public health background. We suggest that Angle's<sup>40</sup> classification be the preferred outcome measure because it is widely recognized and used internationally by dentists, orthodontists, and other clinical dental specialists, who, for the most part, are responsible for identifying, intercepting, or treating malocclusions.

Despite limiting meta-analyses to be used only when there were a sufficient number of studies whose populations were homogenous in terms of participant characteristics, exposures, and outcomes, we encountered moderate statistical heterogeneity (50-90%) in most of the results of the meta-analyses. Methodological differences, such as categorization of participants, differences in the sample sizes and number of events, as well as individual variation in the expression of malocclusions, are possible explanations. Some participants may have engaged in both pacifier and digit sucking. Rather than being allocated into a unique group, they may have been considered according to the predominant or most recent habit, or even double-counted in both the pacifier-sucking and digit-sucking groups. We attempted to find explanations for the heterogeneity, but a lack of sufficient information prevented subgroup analyses; not all authors



TABLE 2

### Summary of meta-analyses\* comparing different exposures against specific malocclusion features in the primary and mixed dentitions.

DENTITION	EXPOSURE	INCREASED OVERJET		
		No. of Studies	Pooled Risk Ratio (95% CI <sup>†</sup> )	P Value
Primary	NNSB <sup>‡</sup> versus no NNSB	Insufficient number of studies for meta-analysis		
	Pacifier versus digit sucking	2	0.68 (0.36-1.29)	.24
	Pacifier versus no pacifier sucking habit	Insufficient number of studies for meta-analysis		
	Digit versus no digit sucking habit	Insufficient number of studies for meta-analysis		
Mixed	Digit versus no sucking habit	Insufficient number of studies for meta-analysis		

\* All meta-analyses were conducted using the random-effects model.

† CI: Confidence interval.

‡ NNSB: Nonnutritive sucking behavior.

§ Results of meta-analyses that were conducted with the fixed-effects model in addition to the random-effects model.

¶ Please note that these values represent class II molar relationship rather than class II canine relationship.

we approached for clarification replied. We nonetheless endeavored to avoid the problems presented by statistical heterogeneity by applying a random-effects model in all meta-analyses, supplemented by applying a fixed-effects model when heterogeneity was low.

In light of the across-study heterogeneity, which can hamper the conduct of meta-analyses, we recommend that investigators adopt uniform, standard, and widely accepted definitions and classifications when measuring and reporting orthodontic outcome measures. This facilitates precise communication between clinicians and researchers. Also, we urge researchers to allocate study participants to exposure-specific groups in future studies, which may help investigators using meta-analyses to reach clearer directions of effect, rather than identifying inconclusive results or reporting an absence of differences. Adoption of these recommendations can help achieve across-study homogeneity, which can ensure validity of the overall conclusions of reviews and meta-analyses, so that the clinical interpretations are not misleading and can be relied on to inform the decision-making process. The authors of a seminal article<sup>41</sup> written more than 40 years ago raised the importance of this issue.

Some of the component studies had inconsistent findings when compared with the results of the meta-analyses. dos Santos and colleagues<sup>34</sup> found pacifier sucking to be favorable for anterior open bite in the primary dentition compared with digit sucking, as did Farsi and Salama,<sup>22</sup> who also found that pacifier sucking favored class II canine relationships and posterior crossbite. Random error and small-study effect may explain these differences. Opposing results concerning the sagittal relationship in the mixed dentition also was evident.<sup>31,32</sup> Confounding factors, such as the early loss of primary molars allowing mesial drift of secondary molars into the leeway space to establish a class II sagittal

relationship, might be responsible, and we suggest that investigators consider and adjust for these factors in future studies. We were unable to assess publication bias in this review as none of our meta-analyses had more than 10 component studies.

NNSB is 1 of several variables influencing malocclusions. Despite study investigators' attempts to avoid or minimize bias by means of controlling for confounders or mediators, such as neonatal characteristics of the child, socioeconomic status of the child's household, dental behaviors, and infant feeding methods, individual variation nonetheless may exert sufficient influence to render any attempt to demonstrate the existence or significance of differences difficult.<sup>42</sup> Some of our results did not reach statistical significance; this should not be misinterpreted as evidence of no effect or difference. Statistical significance, often represented by a *P* value, is related to sample size and, therefore, could be improved by increasing the number of study participants.<sup>43</sup> It is also important to reflect that statistical significance does not necessarily equal clinical significance, the latter referring to "whether the [intervention] makes a real (for example, genuine, palpable, practical, noticeable) difference in the everyday life" of people.<sup>44</sup> Aside from validated qualitative research methods that can help health care professionals better appreciate the impact of different features of malocclusions on study participants, investigators also may determine clinical significance by examining the effect size, such as the relative risk, which helps "estimate the magnitude of effect or association between 2 or more variables."<sup>45</sup> Investigators should consider effect size in relation to the size of the 95% CI (influenced by sample size and number of events) and its upper and lower boundaries, because the effect size may not be accurate in the presence of statistical heterogeneity. We found that the upper and lower boundaries of



TABLE 2 (CONTINUED)

CLASS II CANINE RELATIONSHIP			POSTERIOR CROSSBITE			ANTERIOR OPEN BITE		
No. of Studies	Pooled Risk Ratio (95% CI)	P Value	No. of Studies	Pooled Risk Ratio (95% CI)	P Value	No. of Studies	Pooled Risk Ratio (95% CI)	P Value
2	5.27 (0.72-38.39)	.10	5	2.32 (1.39-3.88)	.001	5	10.33 (5.29-20.15)	< .00001
3	1.80 (0.61-5.32)	.29	7	1.42 (1.18-1.70)	.0001	6	1.15 (0.87-1.53)	.32
				1.45 <sup>§</sup> (1.21-1.74)	< .0001 <sup>§</sup>			
Insufficient number of studies for meta-analysis			3	2.53 (1.68-3.81)	< .00001	3	3.03 (0.95-9.72)	.06
Insufficient number of studies for meta-analysis			3	1.01 (0.58-1.77)	.96	3	1.42 (1.10-1.84)	.007
2 <sup>¶</sup>	1.09 (0.63-1.90) <sup>¶</sup>	.76 <sup>¶</sup>	2	2.06 (0.95-4.48)	.07	2	6.37 (1.17-34.86)	.03
							4.11 <sup>§</sup> (3.31-5.10)	< .00001 <sup>§</sup>

the 95% CIs of nearly one-half of our meta-analyses clearly favored an exposure or a control over the other. In other words, there was consistency in the direction of the effect. Such findings help health care professionals give appropriate advice to patients and their caregivers or families. For example, the highest effect size estimate in our systematic review related to NNSB and anterior open bite, which had a moderate degree of statistical heterogeneity (Table 2, eFigure 1). As both boundaries of the CI favored no sucking habit, the correct clinical advice would be to refrain from NNSB in the primary dentition so as to avoid the development of an anterior open bite.

The results of our systematic review confirm the association between NNSB and malocclusions and offer a higher level of evidence than was previously available. The investigators of future systematic reviews and meta-analyses on this topic may benefit from the inclusion of prospective and high-quality research on the effects of NNSB on malocclusions that are scarce. Although infants may determine whether they will suck their digits, parents and caregivers have the right to choose whether to introduce a pacifier. It is important that they are properly informed about the facts to make the most appropriate decisions.

## CONCLUSIONS

In the primary dentition, NNSB should be discouraged to avoid the development of malocclusions. Pacifier and digit sucking both present varying risks of developing features of malocclusions. When comparing pacifier with digit sucking, children are less likely to have an increased overjet if they use a pacifier, however, they are at greater risk of developing other malocclusions such as a class II canine relationship and posterior crossbite. In the mixed dentition, a history of digit sucking carries an increased risk of developing posterior crossbite and anterior open bite. Longer duration of NNSB is associated with increased risk of developing a malocclusion. ■

## SUPPLEMENTAL DATA

Supplemental data related to this article can be found at <http://dx.doi.org/10.1016/j.adaj.2016.08.018>.

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eTABLE

Electronic database search strategies.				
SEARCH TERM ID/STEP	MEDLINE (OVID)	EMBASE (OVID)	SCOPUS	CINAHL* (EBSCO)
1	Sucking Behavior/	Sucking behavior.mp	(( ( TITLE-ABS-KEY ( sucking behavior ) OR TITLE-ABS-KEY ( suck\$ AND ( habit\$ OR behav\$ OR routine\$ ) ) OR TITLE-ABS-KEY ( non nutritive suck\$ OR non-nutritive suck\$ ) ) ) AND ( ( TITLE-ABS-KEY ( pacifiers ) OR TITLE-ABS-KEY ( fingersucking ) OR TITLE-ABS-KEY ( pacifier\$ OR digit\$ OR dummy OR dummies OR soother\$ OR blanket\$ OR finger\$ OR thumb\$ ) ) ) ) AND ( ( TITLE-ABS-KEY ( malocclusion ) OR TITLE-ABS-KEY ( malocclusion, angle class i ) OR TITLE-ABS-KEY ( malocclusion, angle class ii ) OR TITLE-ABS-KEY ( malocclusion, angle class iii ) OR TITLE-ABS-KEY ( dental occlusion ) OR TITLE-ABS-KEY ( tooth occlusion ) OR TITLE-ABS-KEY ( occlusion ) OR TITLE-ABS-KEY ( distocclusion OR disto-occlusion OR distocclusion ) OR TITLE-ABS-KEY ( mesiocclusion OR mesio-occlusion OR mesiocclusion ) AND TITLE-ABS-KEY ( canine relationship ) AND TITLE-ABS-KEY ( molar relationship ) ) ) OR ( ( TITLE-ABS-KEY ( retrognathia ) OR TITLE-ABS-KEY ( prognathism ) ) ) OR ( ( TITLE-ABS-KEY ( open bite ) OR TITLE-ABS-KEY ( anterior open bite OR asymmetric anterior open bite OR symmetric anterior open bite ) ) ) OR ( ( TITLE-ABS-KEY ( overbite ) OR TITLE-ABS-KEY ( overjet OR crossbite OR deep bite ) OR TITLE-ABS-KEY ( centerline discrepancy ) OR TITLE-ABS-KEY ( Index of orthodontic treatment needs ) OR TITLE-ABS-KEY ( dental arch ) OR TITLE-ABS-KEY ( palate ) OR TITLE-ABS-KEY ( growth, development AND ageing ) ) ) ) AND ( LIMIT-TO ( EXACTKEYWORD , "Human" ) ) )	MH "Sucking Behavior"
2	(suck\$ and (habit\$ or behav\$ or routine\$)).mp	(suck* and (habit* or behave* or routine*)).mp		( ( suck* and habit* ) ) OR ( ( suck* and behav* ) ) OR ( ( suck* and routine* ) )
3	("non nutritive suck\$" or "non-nutritive suck\$" or "nonnutritive suck\$").mp	("non nutritive suck*" or "non-nutritive suck*" or "nonnutritive suck*").mp		"Non nutritive suck*" OR "nonnutritive suck*" OR "non-nutritive suck*"
4	1 or 2 or 3	1 or 2 or 3		MH "Pacifiers"
5	Pacifiers/	pacifier.mp		pacifier* OR digit* OR dummy OR dummies OR soother* OR blanket* OR finger* OR thumb*
6	Fingersucking/	fingersucking.mp		S1 or S2 or S3
7	(pacifier\$ or digit\$ or dummy or dummies or soother\$ or blanket\$ or finger\$ or thumb\$).mp	(pacifier* or digit* or dummy or dummies or soother* or blanket* or finger* or thumb*).mp		S4 or S5
8	5 or 6 or 7	5 or 6 or 7		S6 and S7
9	4 and 8	4 and 8		MH "Malocclusion" OR "Malocclusion, Angle Class I" OR "Malocclusion, Angle Class II" OR "Malocclusion, Angle Class III"
10	Malocclusion/ or Malocclusion, Angle Class I/ or Malocclusion, Angle Class II/ or Malocclusion, Angle Class III/	Malocclusion.mp		dental occlusion OR tooth occlusion
11	Dental occlusion/ or tooth occlusion.mp	Malocclusion, Angle Class I.mp		occlusion
12	occlusion.mp	Malocclusion, Angle Class II.mp		distocclusion OR disto-occlusion OR distocclusion
13	(distocclusion or disto-occlusion or distocclusion).mp	Malocclusion, Angle Class III.mp		mesiocclusion OR mesio-occlusion OR mesiocclusion
14	(mesiocclusion or mesio-occlusion or mesiocclusion).mp	10 or 11 or 12 or 13		canine relationship
15	canine relationship.mp	((dental or tooth) and occlusion).mp		molar relationship
16	molar relationship.mp	occlusion.mp		S9 or S10 or S11 or S12 or S13 or S14 or S15
17	11 or 12 or 13 or 14 or 15 or 16	15 or 16		retrognathia
18	Retrognathia/	(distocclusion* or disto-occlusion* or distocclusion*).mp		prognathism
19	Prognathism	(mesiocclusion* or mesio-occlusion* or mesiocclusion*).mp		S17 or S18
20	18 or 19	retrognath*.mp		open bite
21	Open Bite/	prognath*.mp		anterior open bite OR asymmetric anterior open bite OR symmetric anterior open bite
22	(Anterior open bite or asymmetric anterior open bite or symmetric anterior open bite).mp	((canine or molar) and relationship).mp		S20 or S21
23	21 or 22	18 or 19 or 20 or 21 or 22		overbite
24	Overbite/	(posterior adj3 occlusion*).mp		overjet or crossbite or deep bite
25	(Overjet or crossbite or deep bite).mp	(anterior adj3 occlusion).mp		centerline discrepancy

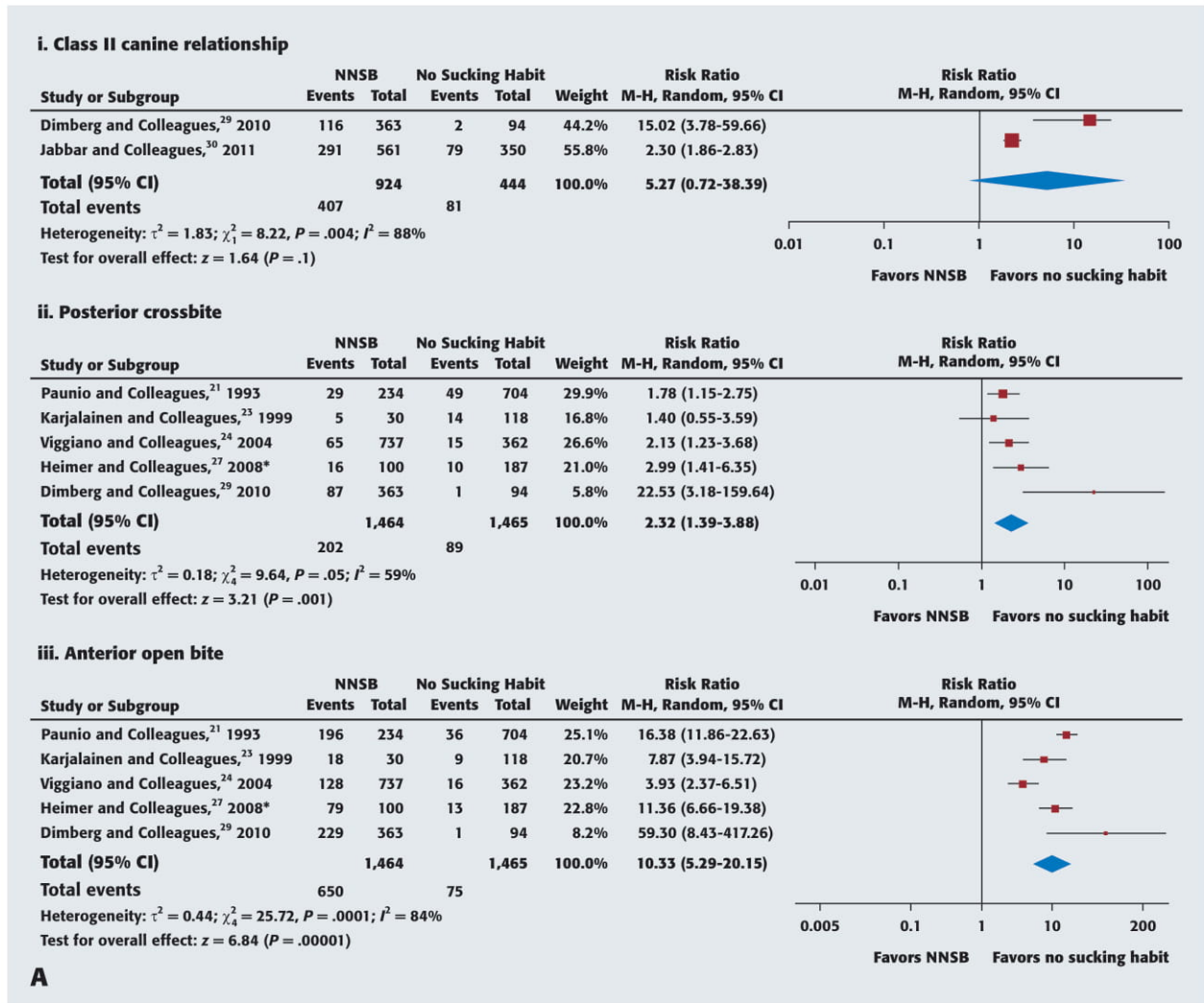
\* CINAHL: Cumulative Index to Nursing and Allied Health Literature.



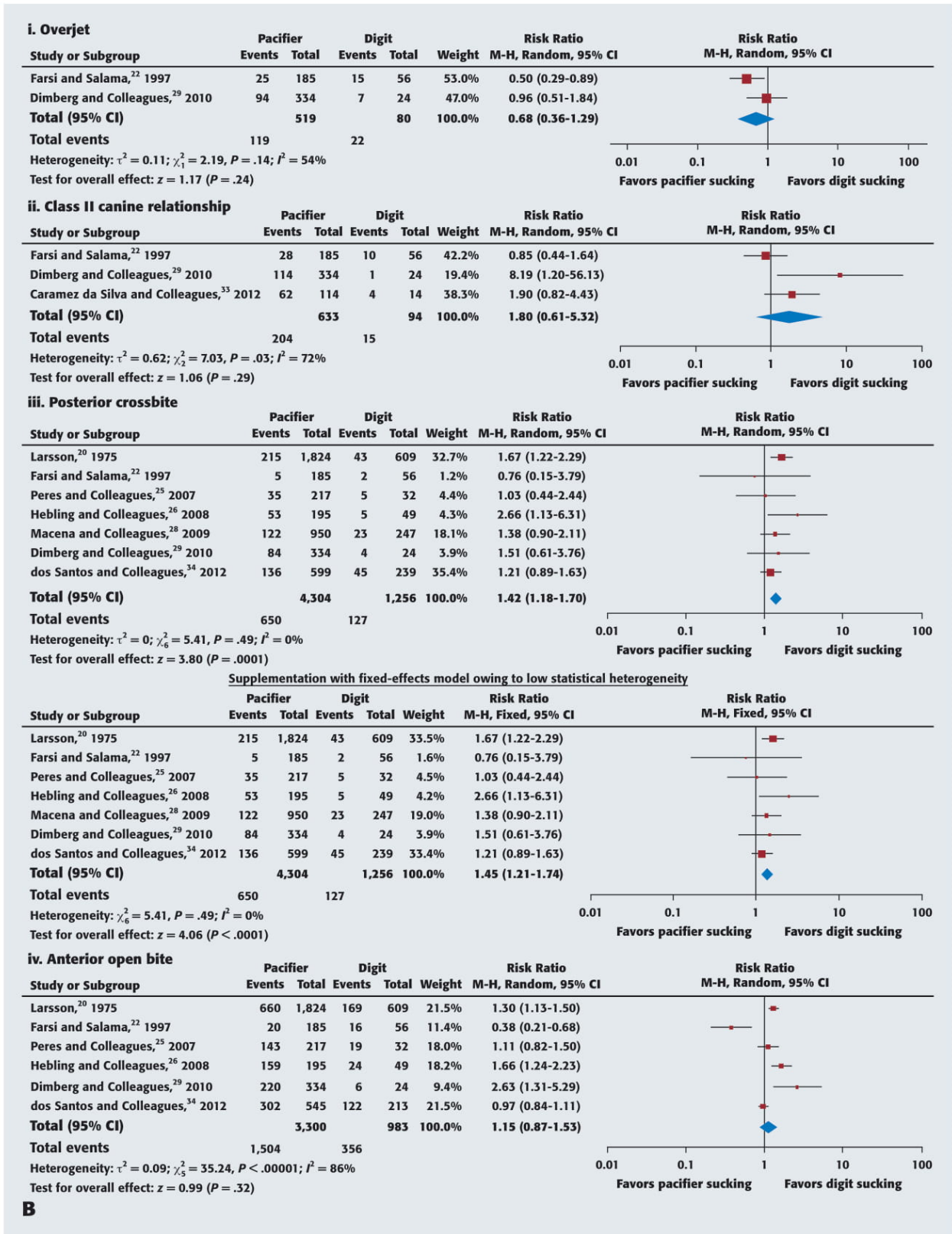
| ORIGINAL CONTRIBUTIONS |

**eTABLE (CONTINUED)**

SEARCH TERM ID/STEP	MEDLINE (OVID)	EMBASE (OVID)	SCOPUS	CINAHL* (EBSCO)
26	centerline discrepancy.mp	(overjet* or over jet* or over-jet*).mp		Index of Orthodontic Treatment Need
27	"Index of Orthodontic Treatment Need"/	(crossbite* or cross bite* or cross-bite*).mp		dental arch
28	Dental Arch/	(deep bite* or deepbite* or deep-bite*).mp		palate
29	Palate/	(overbite* or over bite* or over-bite*).mp		growth, development and aging
30	(Growth, development and aging).mp	(open bite* or openbite* or open-bite*).mp		S16 or S19 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29
31	10 or 17 or 20 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30	(anterior open bite* or anterior openbite* or anterior open-bite*).mp		S8 and S30
32	9 and 31	((asymmetric or symmetric) and anterior).mp		
33	limit 32 to humans	30 and 32		
34		Index of Orthodontic Treatment Need.mp		
35		dental arch*.mp		
36		palate*.mp		
37		(growth, development and aging).mp		
38		14 or 17 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 31 or 33 or 34 or 35 or 36 or 37 or 38		
39		9 and 38		
40		limit 39 to human		
<b>Total Records</b>	<b>246</b>	<b>210</b>	<b>91</b>	<b>22</b>



**eFigure 1.** Forest plots of meta-analyses investigating the effects of nonnutritive sucking behavior (NNSB) on malocclusion outcomes in the primary dentitions. **A.** NNSB versus no NNSB. **B.** Pacifier sucking versus digit sucking. **C.** Pacifier sucking habit versus no pacifier sucking habit. **D.** Digit sucking habit versus no digit sucking habit. \*: Data from initial examination in 2002 used in this analysis. CI: Confidence interval. M-H: Mantel-Haenszel test.



eFigure 1. Continued

**i. Posterior crossbite**



**ii. Anterior open bite**



**C**

**i. Posterior crossbite**



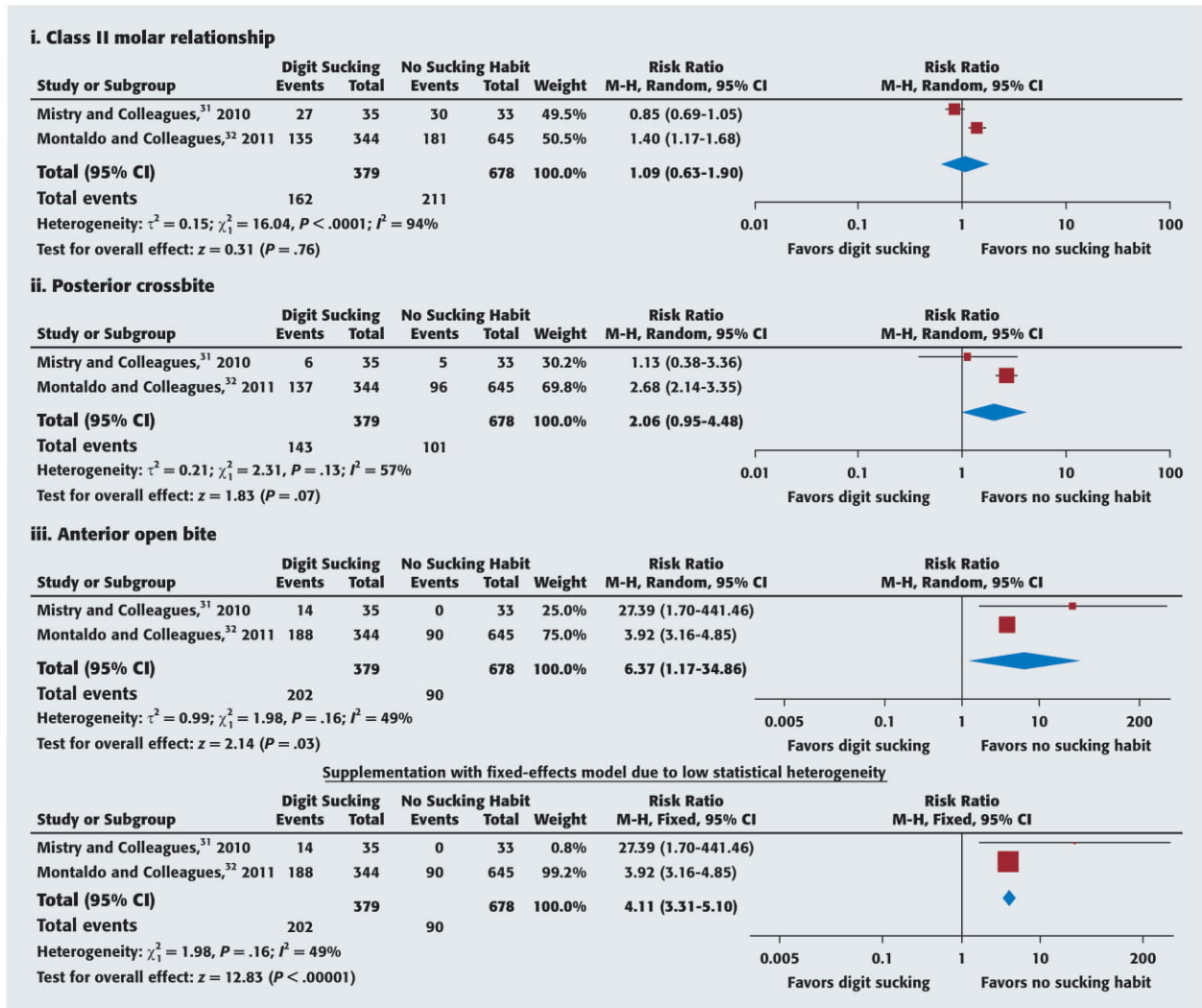
**ii. Anterior open bite**



**D**

eFigure 1. Continued





**eFigure 2.** Forest plots of meta-analyses investigating the effects of nonnutritive sucking behavior (NNSB) on malocclusion outcomes in mixed dentitions.

## RESEARCH PUBLICATION 3

### ***Effect of breastfeeding on different features of malocclusions in the primary dentition: a systematic review protocol.***

Doğramacı EJ, Rossi-Fedele G, Dreyer CW.

JBI Database System Rev Implement Rep. 2017;15(7):1856-1866.

DOI: [10.11124/JBISRIR-2016-003069](https://doi.org/10.11124/JBISRIR-2016-003069)

PMID: 28708750

### **Contextual statement**

The next systematic review and meta-analysis focussed on the association of breastfeeding and malocclusions, despite a systematic review having been published at the time of conceptualisation of the idea for this study.<sup>28</sup> There are, however, important limitations of heterogeneity that are clearly observed in that study, which restrict generalisability of its findings. These are: 1. All malocclusions were pooled into a single generic group labelled “non-specific malocclusion”, thus treating all types of malocclusions as a single entity. From a clinical standpoint, this has a very narrow scope for translation. Clinicians, specifically dentists and orthodontists, distinguish the nature of malocclusions in a patient, identifying all the different features present, as well as the severity of each component, since not all malocclusion features have equal severity or need for treatment.<sup>29</sup> Furthermore, such distinction also helps in one’s understanding of the aetiology of the clinical presentation within each dentition stage so that appropriate treatment or management strategies can be devised, based on the clinical diagnosis. 2. All study participants, regardless of age or dentition, were pooled into the same meta-

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<sup>28</sup> Peres KG, Cascaes AM, Nascimento CG, Victora CG. Effect of breastfeeding on malocclusions: a systematic review and meta-analysis. *Acta Pediatr.* 2015; 104: 54-61.

<sup>29</sup> Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. *Eur J Orthod.* 1989; 11: 309-320.

analyses. This is a type of selection bias and is problematic since heterogeneity of participant characteristics and study methodology can produce imprecise estimates of effect or may misrepresent the true effect size. Furthermore, results drawn from participants with dissimilar characteristics cannot be clinically translated, indiscriminately, to every patient. This would be erroneous.

Fewer than 50% of children breastfeed up to the age of two years,<sup>30</sup> and the primary dentition is only fully established by the age of three years,<sup>31</sup> therefore, any effects on occlusal development could be expected to be observed only for the period that breastfeeding occurs. In other words, young children in the primary dentition are closer to the period in life where they may have been exposed to breastfeeding, therefore any malocclusions as a result of sub-optimal breastfeeding are more likely to be distinguishable in the primary dentition compared to the mixed or secondary dentitions. With increasing age, the effect of genetics (e.g. hypodontia, canine impaction) or other environmental factors (e.g. trauma, dental caries) can exert an adverse effect on normal dental development. Consequently, strict delineation of malocclusion aetiology, particularly between different environmental factors, can become difficult. Hence, it was felt that in order to understand the association of breastfeeding on malocclusion development, a systematic review focussed solely on the primary dentition, and investigating different exposures of breastfeeding and its association with specific types of malocclusions, would provide a more accurate estimate of effect.

Although the rationale for conducting this systematic review was compelling, it was decided that it would be favourable to have the study protocol reviewed by the JBI whose methodology was also chosen for this study. This would ensure that the proposed

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<sup>30</sup> UNICEF. UNICEF Data: Monitoring the situation of Children and Women. Infant and young child feeding. Available at: <http://data.unicef.org/nutrition/iycf.html>

<sup>31</sup> Berkovitz BK, Holland GR, Moxham BL. Color atlas and textbook of oral Anatomy, Histology and Embryology. 2<sup>nd</sup> ed. St Louis: MO: Mosby; 1992.

methodology was feasible and acceptable by them, *a priori*. Also, having external validation by the JBI through publication in their journal would give strength to the methodological process followed, which would help allay any doubts about the research question, methodology or interpretation of results during the peer-review process for publication or beyond.

The title of the systematic review was registered *a priori*, and the protocol submitted for peer review in July 2016. It was accepted for publication in November 2016.



## Statement of authorship

Title of Paper	Effect of breastfeeding on different features of malocclusions in the primary dentition: a systematic review protocol.
Publication Status	Published
Publication Details	JBI Database System Rev Implement Rep. 2017;15(7):1856-1866.

## Principal Author

Name of Principal Author (Candidate)	Esma J Dođramacı		
Contribution to the Paper	Conceptualized and designed the protocol, wrote and critically reviewed the manuscript. Corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	26 July 2016

## Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

- i. the candidate's stated contribution to the publication is accurate (as detailed above);
- ii. permission is granted for the candidate to include the publication in the thesis; and
- iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Giampiero Rossi-Fedele		
Contribution to the Paper	Critically reviewed and revised, and approved the final manuscript as submitted.		
Signature		Date	26 July 2016

Name of Co-Author	Craig W Dreyer		
Contribution to the Paper	Critically reviewed and approved the final manuscript (protocol) as submitted.		
Signature	Please refer to statement of authorship of publication 4 on page 65.		

# Effect of breastfeeding on different features of malocclusions in the primary dentition: a systematic review protocol

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**Review question/objective:** The objective of this review of association (etiology) is to identify the association of breastfeeding with the development of different features of malocclusions in the primary dentition. The specific review questions are: What is the risk of developing different features of malocclusions in the primary dentition:

- In those who have been breastfed compared to those who have not been breastfed?
- In those who have been exclusively breastfed compared to those who have not been exclusively breastfed?
- In those who have been breastfed for a long duration compared to those who have been breastfed for a short duration?

**Keywords** Breastfeeding; malocclusion; orthodontics; primary dentition; systematic review

*JBI Database System Rev Implement Rep* 2017; 15(7):1856–1866.

## Background

The benefits of breastfeeding for infants and nursing women are well known, and this feeding method is actively encouraged through global strategies to promote and protect this practice.<sup>1</sup> Recently, breastfeeding has been reported to afford protection against the development of malocclusions,<sup>2</sup> defined as “[a] deviation in intramaxillary and/or intermaxillary relations of teeth from normal occlusion [contact between teeth]”.<sup>3(p.29)</sup> Study participants who were breastfed were found to be 70% less likely to develop a malocclusion compared with those who were never breastfed or were breastfed for short periods.<sup>2</sup>

Malocclusions are of multifactorial etiology and individuals usually present with various features of malocclusion rather than a single isolated feature. However, certain aspects of malocclusions can predispose individuals to significant risks, and, therefore, timely identification and interception is imperative. An appreciation of whether genetic or environmental factors, or an interaction of both, contribute to the different features of presenting

malocclusions helps in the formulation of appropriate treatment plans. For example, an impacted tooth is one “which is unable to erupt as a result of either insufficient space in the dental arch, ectopic position of the tooth in relation to where it would normally be expected, or the presence of an obstruction such as a retained tooth, supernumerary or scar tissue”.<sup>4(p.212)</sup> Genetic factors are acknowledged as playing an important role in the etiology of impaction of secondary maxillary canine teeth. As genetic factors are currently not amenable to modification, identification and prevention of impaction are important in order to avoid resorption,<sup>5</sup> a significant risk that can potentially compromise the long-term prognosis of the affected teeth. Anterior open bite (“lack of [anterior] tooth contact in an occluding position”),<sup>3(p.32)</sup> and increased overjet (“horizontal projection of maxillary teeth beyond the mandibular anterior teeth”)<sup>3(p.33)</sup> are strongly associated with non-nutritive sucking behaviors,<sup>6,7</sup> and their presence carries an increased risk of traumatic dental injury.<sup>6,8</sup> Incisor relationships that deviate from normal elicit unfavorable social responses.<sup>9</sup> Furthermore, features of malocclusions can present with varying severities which are associated with different levels of orthodontic treatment need that can be stratified against reliable and validated indices such as the Index of Orthodontic Treatment Need.<sup>10</sup>

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There is no conflict of interest in this project.

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Prevention of malocclusions during growth and development helps avert the possibility of orthodontic treatment, which has substantial implications for patients and their carers/families (absenteeism from school or work, and travel to attend appointments), health service providers (rationalization of limited resources for those most needy) and society as a whole.<sup>11,12</sup> Though the investigators of a recent review reported breastfeeding having a protective effect against the development of malocclusions,<sup>2</sup> the included studies comprised study participants across many age groups in the primary, mixed or secondary dentition who were treated as a single group during data analysis. As no sub-group analysis was performed according to type of dentition, it is possible that heterogeneity of the included studies may have inadvertently allowed conclusions to be drawn that might not be dentition specific.

The World Health Organization suggests that the index age for oral assessment of the primary and secondary dentition is five and 12 years, respectively;<sup>13</sup> many oral health epidemiological studies subsequently use these index ages to delineate their subject characteristics. The significance of limiting a study to the primary dentition is the closeness of the participant's age to the period when breastfeeding occurred or might still be occurring, when compared to participants in the mixed or secondary dentitions. Any associations established in the primary dentition may, therefore, be expected to be more accurate compared to studies whose participants are in the mixed and/or secondary dentition. This is because participants in more developed dentition stages are older and a greater interval has elapsed between oral examination and when they breastfed. In the intervening period, it is likely that confounding factors have influenced the dentition and while most can be controlled for during statistical analysis, this is not always possible for all. Consequently, evaluation of any associations between breastfeeding and malocclusions in either the mixed or secondary dentition are expected to be different to those elucidated in studies limited to the primary dentition. It would also be imprecise to apply the findings from more developed dentition stages to the primary dentition. Interestingly, in line with this view, a systematic review is currently being undertaken to investigate the relationship between breastfeeding and malocclusion in the mixed

dentition.<sup>14</sup> This was identified following a search of the *JBI Database of Systematic Reviews and Implementation Reports*, Cochrane and PROSPERO databases.

As the protective effect that breastfeeding affords against the development of particular features of malocclusions, limited to the primary dentition, remains unclear and, to our knowledge, has not previously been studied, the aim of this systematic review is to investigate whether breastfeeding decreases the risk of different features of malocclusions in the primary dentition.

### Inclusion criteria

#### *Population (types of participants)*

Healthy human participants (not reported in the study as having been diagnosed presently or in the past with a disease, condition and impairment) of any age and in the primary dentition (teeth that develop and erupt first in order of time and are normally shed and replaced by permanent [succedaneous] teeth),<sup>3</sup> with a history of any type of breastfeeding and no previous orthodontic or related surgical treatment, will be considered for inclusion. Studies of participants having a cleft lip and/or palate, or other craniofacial deformity, any syndrome or a history of maxillofacial trauma will be excluded, as will studies that have participants in other dentition stages, such as the mixed dentition.<sup>3</sup>

#### *Exposure of interest*

Studies will be considered in relation to the type of breastfeeding exposure that we will categorize as follows:

- Breastfeeding versus no breastfeeding: studies investigating participants who have ever breastfed (from the breast) against those who have never breastfed.
- Exclusive versus non-exclusive breastfeeding: studies that investigate participants who have a history of exclusive breastfeeding (all definitions of exclusive breastfeeding as provided by the study authors) compared with those who do not have any history of exclusive breastfeeding. Exclusivity will be considered independent of its duration.
- Longer ( $\geq 12$  months) versus shorter ( $< 12$  months) duration of breastfeeding (from the breast).



It is possible that studies may fall into more than one category. In this instance, the studies will be grouped into multiple categories and meta-analyses will be conducted only if there are sufficient numbers of homogenous studies within each category. If any studies are retrieved that include participants who have been breastfed and bottle fed (breast milk, formula or both), the data will be analyzed, where possible, under any applicable categories. Any studies that fulfill other aspects of the inclusion criteria but which cannot be categorized within our designations of exposure of interest will not be considered for inclusion.

### Outcomes

The current review will consider studies that report specific features of malocclusions as outcome measures, which are all dichotomous, or will be dichotomized. These will include but are not limited to: overjet (“horizontal projection of maxillary teeth beyond the mandibular anterior teeth, usually measured parallel to the occlusal plane”),<sup>3(p.33)</sup> anterior open bite (“lack of tooth contact in an occluding position”),<sup>3(p.32)</sup> crossbite (“an abnormal relationship of a tooth or teeth to the opposing teeth, in which normal buccolingual or labiolingual relationships are reversed”),<sup>3(p.14)</sup> and sagittal relationship of canine/molar teeth. These outcomes should be recorded following clinical examination.

### Types of studies

The current review will consider, prospective and retrospective cohort (longitudinal) studies, case-control studies and analytical cross-sectional studies for inclusion. Reviews, text and opinion based articles, conference abstracts and descriptive studies (such as case reports, case-series and cross-sectional studies) will not be included.

### Search strategy

The search strategy aims to find published studies. A three-step search strategy will be utilized in this review. An initial limited search of MEDLINE and Scopus will be undertaken followed by analysis of the text words [tw] contained in the title and abstract and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases. Third, a citation search of the reference lists of all included articles will also be

undertaken. There will be no restrictions placed on the language of publication or exclusion of articles based on publication year.

The electronic bibliographic databases to be searched will include the following:

- MEDLINE via OVID
- Embase via OVID
- Scopus
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO.

Initial keywords to be used will be as follows:

#### Exposure:

Breastfeeding [tw]; or breast feeding [tw]; or feeding, breast [tw]; or milk, human [tw].

AND

#### Outcome:

Malocclusion [tw] or overjet [tw] or openbite [tw] or overbite [tw] or crossbite [tw] or crowded teeth [tw] or deep bite [tw] or Malocclusion, Angle Class I[tw]/II[tw]/III[tw] or canine relationship [tw] or molar relationship [tw] or Index of Orthodontic Treatment Need [tw] or retrognathism [tw] or prognathism [tw] or class II [tw] or class 2 [tw] or class III [tw] or class 3 [tw] or distocclusion [tw] or disto-occlusion [tw] or distocclusion [tw] or mesiocclusion [tw] or mesio-occlusion [tw] or mesiocclusion [tw].

After the exclusion of duplicates, two reviewers will screen the titles, abstracts of studies independently in order to identify potentially relevant articles. Quantitative papers selected for retrieval will be assessed by the two reviewers for methodological validity prior to inclusion in the review using standardized critical appraisal instruments from the JBI Meta Analysis of Statistics Assessment and Review Instrument (JBI-MASARI, Adelaide, South Australia, Australia) (Appendix I).

### Assessment of methodological quality

Those papers determined to be of poor quality studies (<8 in any JBI Critical Appraisal Instrument) will not be included in the review proper. Comparable reviews in this subject area, using the JBI methodology, have used similar cutoff points.<sup>2,7</sup> Any disagreements that arise between the reviewers will be resolved through discussion until a decision is reached by consensus; assistance will be sought from a third reviewer as required.

### Data extraction

Data will be extracted from papers included in the review using the standardized data extraction tool from JBI-MAStARI (Appendix II). The data extracted will include the following information: author(s), year of publication, setting (country/countries where study took place), specific details about the exposures, populations (sample size, characteristics of subjects), study method and outcomes of significance to the review question. The authors of the included studies will be contacted if important data that is relevant to the review is missing from the published papers.

### Data synthesis

Quantitative papers, where possible, will be pooled in statistical meta-analysis using the JBI-MAStARI software. All results will be subject to double data entry to minimize the risk of error during data entry. Effect sizes of dichotomous data, expressed as relative risks and/or odds ratio and their associated 95% confidence intervals, will be calculated for analysis. Heterogeneity will be assessed statistically using the standard Chi-square test and, if found, will be investigated prior to any further analysis. Where statistical pooling is not possible, the findings will be presented in narrative form. Forest plots may be used to aid in the presentation of results.

### Acknowledgements

The current systematic review will be undertaken as partial fulfillment toward attainment of Doctor of Philosophy in Dentistry at The University of Adelaide. The first author acknowledges support through an Australian Government Research Training Program Scholarship.

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**Appendix I: Appraisal instruments**

**MAStARI appraisal instruments**

**JBI Critical Appraisal Checklist for Randomised Control / Pseudo-randomised Trial**

Reviewer ..... Date .....

Author ..... Year ..... Record Number .....

	Yes	No	Unclear	Not Applicable
1. Was the assignment to treatment groups truly random?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were participants blinded to treatment allocation?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Was allocation to treatment groups concealed from the allocator?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Were those assessing outcomes blind to the treatment allocation?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Were the control and treatment groups comparable at entry?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were groups treated identically other than for the named interventions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in the same way for all groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal:    Include                   Exclude                   Seek further info.

Comments (Including reason for exclusion)

\_\_\_\_\_

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\_\_\_\_\_

**JBI Critical Appraisal Checklist for Descriptive / Case Series**

Reviewer ..... Date .....

Author ..... Year ..... Record Number .....

	Yes	No	Unclear	Not Applicable
1. Was study based on a random or pseudo-random sample?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were the criteria for inclusion in the sample clearly defined?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Were confounding factors identified and strategies to deal with them stated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were outcomes assessed using objective criteria?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. If comparisons are being made, was there sufficient descriptions of the groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Was follow up carried out over a sufficient time period?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal:      Include                   Exclude                   Seek further info

Comments (Including reason for exclusion)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**JBI Critical Appraisal Checklist for Comparable Cohort/ Case Control**

Reviewer ..... Date .....

Author ..... Year ..... Record Number .....

	Yes	No	Unclear	Not Applicable
1. Is sample representative of patients in the population as a whole?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Are the patients at a similar point in the course of their condition/illness?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Has bias been minimised in relation to selection of cases and of controls?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Are confounding factors identified and strategies to deal with them stated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Are outcomes assessed using objective criteria?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Was follow up carried out over a sufficient time period?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal:    Include                     Exclude                     Seek further info.

Comments (Including reason for exclusion)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data

Reviewer \_\_\_\_\_ Date \_\_\_\_\_

Author \_\_\_\_\_ Year \_\_\_\_\_ Record Number \_\_\_\_\_

	Yes	No	Unclear	Not applicable
1. Was the sample representative of the target population?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were study participants recruited in an appropriate way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Was the sample size adequate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were the study subjects and the setting described in detail?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Was the data analysis conducted with sufficient coverage of the identified sample?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Were objective, standard criteria used for the measurement of the condition?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Was the condition measured reliably?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Was there appropriate statistical analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Are all important confounding factors/ subgroups/ differences identified and accounted for?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Were subpopulations identified using objective criteria?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal:    Include     Exclude     Seek further info

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**Appendix II: Data extraction instrument**

**MAStARI data extraction instrument**

**JBI Data Extraction Form for  
Experimental / Observational Studies**

Reviewer ..... Date .....

Author ..... Year .....

Journal ..... Record Number .....

**Study Method**

RCT                       Quasi-RCT                       Longitudinal

Retrospective                       Observational                       Other

**Participants**

Setting \_\_\_\_\_

Population \_\_\_\_\_

**Sample size**

Group A \_\_\_\_\_ Group B \_\_\_\_\_

**Interventions**

Intervention A \_\_\_\_\_

Intervention B \_\_\_\_\_

Authors Conclusions:

\_\_\_\_\_  
\_\_\_\_\_

Reviewers Conclusions:

\_\_\_\_\_  
\_\_\_\_\_

**Study results**

**Dichotomous data**

Outcome	Intervention ( ) number / total number	Intervention ( ) number / total number

**Continuous data**

Outcome	Intervention ( ) number / total number	Intervention ( ) number / total number

**JBI Data Extraction Form for Prevalence and Incidence Studies**

## Study details

Reviewer –

Study ID/Record Number -

Date –

Study title –

Author –

Year –

Journal –

Aims of the study –

## Study Method

Setting –

Study design –

Follow-up or study duration –

Subject characteristics –

Dependent variable -

Outcomes –

Outcome measurements –

Ethical approval –

Method of data analysis -

## Results

Prevalence n/N (%)

Proportion and 95% Confidence Intervals

Incidence n/N (%)

Proportion and 95% Confidence Intervals and duration of recruitment or the study

Authors' comments

Reviewer comments

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## RESEARCH PUBLICATION 4

### ***Malocclusions in young children: Does breastfeeding really reduce the risk? A systematic review and meta-analysis.***

Doğramacı EJ, Rossi-Fedele G, Dreyer CW.

J Am Dent Assoc. 2017;148(8):566-574.

DOI: [10.1016/j.adaj.2017.05.018](https://doi.org/10.1016/j.adaj.2017.05.018)

PMID: 28754184

### **Contextual statement**

After the protocol was approved by the JBI, work commenced on the systematic review and meta-analysis.

### **Key findings**

1. Adoption of a strict methodological approach produced results with a narrow confidence interval, with most meta-analyses having nil heterogeneity and statistical significance. This was achieved by only including and analysing studies of high methodological quality, focussing on a defined population, and examining specific types of breastfeeding exposures against different malocclusion features.
2. Children who breastfed sub-optimally had a higher risk ratio for developing malocclusions compared with children who breastfed optimally.
3. Children who did not breastfeed or who experienced only a short duration of breastfeeding had a strong and significantly increased risk for developing an anterior open bite.



4. Children who breastfed for a short duration had a very strong and significantly increased risk for developing a Class II canine relationship.
5. Children who did not breastfeed exclusively were at increased risk for developing a posterior crossbite.

### ***Implications***

1. The estimates of effect are the strongest and most precise recorded from any study to date investigating the association of breastfeeding and malocclusions in the primary dentition.
2. Malocclusions may still occur in children who breastfeed optimally, however, their risk level appears to be lower compared to children who breastfeed sub-optimally. This is not equivalent to optimal breastfeeding decreasing the risk of developing malocclusions. Rather, the higher risk in sub-optimally breastfed children is likely the result of different environmental factors causing malocclusions when breastfeeding is not occurring optimally or has ceased.
3. Pacifier use is associated with shorter breastfeeding duration,<sup>32</sup> including shorter duration in exclusivity of breastfeeding.<sup>33</sup> Parents or carers of young infants may introduce pacifiers to infants for a wide variety of reasons, with most being ingrained in the wider social environment of the mother/carer.<sup>34</sup> These include the belief that its use is normal, it is a social status symbol, and that it can promote growth during weaning when dipped in food that the infant is encouraged to consume.<sup>34</sup> It is also used for soothing (i.e. pacifying) upset and crying infants, and can be used as a sucking substitute for the infant when a mother is in discomfort from breastfeeding.<sup>34</sup> If such reasons are viewed as necessary and important for

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<sup>32</sup> Karabulut E, Yalçın SS, Özdemir-Geyik P, Karaağaoğlu E. Effect of pacifier use on exclusive and any breastfeeding: a meta-analysis. *Turk J Pediatr.* 2009; 51: 35-43.

<sup>33</sup> Buccini GDS, Pérez-Escamilla R, Paulino LM, Araújo CL, Venancio SI. Pacifier use and interruption of exclusive breastfeeding: systematic review and meta-analysis. *Matern Child Nutr.* 2017; 13: e12384.

<sup>34</sup> Victora CG, Behague DP, Barros FC, Olinto MTA, Weiderpass E. Pacifier use and short breastfeeding duration: Cause, consequence, or coincidence? *Pediatrics.* 1997; 99: 445-453.

persisting with pacifier use, compared to the benefits an infant could gain from optimal breastfeeding, it is not unreasonable to expect that pacifier use would continue unabated. Against this background, there is evidence that pacifiers, a type of NNSB, have a causal relationship with certain specific malocclusion features in the primary dentition.<sup>35</sup> Although breastfeeding is purported to decrease the risk of developing malocclusions, causality of this relationship is yet to be fully established. Owing to the similarity of the inclusion criteria, setting and methods of the component studies in both systematic reviews,<sup>35,36</sup> there is the possibility that performing a network meta-analysis could improve our understanding of the connectivity of NNSBs and breastfeeding with malocclusions, by providing further and more precise estimates, beyond the pairwise analyses performed thus far.

4. Future studies examining malocclusions could benefit by collecting data on core outcomes,<sup>37</sup> and allocating participants to exposure-specific groups. This could help reduce heterogeneity amongst component studies and also enable studies to be considered eligible in future systematic reviews, on account of having collected the minimum required data. However, it is important to acknowledge that component studies are often sub-studies of larger parent epidemiological population health studies, thus it is not always possible to collect comprehensive data about oral habits, malocclusions or their treatment, or clinical outcomes.

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<sup>35</sup> Dođramacı EJ, Rossi-Fedele G. Establishing the association between non-nutritive sucking behaviour and malocclusions: A systematic review and meta-analysis. *J Am Dent Assoc.* 2016; 147: 926-934.

<sup>36</sup> Dođramacı EJ, Rossi-Fedele G, Dreyer CW. Malocclusions in young children. Does breastfeeding really reduce the risk? A systematic review and meta-analysis. *J Am Dent Assoc.* 2017; 148: 566-574.

<sup>37</sup> Tsihlaki A, O'Brien K, Johal A, Marshman Z, Benson P, Colonio Salazar FB, Fleming PS. Development of a core outcome set for orthodontic trials using a mixed-methods approach: protocol for a multicentre study. *Trials.* 2017; 18: 366

## Statement of authorship

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# Malocclusions in young children

## Does breast-feeding really reduce the risk? A systematic review and meta-analysis

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### ABSTRACT

**T**he innumerable benefits of breast-feeding for infants and nursing women are well known. Optimal breastfeeding, which is exclusive (only breast milk and no other food or drink, including water) for the first 6 months of life, then continued breastfeeding alongside complementary feeding up to the age of 2 years or beyond, is actively

encouraged through global strategies to promote and protect this practice.<sup>1</sup> For many years, investigators have reported that breast-feeding can decrease the risk of developing malocclusions,<sup>2</sup> defined as “[a] deviation in intramaxillary and/or intermaxillary relations of teeth from normal occlusion [contact between teeth].”<sup>3</sup> However, clinicians should consider this finding against the background of malocclusions having multifactorial etiology.<sup>4</sup>

The spectrum of malocclusions is wide. Different features of malocclusions are associated with variable levels of treatment need; these can be stratified by using reliable and validated indexes such as the

**Background.** Researchers have purported that breast-feeding can decrease the risk of malocclusions. The authors studied the relationship of breast-feeding on malocclusions in young children by means of conducting a systematic review of association (etiology).

**Types of Studies Reviewed.** The authors used a 3-step search strategy, including electronic searches. They considered studies whose investigators included healthy children with primary dentition with a history of breast-feeding and in which the study investigators had assessed specific malocclusion outcomes to be eligible for inclusion in this review. The authors considered prospective and retrospective (longitudinal) studies, case-control studies, and analytical cross-sectional studies. Two of the authors, using standardized instruments, independently assessed the methodological quality and extracted data from the included studies. For situations for which there were a sufficient number of studies, the authors conducted meta-analyses using the random-effects model, supplemented with the fixed-effects model in situations for which statistical heterogeneity was 50% or less, assessed using the  $I^2$  statistic.

**Results.** The authors identified 7 studies that were included in the review. They found that children who had breast-fed suboptimally had an increased risk of developing malocclusions and that a strong and significant association existed between a shorter duration of breast-feeding (less than 12 months) and the development of an anterior open bite ( $n = 1,875$ ; risk ratio, 3.58; 95% confidence interval, 2.55 to 5.03;  $P < .00001$ ) and a class II canine relationship ( $n = 1,203$ ; risk ratio, 1.65; 95% confidence interval, 1.38 to 1.97;  $P < .00001$ ).


**Conclusions.** Young children with a history of suboptimal breast-feeding have a higher prevalence and risk ratio for malocclusions. These children have an increased risk of developing a class II canine relationship, posterior crossbite, and anterior open bite.

**Practical Implications.** Dental health care professionals should continue to encourage and promote breast-feeding; however, patients should be aware that children still can develop malocclusions, despite having received optimal breast-feeding, owing to the multifactorial etiology of malocclusions.

**Key Words.** Breast-feeding; evidence-based dentistry; malocclusion; meta-analysis; orthodontics; pediatric dentistry; primary dentition; systematic review.

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Index of Orthodontic Treatment Need (IOTN),<sup>5</sup> which defines malocclusion features according to their deleterious effects and the potential benefits of orthodontic treatment.<sup>6</sup> Malocclusions may range from those that are mild, such as imbrication (an overlap of incisors and canines owing to crowding<sup>3</sup>) that can be categorized within the IOTN's dental health component grades of 1 or 2 (requiring little or no need for treatment)<sup>5</sup> and whose potential treatment may be associated with more risks than benefits for the patient, to severe malocclusions, such as an impacted tooth, defined as one that is "unable to erupt as a result of either insufficient space in the dental arch, ectopic position of the tooth in relation to where it would normally be expected, or the presence of an obstruction such as a retained tooth, supernumerary or scar tissue."<sup>7</sup> Impacted teeth can cause resorption of adjacent teeth and potentially compromise their long-term prognosis.<sup>8</sup> Owing to the potential serious consequences and depending on the degree of the tooth's eruption into the oral cavity or otherwise, clinicians can categorize impacted teeth within the IOTN's dental health component grades of 4 or 5, which represent a great or very great need for treatment.<sup>5</sup> Between these ends of the spectrum lie crossbites (an abnormal relationship of a tooth or teeth to the opposing teeth in which normal buccolingual or labiolingual relationships are reversed<sup>3</sup>), anterior open bites, and increased overjets (horizontal projection of maxillary teeth beyond the mandibular anterior teeth<sup>3</sup>) that are associated with an increased risk of experiencing traumatic dental injury,<sup>9,10</sup> which subsequently may commit a patient to a lifetime of restorative treatment.<sup>11,12</sup> Where possible, steps should be taken to prevent the development of malocclusions, or, they should be identified early, and in cases in which they may contribute to important adverse outcomes, they should be intercepted in order to minimize a patient's exposure to risks. Such strategies may reduce the chance of developing malocclusions and the possibility of requiring orthodontic treatment. In turn, the demand for orthodontic treatment should decrease, as should the associated social and economic burden on people, families, and society as a whole.<sup>2,4</sup> The importance of preventing modifiable, environmental factors from contributing to the development of malocclusions becomes relevant, particularly in the absence of high-level, evidence-based guidelines for the treatment of malocclusions in the primary dentition.

The extent of the effect that breast-feeding may decrease the risk of developing malocclusions in the primary dentition is unknown, and to our knowledge, no investigators have previously studied this. Therefore, the aim of this systematic review was to investigate whether breast-feeding decreases the risk of developing malocclusions in the primary dentition.

## METHODS

We prospectively registered the title of this review and specified the objective, inclusion criteria, and methods of analysis in advance and documented this information in a protocol that was peer-reviewed and approved by the Joanna Briggs Institute (JBI)<sup>13</sup>; we followed the JBI methodology for systematic reviews of association (etiology).<sup>14</sup>

**Review questions.** The objective of this review was to identify the relationship of breast-feeding with the development of different features of malocclusions in the primary dentition. We addressed the following specific review questions:

- What is the risk of developing different features of malocclusions in the primary dentition in those who have been breast-fed compared to those who have not been breast-fed?
- What is the risk of developing different features of malocclusions in the primary dentition in those who have been exclusively breast-fed compared to those who have not been exclusively breast-fed?
- What is the risk of developing different features of malocclusions in the primary dentition in those who have been breast-fed for a long duration compared to those who have been breast-fed for a short duration?

**Inclusion criteria.** The usual criteria of population, intervention, comparator, and outcome for systematic reviews do not align with reviews related to etiology; therefore, we used population, exposure, and outcome to generate the review questions.<sup>14</sup>

**Population.** We conducted a search for studies of healthy participants with primary dentition and no history of orthodontic or surgical treatment. We placed no restrictions on the basis of participants' age or sex. We excluded studies whose investigators had included participants who had a cleft lip, cleft palate, or both, other craniofacial deformities, any syndrome, or a history of maxillofacial trauma.

**Exposures of interest.** We considered for inclusion studies whose investigators had included participants with 1 or more of the following types of breast-feeding exposure:

- breast-fed versus not breast-fed (that is, participants who had ever breast-fed compared with participants who had never breast-fed);
- exclusively breast-fed versus nonexclusively breast-fed (that is, participants who had a history of exclusive breast-feeding [including all definitions of exclusive breast-feeding as provided by the study authors])

**ABBREVIATION KEY.** AOB: Anterior open bite. BF: Breast-feeding. CINAHL: Cumulative Index to Nursing and Allied Health Literature. CR: Canine relationship. IOTN: Index of Orthodontic Treatment Need. JBI: Joanna Briggs Institute. NNSB: Nonnutritive sucking behavior. OJ: Overjet.



compared with participants who did not have any history of exclusive breast-feeding, independent of its duration); and

■ a longer (12 months or more) duration of being breast-fed versus a shorter (less than 12 months) duration of being breast-fed.

**Types of outcomes.** Among the specific malocclusion outcomes that were assessed were increased overjet, sagittal relationship (canines, molars, or both), posterior crossbite, and anterior open bite.

**Types of studies.** In this review, we considered for inclusion prospective and retrospective cohort (longitudinal) studies, case-control studies, and analytical cross-sectional studies. We excluded reviews, text- and opinion-based articles, conference abstracts, case reports, case series, and descriptive cross-sectional studies.

**Search strategy for identification of studies.** We used a 3-step search strategy. First, we conducted an initial, limited search of MEDLINE and Scopus, followed by an analysis of the text words contained in the title and abstract and the index terms used to describe the article. We conducted a second search using all of the identified key words and index terms across MEDLINE (via Ovid), Embase (via Ovid), Scopus, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL, via EBSCO), from the inception date of each database through to the end of November 2016 (eTable, available online at the end of this article). After we removed the duplicate records, 2 authors (E.J.D., G.R.F.) independently and in duplicate screened the titles and abstracts (or summaries, where available) as well as the descriptors or Medical Subject Heading terms of the identified records to distinguish potentially relevant articles for full-text assessment. Finally, we performed a citation search of the reference lists of all of the included articles. We placed no restrictions on the language or year of publication.

**Assessment of methodological quality.** Two authors (E.J.D., G.R.F.), who are JBI-trained and accredited reviewers, independently assessed the methodological quality of full-text articles, by means of using standardized critical appraisal instruments from JBI SUMARI.<sup>13,15</sup> This process aims to identify sources of bias by using criteria that can be scored as being met, not met, unclear, or not applicable to the particular study.<sup>16</sup> Our protocol stated a priori that the cutoff for inclusion of a study would be a score of 8 (maximum score = 10).<sup>13</sup> We resolved any disagreements that arose through discussion until we reached a decision by consensus.

**Data extraction.** Using standardized tools from JBI SUMARI,<sup>13,15</sup> we independently extracted data from the studies included in the review. The data included authors' names, year of publication, study setting, study design, population details, exposures, and outcomes of importance to the review questions. We contacted

authors for clarification or to request additional information as required.

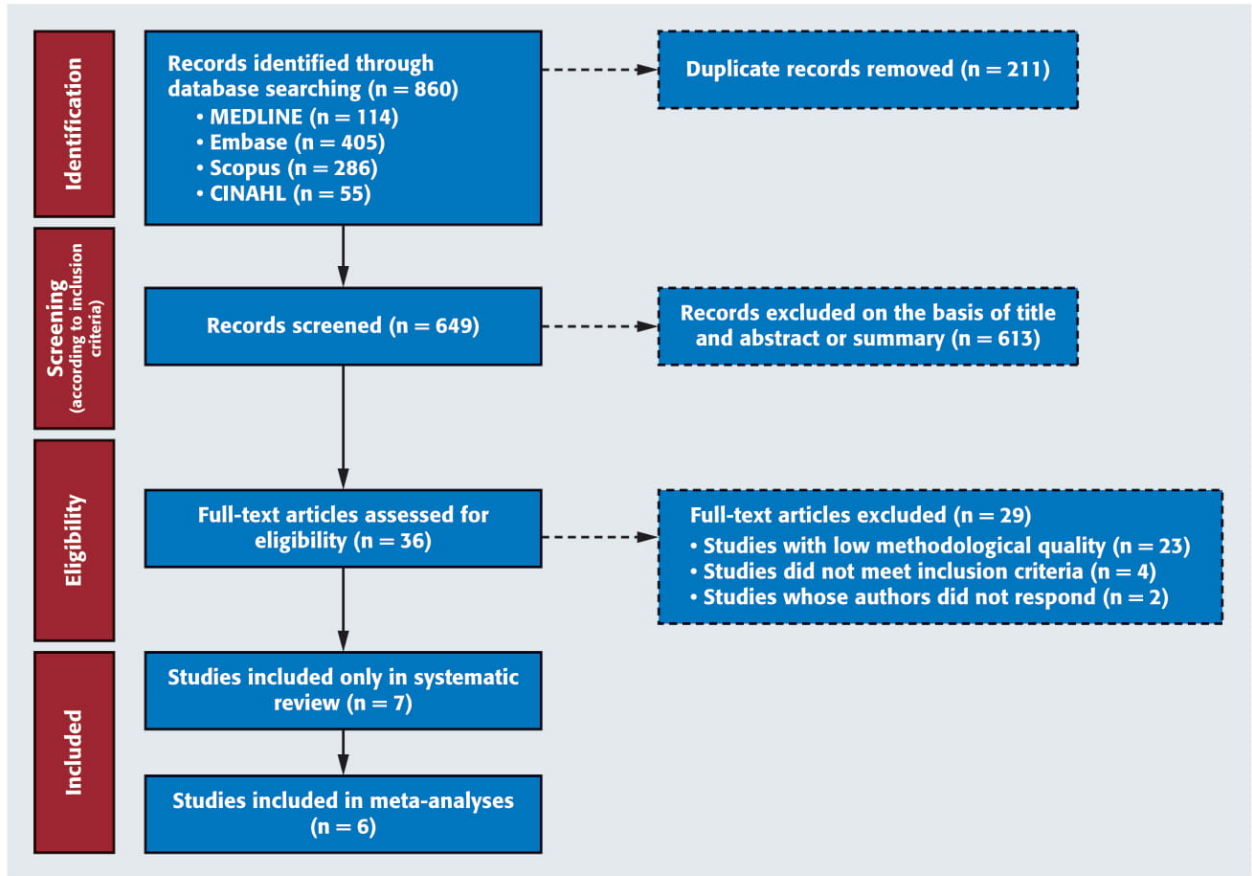
**Data analysis and synthesis.** All of the outcome measures were dichotomous or were dichotomized. In situations for which there were studies with homogenous exposures and outcome measures, we performed a meta-analysis. We used the random-effects model, which we supplemented by using the fixed-effects model in situations for which statistical heterogeneity was low ( $\leq 50\%$ ); we assessed these data using the  $I^2$  statistic, as a means of sensitivity analysis. We calculated risk ratios (RR) with 95% confidence intervals (CI) for each study, as well as for the pooled results of all of the component studies. We performed all of the analyses using Review Manager (RevMan), Version 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration). In situations for which it was not possible for us to conduct statistical pooling, we described the findings in narrative form.

## RESULTS

**Search strategy results.** We identified 860 articles through the electronic database searches; 211 were duplicates. Of the remaining 649 articles, we discarded 613 after screening the titles and abstracts or summaries. As a result of conducting a full-text assessment into the methodological quality of the remaining 36 articles, we eliminated an additional 23 articles. We excluded 4 articles because they did not fulfill the inclusion criteria. We contacted the authors of 2 articles to clarify data and to obtain additional information relevant to the review that was not apparent; however, we did not receive a reply. Therefore, we excluded those articles. The figure shows the flowchart for the selection of the 7 studies included in the systematic review.<sup>17-23</sup> We conducted a citation search of the included articles, but the search did not reveal additional records.

**Included studies.** Table 1<sup>17-23</sup> shows the main characteristics of the 7 studies,<sup>17-23</sup> all of which were published in English. Investigators conducted 5 of the included studies in Brazil,<sup>19-23</sup> and 1 each in the United States<sup>17</sup> and Italy.<sup>18</sup> The authors of 3 studies considered malocclusion outcomes related to the presence or absence of breast-feeding.<sup>17,19,21</sup> The authors of 2 studies examined exclusive and nonexclusive breast-feeding,<sup>18,21</sup> and the authors of 5 studies examined specific malocclusions in association with longer duration versus shorter duration of breast-feeding.<sup>17,19-21,23</sup> With the available data, we were able to perform meta-analyses related to 3 malocclusion outcomes. eFigure 1,<sup>17,19,21</sup> eFigure 2,<sup>18,21</sup> eFigure 3,<sup>17,19-21,23</sup> and eFigure 4<sup>17,19,21</sup> (available online at the end of this article) show forest plots for all of the meta-analyses.

**Breast-feeding versus no breast-feeding.** The results into posterior crossbite were inconclusive. However, we found a significant association between the absence of breast-feeding and an anterior open bite ( $n = 2,228$ ; RR, 1.44; 95% CI, 1.15 to 1.81;  $P = .001$ ). We found that



**Figure.** Flowchart of study selection. CINAHL: Cumulative Index to Nursing and Allied Health Literature.

both random- and fixed-effects models produced similar results (Table 2, eFigure 1<sup>17,19,21</sup>).

**Exclusive versus nonexclusive breast-feeding.** Children who were not exclusively breast-fed were at risk of developing a posterior crossbite. We did not find any significant difference related to the risk of developing an anterior open bite (Table 2, eFigure 2<sup>18,21</sup>).

**Longer duration versus shorter duration of breast-feeding.** We found that a strong and significant association exists between a shorter duration of breast-feeding and the development of a class II canine relationship (n = 1,203; RR, 1.66; 95% CI, 1.39 to 1.98;  $P < .00001$ ) (eFigure 3<sup>17,20,23</sup>). We found that both random- and fixed-effects models produced similar results. No overall difference was demonstrated in the development of a posterior crossbite, although we did find a significant association between a shorter duration of breast-feeding and the development of an anterior open bite (Table 2, eFigure 3<sup>17,19-21,23</sup>).

The results of 1 component study in this review had noticeable inconsistencies compared with the results of our meta-analyses. Warren and Bishara<sup>17</sup> reported that

children who had ever been breast-fed and children who were breast-fed for longer durations were at greater risk of developing an anterior open bite, despite the investigators' efforts to control for the confounding effects of nonnutritive sucking behaviors (NNSB). We considered this study as an outlier, and when we repeated the meta-analyses with exclusion of this study, we found negligible differences between breast-feeding versus no breast-feeding (Table 2, eFigure 4<sup>17,19,21</sup>). However, we found that the association between shorter duration of breast-feeding and anterior open bite became significantly stronger (RR, 3.58; 95% CI, 2.55 to 5.03;  $P < .00001$ ) (Table 2, eFigure 4<sup>17,19,21</sup>). Importantly, we found that the direction of the effect did not change when we repeated the meta-analyses. Small-study effect may explain the originally observed inconsistent results. We were unable to assess publication bias in this review, as none of our meta-analyses had more than 10 component studies.

The results of a study by investigators who examined children from nonurban indigenous populations in which optimal breast-feeding was practiced also



TABLE 1

Characteristics of the studies included in the systematic review.						
STUDY	COUNTRY	STUDY DESIGN	SAMPLE SIZE	AGE OF PARTICIPANTS, Y	EXPOSURE	OUTCOME MEASURES
Warren and Bishara, <sup>17</sup> 2002	United States	Cross-sectional nested within a cohort	119	4-5	<ul style="list-style-type: none"> <li>■ BF* versus no BF</li> <li>■ Longer duration of BF versus shorter duration of BF</li> </ul>	<ul style="list-style-type: none"> <li>■ OJ<sup>†</sup></li> <li>■ CR<sup>‡</sup></li> <li>■ Posterior crossbite</li> <li>■ AOB<sup>§</sup></li> </ul>
Viggiano and Colleagues, <sup>18</sup> 2004	Italy	Cross-sectional	1,099	3-5	Exclusive BF versus nonexclusive BF	<ul style="list-style-type: none"> <li>■ Posterior crossbite</li> <li>■ AOB</li> </ul>
Romero and Colleagues, <sup>19</sup> 2011	Brazil	Cross-sectional	1,377	3-6	<ul style="list-style-type: none"> <li>■ BF versus no BF</li> <li>■ Longer duration of BF versus shorter duration of BF</li> </ul>	AOB
Caramex da Silva and Colleagues, <sup>20</sup> 2012	Brazil	Cross-sectional nested within a cohort	153	3-5	Longer duration of BF versus shorter duration of BF	CR
de Sousa and Colleagues, <sup>21</sup> 2014	Brazil	Cross-sectional	732	3-5	<ul style="list-style-type: none"> <li>■ BF versus no BF</li> <li>■ Exclusive BF versus nonexclusive BF</li> <li>■ Longer duration of BF versus shorter duration of BF</li> </ul>	<ul style="list-style-type: none"> <li>■ Posterior crossbite</li> <li>■ AOB</li> </ul>
de Souza and Colleagues, <sup>22</sup> 2015	Brazil	Cross-sectional prevalence study	53	2 (unspecified upper age limit)	All study participants were breastfed only	<ul style="list-style-type: none"> <li>■ OJ</li> <li>■ CR</li> <li>■ Posterior crossbite</li> </ul>
Feldens and Colleagues, <sup>23</sup> 2016	Brazil	Cross-sectional	1,336	2-5	Longer duration of BF versus shorter duration of BF	CR

\* BF: Breast-feeding.  
† OJ: Overjet.  
‡ CR: Canine relationship.  
§ AOB: Anterior open bite.

provided valuable insights.<sup>22</sup> In a study of 53 children who were indigenous (that is, belonging to 1 of 2 ethnic backgrounds and living in 1 of 3 nonurban and geographically isolated villages in the Amazon region of Brazil), the investigators reported that only a single child had a posterior crossbite and that another child had an anterior open bite.<sup>22</sup> They also reported that children had skeletal and dental sagittal discrepancies that manifested as convex facial profile contours and class II canine relationships, respectively, and that 15% of the children had an increased overjet.<sup>22</sup> In contrast, the investigators of a study conducted in the United States reported that no child who had been breast-fed for longer than 12 months had an increased overjet, although the prevalence of having an increased overjet among children who had never been breast-fed was lower than among children who had been breast-fed.<sup>17</sup>

## DISCUSSION

It is important to know the extent to which environmental factors are associated with malocclusions, this

being a relevant issue for all patients, including young children with primary dentition. Researchers of a number of studies have confirmed the multifactorial etiology of malocclusions. Environmental factors and a person's genotype interact in a complex manner that can result in the manifestation of a malocclusion. As there are no routine means to intercept genetic elements before they might contribute to malocclusion development, environmental factors are viewed as being more readily amenable to modification. The importance of preventing the development of malocclusions during growth and development is the possibility of averting future orthodontic treatment, which can have substantial implications for patients and

their caregivers and families, as well as health care providers and society as a whole.<sup>13</sup>

In our review, we investigated the association of breast-feeding, an environmental factor, on the vertical, transverse, and sagittal dental relationships in the primary dentition. We found that children who had not been breast-fed or who had experienced only a short duration of breast-feeding had an increased risk of developing an anterior open bite. Similarly, children who were breast-fed for fewer than 12 months had a strong and significantly increased risk of developing a class II canine relationship. We also found that the risk of developing a posterior crossbite was increased in children who were not breast-fed exclusively, but the evidence related to other types of exposures was inconclusive.

Malocclusions are detectable in children who breast-feed optimally and suboptimally, although children who breast-feed suboptimally tend to have increased prevalence and RRs for developing malocclusions. This should not be misinterpreted as optimal



TABLE 2

**Summary of meta-analyses comparing different exposures with specific malocclusion features in the primary dentition.**

EXPOSURE	CLASS II CANINE RELATIONSHIP			POSTERIOR CROSSBITE			ANTERIOR OPEN BITE		
	No. of Studies	Pooled Risk Ratio (95% CI*)	P Value	No. of Studies	Pooled Risk Ratio (95% CI)	P Value	No. of Studies	Pooled Risk Ratio (95% CI)	P Value
<b>Breastfeeding Versus No Breastfeeding</b>	Insufficient number of studies for meta-analysis			2	1.09 (0.62 to 1.92)	.77	3	1.44 (1.15 to 1.81)	.001
					1.09 <sup>†</sup> (0.62 to 1.93)	.77 <sup>†</sup>	2 <sup>‡</sup>	1.42 <sup>†</sup> (1.13 to 1.78)	.002 <sup>†</sup>
<b>Exclusive Breastfeeding Versus Nonexclusive Breastfeeding</b>	Insufficient number of studies for meta-analysis			2	1.84 (0.94 to 3.58)	.07	2	1.46 <sup>‡</sup> (1.17 to 1.84)	.001 <sup>‡</sup>
							2	1.46 <sup>†,‡</sup> (1.17 to 1.83)	.001 <sup>†,‡</sup>
<b>Longer Duration of Breastfeeding Versus Shorter Duration of Breastfeeding</b>	3	1.66 (1.39 to 1.98)	< .00001	2	0.94 (0.08 to 11.18)	.96	3	1.03 (0.83 to 1.27)	.81
		1.65 <sup>†</sup> (1.38 to 1.97)	< .00001 <sup>†</sup>				2 <sup>‡</sup>	1.03 <sup>†</sup> (0.83 to 1.28)	.79 <sup>†</sup>
							3	2.40 (1.04 to 5.54)	.04
							2 <sup>‡</sup>	3.51 <sup>‡</sup> (2.51 to 4.91)	< .00001 <sup>‡</sup>
							3	3.58 <sup>†,‡</sup> (2.55 to 5.03)	< .00001 <sup>†,‡</sup>

\* CI: Confidence interval.  
<sup>†</sup> All meta-analyses were conducted using the random-effects model. For these meta-analyses marked, the fixed-effects model also was used.  
<sup>‡</sup> Meta-analysis repeated with exclusion of outlier study.

breast-feeding decreasing the risk of developing a malocclusion, as this cannot be inferred from our findings, nor do the results of our review confirm the hypothesis that breast-feeding can lead to the correct development of dentofacial structures.<sup>24</sup> The objective of our review was to identify the relationship of breast-feeding on the development of malocclusion in the primary dentition; children who breast-fed optimally did not share the same risk level of developing malocclusions as children who breast-fed suboptimally. In our review, we did not aim to explore why or how these associations exist.

Orofacial development and growth, including dental development, commences prenatally. The primary dentition usually begins to erupt at the age of 6 months; the primary incisors erupt between 6.5 to 8.0 months, the primary canines at 16 to 20 months, and the primary molars between 12 and 30 months.<sup>25</sup> Globally, only 43% of infants are exclusively breast-feeding at 6 months.<sup>26</sup> Thus, we might not expect exclusive breast-feeding for the first 6 months of life to influence the primary dentition in a significant manner, given that this period coincides with an edentulous state in infants. By the same token, the primary dentition is established fully by approximately 3 years,<sup>25</sup> but fewer than one-half of all children continue to breast-feed up to 2 years.<sup>26</sup> Therefore, we may surmise that breast-feeding might exert an impact on occlusal development only for the duration that breast-feeding takes place. None of the investigators of the component studies reported the higher age limit (duration) of breast-feeding among the children, as this was not related to a research objective for any of the included studies. Consequently, it

was not possible to perform subgroup analyses according to the child's age when breast-feeding ceased. Nonetheless, the collection and interpretation of such data can be problematic, particularly for cross-sectional studies such as those included in our review, because retrospective recollection of breast-feeding practices is susceptible to recall bias. By conducting birth cohort studies, investigators can circumvent this problem; however, these types of studies are time-consuming and expensive to conduct.

The ages of participants in the component studies ranged from 2 to 6 years. One could argue that conducting subgroup analyses of studies with 2-year-old participants may provide findings that are more accurate, as the clinical and nonclinical data collected from them are closer to the time when breast-feeding ceased or was still occurring, and confounders such as NNSB have not acted on the dentition for as long compared with a 6-year-old child, for example.<sup>13</sup> Although we used the broadest inclusion criteria for participant age to ensure that our review findings would be generalizable for the primary dentition, we found that none of the investigators of the component studies reported their findings according to the specific ages of the participants. This impeded subgroup analyses that we otherwise might have been able to conduct to give an insight into the strength of the associations with increasing age within a single stage of dental development.

Despite optimal breast-feeding and in the absence of deleterious habits, malocclusions still develop. Investigators observed this finding in a study among children within geographically isolated and genetically homogeneous populations.<sup>22</sup> This provides credence to



the critical role of genetics in orofacial development and growth. Patients' skeletal and soft-tissue relationships are influenced principally by their genotype, which may explain the etiology of some malocclusions. Therefore, skeletal and soft-tissue relationships, cranial type, and facial profile contour are the foremost, preliminary features that a clinician assesses in an orthodontic clinical examination. The investigators of only 1 study included in our review collected such data.<sup>22</sup> Our inclusion criteria and subsequent search strategy focused on examining any association between breast-feeding on malocclusion outcomes. It is possible that participants within the component studies had malocclusions that were a result of skeletal, soft-tissue, or dental factors. For example, a class II skeletal relationship also could be responsible for an increased overjet, a class II dental relationship, or both, plus a soft-tissue lip trap also could produce an increased overjet.<sup>4</sup> We were unable to perform subgroup analyses, as the investigators' examinations of the study participants did not extend beyond reporting intraoral findings, with the exception of a single study.<sup>22</sup> Investigators of future studies should collect and report data related to cranial type (whether a study participant is brachycephalic, mesocephalic, or dolichocephalic), facial profile contours (convex, straight, or concave), and facial types (euryprosopic, mesoprosopic, or leptoprosopic). In addition, investigators also should describe soft-tissue relationships, because then they can be analyzed in conjunction with a participant's occlusal features, breast-feeding history, and any confounders to reach more precise findings regarding the true extent of the associations between breast-feeding and occlusal development.

Although the results of our review indicated that children who breast-fed either optimally or suboptimally can develop malocclusions, with children in the latter category having a greater risk of experiencing malocclusions, our findings did not extend to all presentations of malocclusions. Breast-feeding is a type of behavior that constitutes an environmental factor. Modifying pertinent environmental factors would have a limited benefit in cases in which the features of a patient's malocclusion are determined to be of mainly a genetic origin. For example, a patient with nonsyndromic hypodontia, such as oligodontia (Online Mendelian Inheritance in Man 604625)<sup>27</sup>, can have impacted teeth, ectopic teeth, retention of primary teeth, displacement of contact points owing to spacing, crowding, or both, as well as dental centerline discrepancies, increased overbite, reduced vertical dimensions, and deviation from class I dental relationships.<sup>28</sup> Similarly, a clinician would not expect the growth pattern in a patient who has a class II or class III skeletal relationship to change in response to their breast-feeding exposure. Breast-feeding cannot be expected to obviate the possibility of orthopedic

treatment or orthognathic surgery later in life, because breast-feeding is unlikely to affect the amount or the direction of growth of the maxilla or mandible.

Alternatively, NNSBs are a type of environmental factor associated with diminished breast-feeding rates, intensities, and durations.<sup>29,30</sup> Parents normally introduce pacifiers, a type of NNSB, to children in infancy, and along with digit sucking, pacifiers also can exert a harmful effect on the dentition; children can persist with these types of NNSBs beyond the primary dentition, which can result in increased overjets, sagittal discrepancies, posterior crossbites, anterior open bites, or a combination of these.<sup>4</sup> Extrinsic forces from NNSBs can disrupt the dental equilibrium that helps determine tooth position, with the frequency and duration of the forces being more important than their magnitude.<sup>31</sup> As a corollary, a child's dental equilibrium also could change in the absence of optimal breast-feeding, allowing intrinsic forces, external forces, or both, to influence tooth position and, therefore, the occlusion, or malocclusion, of the growing child. Investigators have suggested that the greater use of pacifiers among children who are breast-fed for shorter durations is the principal factor accounting for class II canine relationships, and they have observed that the prevalence of this particular malocclusion reduces as pacifier use decreases, supporting the concept of a dose-response effect.<sup>23</sup> NNSBs are associated with a greater risk of developing malocclusions compared with suboptimal breast-feeding. For example, children who had NNSBs had a 10-fold increased risk of developing an anterior open bite ( $n = 3,654$ ; RR, 10.33; 95% CI, 5.29 to 20.15;  $P = < .00001$ ),<sup>4</sup> whereas in our review, we found that children who do not breast-feed have a much lower risk of developing malocclusions ( $n = 2,228$ ; RR, 1.46; 95% CI, 1.17 to 1.83;  $P = .001$ ).

Within the existing base of biological and medical knowledge concerning orofacial and dental development, and in the absence of finding any published studies whose investigators elucidated the biological mechanism for a causal relationship between breast-feeding and occlusal development, it is not possible for us to support or refute the biological plausibility of this association.

There are 2 specific opportunities in which dental health care practitioners can play an important part in the future dental development of a child. First, they can counsel expectant mothers about the benefits of breast-feeding their infants, highlighting that there is some evidence that children who breast-feed optimally do not share the same degree of risk of developing malocclusions as those who breast-feed suboptimally. It is necessary to provide caveats to indicate that breast-feeding will not guarantee the prevention of malocclusion and that NNSBs also contribute to a greater risk of developing malocclusions compared with suboptimal breast-feeding. Also, it is important to remember that



“mothers [have] a right to choose whether or not they want to breast-feed; ...provided [they are] properly informed about the facts.”<sup>32</sup> Not every mother will be able or will want to breast-feed her infant. Second, the dental health care practitioner or pediatric dentist should observe the developing occlusion in a child so that any deviations from normal can be detected and investigated at an early stage. When a dental health care practitioner detects a malocclusion, it is important that he or she has an understanding of whether genetic or environmental factors, or an interaction of both, have contributed to the patient’s presentation. This understanding can help clinicians reach a diagnosis on which future treatment plans can be based.

By using the JBI methodology, we only considered data from high-quality studies, as they “provide scientifically sound and clinically relevant results in relation to the review question.”<sup>4</sup> These data, in turn, give strength and reliability to the results and, therefore, validity to the meta-analysis.<sup>33</sup> Another strength of our study was that we restricted the parameters of our review to the primary dentition, thus we are able to provide the highest-level evidence into the relationship between breast-feeding and malocclusions that is dentition specific. Furthermore, we considered specific malocclusion outcomes, as they provide findings that are clinically useful for treatment planning purposes.

One limitation we encountered was the low number of studies we identified for the review. This reflects the paucity of high-quality studies on this topic. In addition, many of the study designs were cross-sectional; the retrospective recollection of breast-feeding practices can be susceptible to recall bias, which can affect the precision of the findings of the component studies and the overall conclusions drawn from reviews. Although increased overjet can have significant risks such as traumatic dental injuries, we were precluded from undertaking any meta-analyses related to this outcome, as there was an insufficient number of studies with across-study homogeneity related to the clinical definition of an increased overjet. We encountered moderate heterogeneity (50% to 90%) in the results of 3 meta-analyses. One meta-analysis had the smallest pooled sample size, so small-study effect likely contributed to the heterogeneity. The results of another meta-analysis contained an outlier study; after we excluded this study and repeated the meta-analysis, statistical heterogeneity was lost. Methodological differences might also partially explain the heterogeneity. We recognized that there may have been the possibility of statistical heterogeneity associated with our results, and therefore, we applied the random-effects model to all of the meta-analyses in the first instance to circumvent the associated problems. Finally, we found that 5 of the component studies had been conducted in a single country. Therefore, the generalizability of the findings may be

limited only to the populations that those investigators studied.<sup>4</sup>

## CONCLUSIONS

Within the limitations of this study, our results indicate that there is a higher prevalence and risk of developing malocclusions among children with primary dentition who have a history of suboptimal breast-feeding. More specifically, suboptimal breast-feeding is associated with an increased risk of developing a class II canine relationship, a posterior crossbite, and an anterior open bite. Children who breast-feed optimally did not share the same risk of developing malocclusions as those who breast-fed suboptimally. The design of the component studies included in our review did not allow us to determine whether breast-feeding decreased the risk of developing malocclusions in the primary dentition. ■

## SUPPLEMENTAL DATA

Supplemental data related to this article can be found at: <http://dx.doi.org/10.1016/j.adaj.2017.05.018>.

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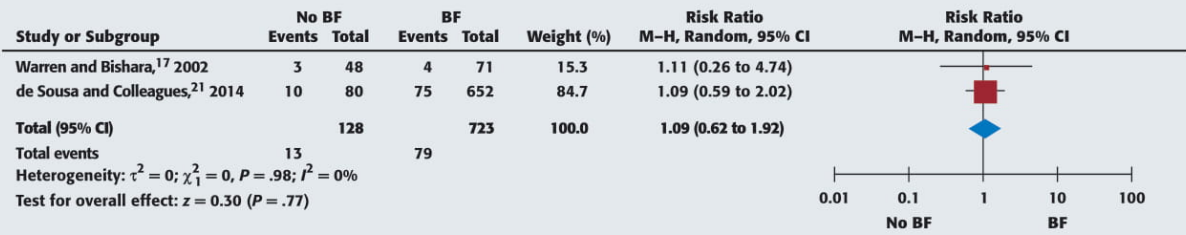
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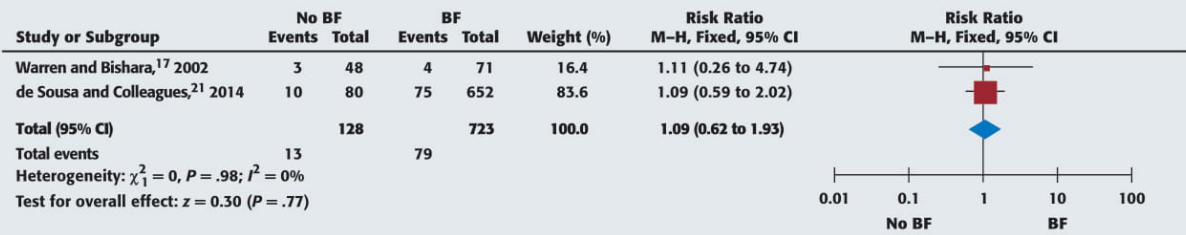
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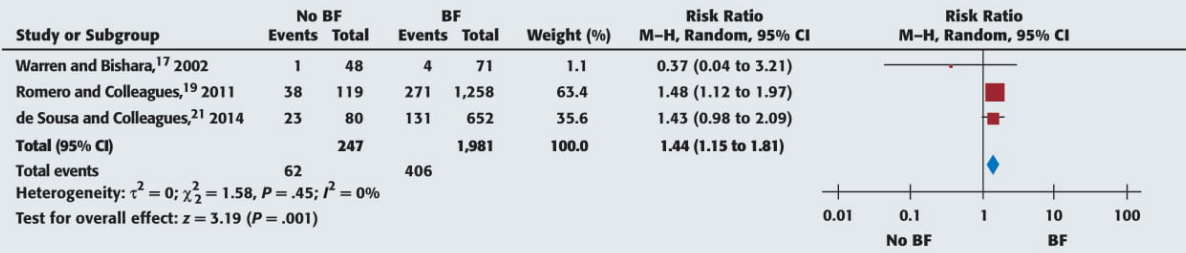
**Posterior crossbite**



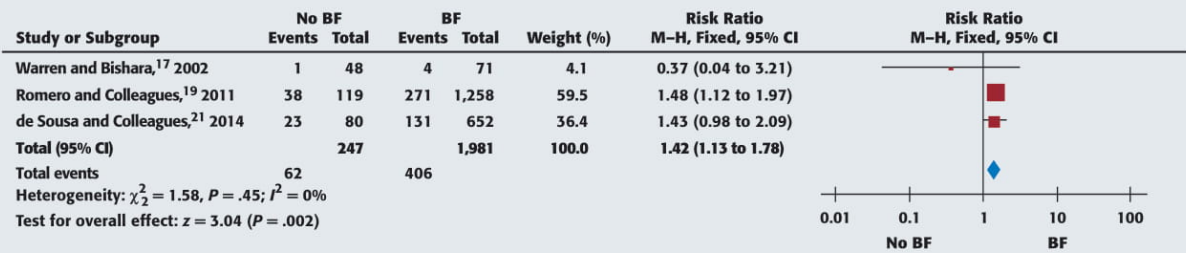
**Supplementation with fixed-effects model due to low statistical heterogeneity**



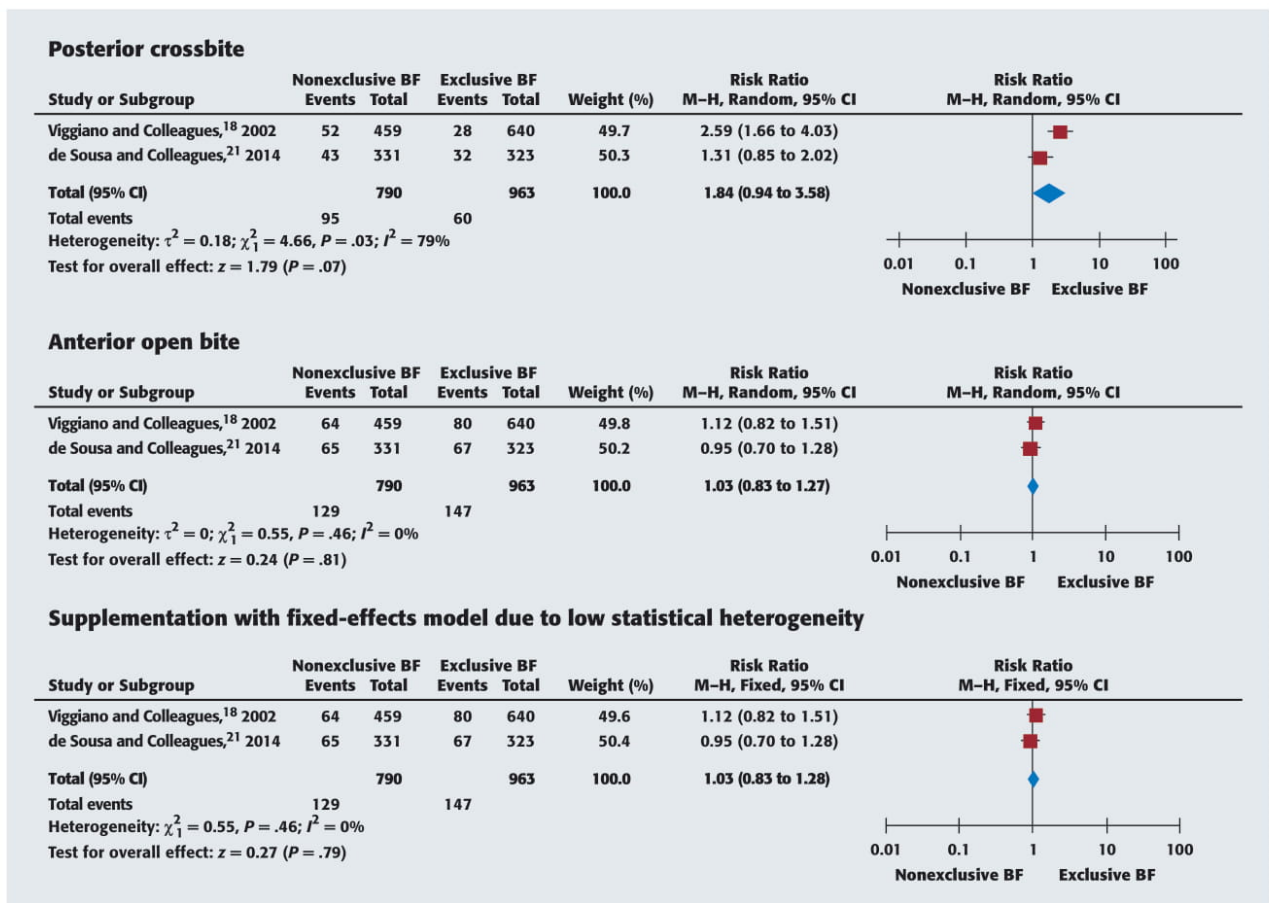
**Anterior open bite**



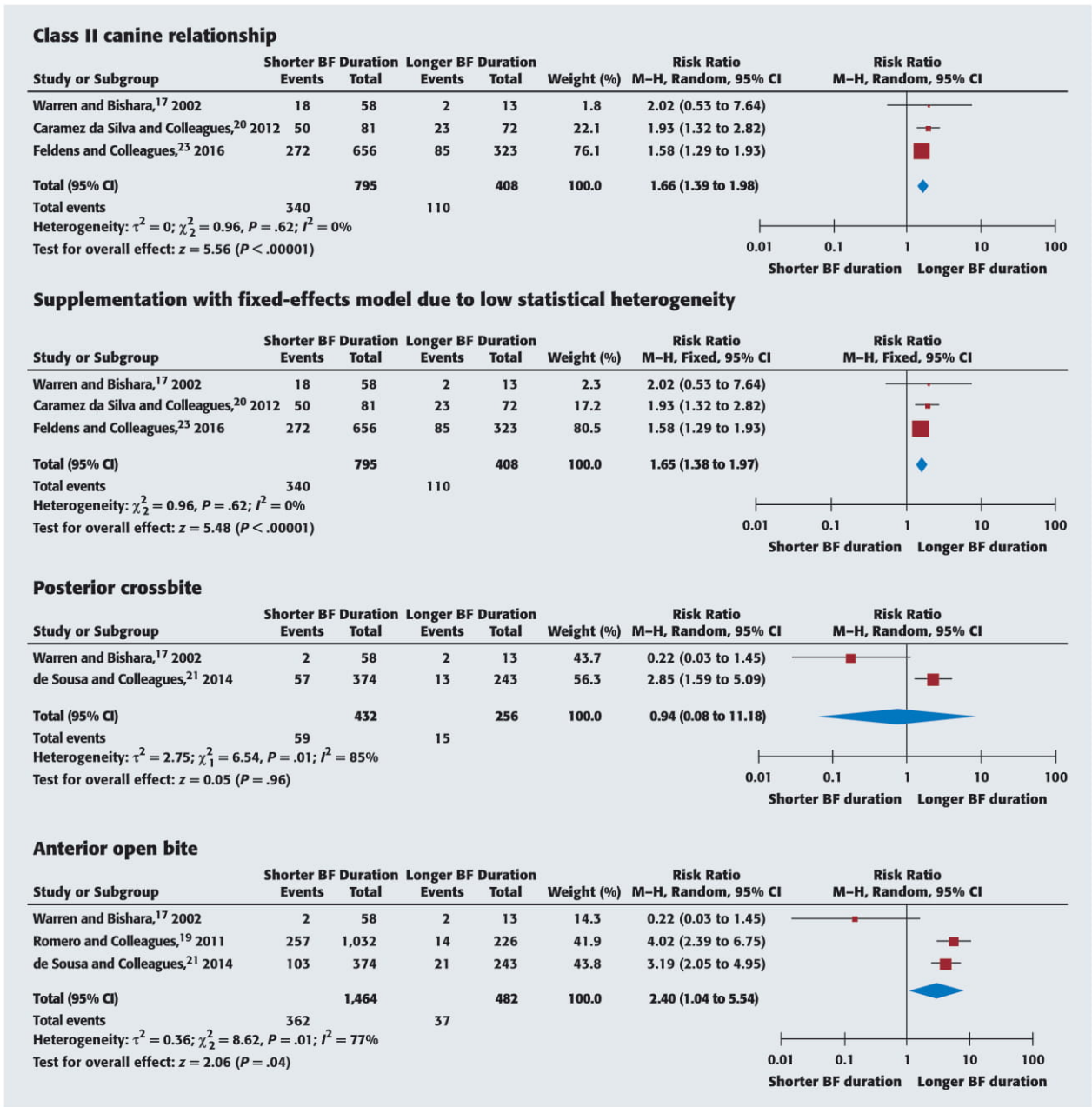
**Supplementation with fixed-effects model due to low statistical heterogeneity**



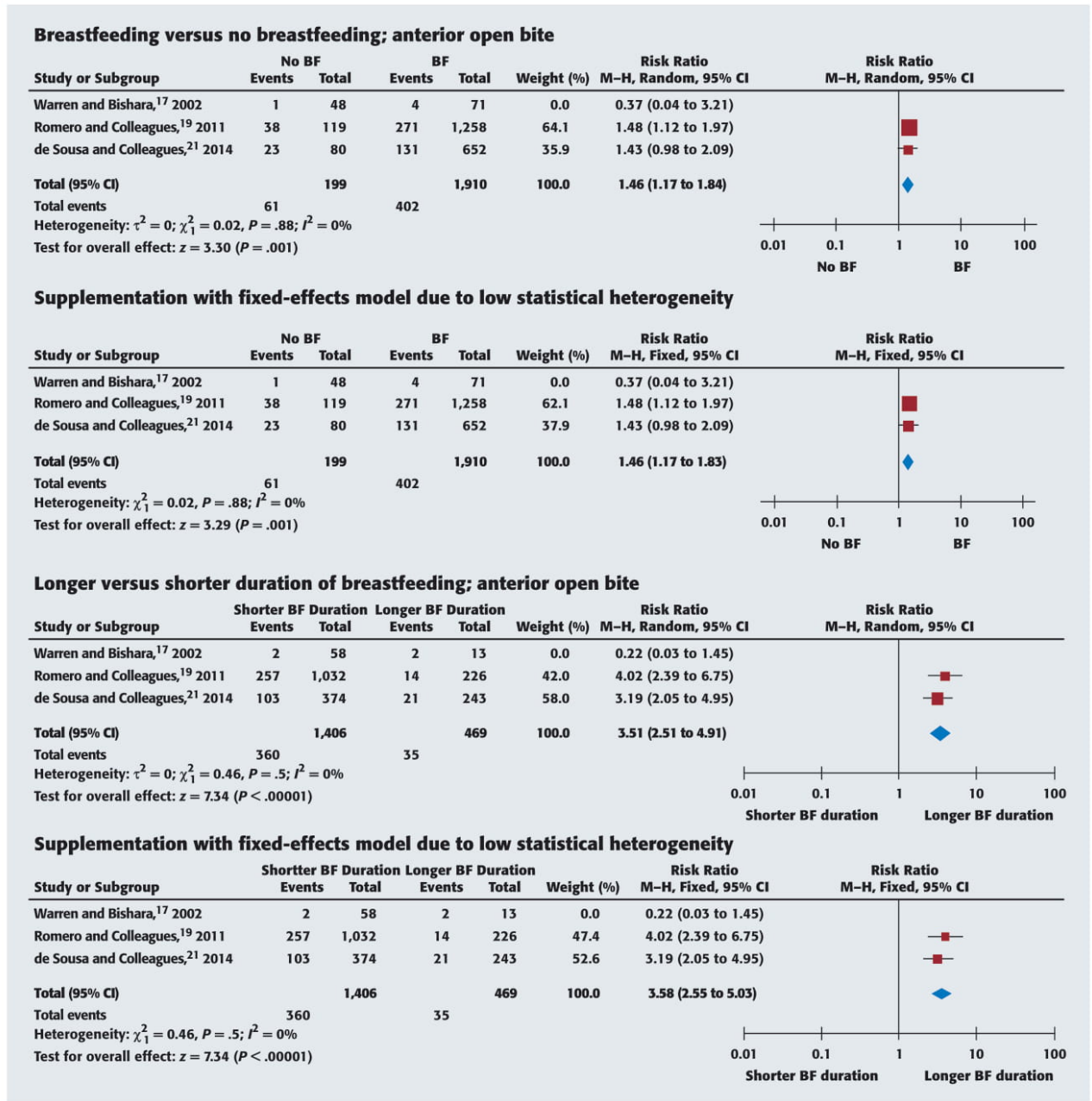
**eFigure 1.** Forest plots of meta-analyses investigating breast-feeding (BF) versus no BF on malocclusion outcomes in the primary dentition. CI: Confidence interval. M-H: Mantel-Haenszel test.



**eFigure 2.** Forest plots of meta-analyses investigating exclusive breast-feeding (BF) versus nonexclusive breast-feeding on malocclusion outcomes in the primary dentition. CI: Confidence interval. M-H: Mantel-Haenszel test.



**eFigure 3.** Forest plots of meta-analyses investigating longer duration of breast-feeding (BF) (12 months or more) versus shorter duration of BF (less than 12 months) on malocclusion outcomes in the primary dentition. CI: Confidence interval. M-H: Mantel-Haenszel test.



**eFigure 4.** Forest plots of repeated meta-analyses with the exclusion of outlier study on malocclusion outcomes in the primary dentition. BF: Breastfeeding. CI: Confidence interval. M-H: Mantel-Haenszel test.



**eTABLE**

**Electronic database search strategies.**

Search Number/ Stage (#/s)	MEDLINE (OVID)	EMBASE (OVID)	SCOPUS	CINAHL <sup>†</sup> (EBSCO)
1	Breast Feeding/	Breast Feeding/	(human) and (((TITLE-ABS-KEY("breast feeding") OR TITLE-ABS-KEY(breastfeeding) OR TITLE-ABS-KEY(breast-feeding)))) and	Breast feeding OR breastfeeding OR breast-feeding
2	Milk, Human/	Breast milk/ or human milk.mp	(((TITLE-ABS-KEY(malocclusion) OR TITLE-ABS-KEY("malocclusion, Angle Class I") OR TITLE-ABS-KEY("malocclusion, Angle Class II") OR TITLE-ABS-KEY("malocclusion, Angle Class III") or ((TITLE-ABS-KEY("dental occlusion") OR TITLE-ABS-KEY("tooth occlusion")) or ((TITLE-ABS-KEY(distocclusion) OR TITLE-ABS-KEY(disto-occlusion)OR TITLE-ABS-KEY(mesiocclusion) OR TITLE-ABS-KEY(mesio-occlusion)OR TITLE-ABS-KEY(mesioocclusion))) or ((TITLE-ABS-KEY("canine relationship") OR TITLE-ABS-KEY("molar relationship")OR TITLE-ABS-KEY("terminal plane")))) or ((TITLE-ABS-KEY(retrognath\$) OR TITLE-ABS-KEY(prognath\$)) or ((TITLE-ABS-KEY("open bite") OR TITLE-ABS-KEY("anterior open bite") OR TITLE-ABS-KEY("asymmetric anterior open bite") OR TITLE-ABS-KEY("symmetric anterior open bite")))) or	Breast milk OR human milk
3	breastfeeding or breast-feeding.mp	breastfeeding or breast-feeding.mp	(((TITLE-ABS-KEY("over bite") OR TITLE-ABS-KEY(overbite)OR TITLE-ABS-KEY(over-bite))) or ((TITLE-ABS-KEY("over jet") OR TITLE-ABS-KEY(overjet)OR TITLE-ABS-KEY(over-jet))) or ((TITLE-ABS-KEY("cross bite") OR TITLE-ABS-KEY(crossbite)OR TITLE-ABS-KEY(cross-bite))) or ((TITLE-ABS-KEY("deep bite") OR TITLE-ABS-KEY(deepbite)OR TITLE-ABS-KEY(deep-bite))) or ((TITLE-ABS-KEY("Index of Orthodontic Treatment Need") OR TITLE-ABS-KEY(IOTN))) or (TITLE-ABS-KEY("dental arch")) or ((TITLE-ABS-KEY(Palate) AND NOT TITLE-ABS-KEY("cleft lip") AND NOT TITLE-ABS-KEY("cleft palate") AND NOT TITLE-ABS-KEY("cleft lip and palate")) or (TITLE-ABS-KEY("growth, development and aging")))) AND ( LIMIT-TO(SRCTYPE,"j" ) ) AND ( LIMIT-TO(DOCTYPE,"ar" ) ) AND ( LIMIT-TO(SUBJAREA,"DENT" ) OR LIMIT-TO(SUBJAREA,"HEAL" ) OR LIMIT-TO(SUBJAREA,"MEDI" ) OR LIMIT-TO(SUBJAREA,"NURS" ) ) AND ( EXCLUDE(EXACTKEYWORD,"Animals" ) OR EXCLUDE(EXACTKEYWORD,"Nonhuman" ) OR EXCLUDE(EXACTKEYWORD,"Animal Experiment" ) )	Infant nutrition OR infant nutrition and the benefits of breastfeeding OR infant nutrition and feeding
4	(Breast/ or breast\$.mp) and feed.mp	(Breast/ or breast\$.mp) and feed.mp		Infant feeding
5	Breast-fe\$.mp	Breast-fe\$.mp		S1 or S2 or S3 or S4
6	Infant nutrition\$.mp	Infant nutrition/		Malocclusion OR Malocclusion, Angle Class I OR Malocclusion, Angle Class II OR Malocclusion, Angle Class III
7	Infant fe\$.mp	Infant feeding/		dental occlusion OR tooth occlusion
8	1 or 2 or 3 or 4 or 5 or 6 or 7	1 or 2 or 3 or 4 or 5 or 6 or 7		canine relationship
9	Malocclusion/ or Malocclusion, Angle Class I/ or Malocclusion, Angle Class II/ or Malocclusion, Angle Class III/	Malocclusion/		molar relationship
10	Dental occlusion/ or tooth occlusion.mp	(Malocclusion, Angle Class I or Malocclusion, Angle Class II or Malocclusion, Angle Class III).mp		terminal plane
11	(distocclusion or disto-occlusion or distocclusion).mp	Tooth occlusion/ or dental occlusion.mp		S6 or S7 or S8 or S9 or S10
12	(mesiocclusion or mesio-occlusion or mesiocclusion).mp	(distocclusion* or disto-occlusion* or distocclusion*).mp		Retrognathia OR retrognathism
13	canine relationship.mp	(mesiocclusion* or mesio-occlusion* or mesiocclusion*).mp		Prognathia OR prognathism
14	molar relationship.mp	canine relationship.mp		S12 or S13
15	terminal plane.mp	molar relationship.mp		Open bite
16	9 or 10 or 11 or 12 or 13 or 14 or 15	((canine or molar) and relationship).mp		Anterior open bite OR asymmetric anterior open bite OR symmetric anterior open bite
17	Retrognathia/	terminal plane.mp		S15 or S16
18	Prognathism/	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17		Overbite OR over bite OR over-bite
19	17 or 18	Retrognathia/ or prognathia/		Overjet OR over jet OR over-jet
20	Open Bite/	Open Bite/		Crossbite OR cross bite OR cross-bite
21	(Anterior open bite or asymmetric anterior open bite or symmetric anterior open bite).mp	(open bite* or openbite* or open-bite*).mp.		Deepbite OR deep bite OR deep-bite
22	20 or 21	((asymmetric or symmetric) and anterior).mp		Index of Orthodontic Treatment Need OR IOTN
23	Overbite/	21 and 22		dental arch
24	(Overjet or over jet or over-jet).mp	(anterior open bite* or anterior openbite* or anterior open-bite*).mp.		Palate

† CINAHL: Cumulative Index to Nursing and Allied Health Literature.

**eTABLE (CONTINUED)**

Search Number/ Stage (#/s)	MEDLINE (OVID)	EMBASE (OVID)	SCOPUS	CINAHL <sup>†</sup> (EBSCO)	
<b>25</b>	(crossbite or cross bite or cross-bite).mp	20 or 23 or 24		growth, development and ageing	
<b>26</b>	(deepbite or deep bite or deep-bite).mp	(overbite* or over bite* or over-bite*).mp.		S11 or S14 or S17 or S18 or S19 or S20 or S21 or S22 or S23 or S24 or S25	
<b>27</b>	"Index of Orthodontic Treatment Need"/	(posterior adj3 occlusion*).mp		(S5 and S26) NOT cleft lip NOT cleft palate NOT (cleft lip and palate)	
<b>28</b>	Dental Arch/	(anterior adj3 occlusion).mp			
<b>29</b>	Palate/	(overjet* or over jet* or over-jet*).mp			
<b>30</b>	(Growth, development and ageing).mp	Crossbite/			
<b>31</b>	16 or 19 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30	(crossbite* or cross bite* or cross-bite*).mp			
<b>32</b>	8 and 31	30 or 31			
<b>33</b>	limit 32 to humans	(deep bite* or deepbite* or deep-bite*).mp			
<b>34</b>		(Index of Orthodontic Treatment Need or IOTN).mp			
<b>35</b>		dental arch*.mp			
<b>36</b>		Palate/ or palate*.mp			
<b>37</b>		(growth, development and ageing).mp			
<b>38</b>		18 or 19 or 25 or 26 or 27 or 28 or 29 or 32 or 33 or 34 or 35 or 36			
<b>39</b>		8 and 38			
<b>40</b>		limit 39 to human			
<b>Total Records</b>	<b>114</b>	<b>405</b>		<b>286</b>	<b>55</b>

## RESEARCH PUBLICATION 5

### ***The influence of orthodontic treatment on dental caries: An Australian cohort study.***

Doğramacı EJ, Brennan DS.

Community Dent Oral Epidemiol. 2019;47(3):210-216.

DOI: [10.1111/cdoe.12446](https://doi.org/10.1111/cdoe.12446)

PMID: 30656705

### **Contextual statement**

Having established the size of the association of modifiable environmental factors with malocclusions and the quality of Internet content translated from similar research to the lay public, the next part of the PhD turned to examining the longer-term consequences of untreated and treated malocclusions. The next three studies used data acquired from a prospective (longitudinal) study titled *Oral Health of Adults Entering their Fourth Decade*. This was a population oral health study that collected baseline data about the cohort participants residing in metropolitan Adelaide and regional centres of South Australia in 1988-1989 when participants were aged 13 years. A subsequent assessment, limited to participants from the original cohort residing in metropolitan Adelaide, who were then 30 years old, was undertaken in 2005-2006. Baseline data included malocclusion, assessed using the Dental Aesthetic Index (DAI).<sup>38</sup> Aside from socio-demographic details, data collected in the follow-up study included oral health, psychosocial outcomes, dental knowledge and behaviours, and receipt of orthodontic treatment. The Australian Research Centre for Population Oral Health (ARCPOH), based in the Adelaide Dental School at The University of Adelaide, coordinated the study and collected the data.

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<sup>38</sup> Cons NC, Jenny J, Kohout FJ. DAI: The Dental Aesthetic Index. Iowa City, IA: College of Dentistry. The University of Iowa. 1986.

Adelaide is a southern coastal city and the state capital of South Australia, which is the fourth largest and driest of all states and territories of Australia.<sup>39</sup> Adelaide has a population of 1,359,760,<sup>40</sup> which is more than three-quarters of the state population.<sup>41</sup> The median annual personal income in South Australia in the financial year ending on 30 June 2013, excluding government pensions and allowances, was AUD\$43,472,<sup>42</sup> with national census data from 2011 recording over 40% of people in South Australia holding a post-secondary qualification.<sup>42</sup>

Some of the pertinent outcomes associated with some malocclusion features include plaque retention,<sup>43</sup> impaction root resorption,<sup>44</sup> traumatic dental injury,<sup>45</sup> and psychosocial impact.<sup>46,47,48</sup> However, the chief concerns of patients seeking comprehensive fixed orthodontic treatment are mostly centred on improving dentofacial aesthetics,<sup>49,50,51,52</sup> and dental health.<sup>53,54</sup> Amongst the various expectations of orthodontic treatment is having fewer cavities later in life because of the belief that teeth will become easier to brush.<sup>55,56</sup>

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<sup>39</sup> McCaskill M, Richards ES. South Australia. Encyclopaedia Britannica. 2020. Available at:

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<sup>40</sup> 3218.0 Regional Population Growth, 2018-19. Australian Bureau of Statistics. Available at:

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<sup>41</sup> 3.101.0 Australian Demographic Statistics, Sep 2019. Australian Bureau of Statistics. Available at:

<https://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/3101.0Main%20Features3Sep%202019?opendocument&tabname=Summary&prodno=3101.0&issue=Sep%202019&num=&view=>

<sup>42</sup> South Australia (STE) (4). Last updated March 2017. Australian Bureau of Statistics. Available at:

[https://itt.abs.gov.au/itt/r.jsp?RegionSummary&region=4&dataset=ABS\\_REGIONAL\\_ASGS&geoconcept=REGION&datasetASGS=ABS\\_REGIONAL\\_ASGS](https://itt.abs.gov.au/itt/r.jsp?RegionSummary&region=4&dataset=ABS_REGIONAL_ASGS&geoconcept=REGION&datasetASGS=ABS_REGIONAL_ASGS)

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<sup>51</sup> Shaw WC, O'Brien KD, Richmond S. Quality control in orthodontics: factors influencing the receipt of orthodontic treatment. *Br Dent J.* 1991; 170: 66-68.

<sup>52</sup> Prabakaran R, Seymour S, Moles DR, Cunningham SJ. Motivation for orthodontic treatment investigated with Q methodology: patients' and parents' perspectives. *Am J Orthod Dentofacial Orthop.* 2012; 142: 213-220.

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<sup>54</sup> Van Wezel NA, Bos A, Prah C. Expectations of treatment and satisfaction with dentofacial appearance in patients applying for orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 2015; 147: 698-703.

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Therefore, the aim of the first study using the observational data from the *Oral Health of Adults Entering their Fourth Decade* research was to assess the influence of fixed orthodontic treatment on dental caries experience in adulthood. The principal dependent variable was the summed decayed, missing and filled teeth (DMFT) score, as well as the individual DMFT components. Explanatory variables comprised socio-demographic variables (sex, income and education level), dental health behaviour (last dental visit, tooth brushing frequency), and the orthodontic variables of baseline DAI (DAI<sub>13</sub>) and receipt of fixed orthodontic treatment. Unadjusted and adjusted negative binomial regression models were used for data analysis.

Research outcomes should be accessible to the lay public, particularly if such knowledge translation could increase knowledge and positively influence attitudes and subsequent health behaviours. The Internet and social media facilitate rapid communication in a virtual environment between users of diverse backgrounds who can be located anywhere in the world, compared to traditional means of communication. While a scientific publication in a journal targets a specific specialist audience, social media content are produced with a broader audience in mind,<sup>57</sup> given that the Internet is the principal source of information that the lay public use for learning about science.<sup>58</sup> Online videos are an interactive mode of communication, with YouTube, owned by Google, being the second most visited website in the world after Google.com.<sup>59</sup> Popular video channels are those that have professionally generated content, use a regular communicator to deliver content, and host fast-paced videos.<sup>60</sup> Therefore, a video abstract was commissioned from Research Square to help disseminate the study results. The screen captions were

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<sup>57</sup> Bubela T, Nisbet MC, Borchelt R, Brunger F, Critchley C, Einsiedel E, Geller G, Gupta A, Hampel J, Hyde-Lay R, Jandciu EW, Jones SA, Kolopack P, Lane S, Lougheed T, Nerlich B, Ogbogu U, O'Riordan K, Ouellette C, Spear M, Strauss S, Thavaratnam T, Willemse L, Caufield T. Science communication reconsidered. *Nat Biotechnol*. 2009; 27: 514-518.

<sup>58</sup> National Science Board. (2012). Science and engineering indicators. Available at: <https://wayback.archive-it.org/5902/20150629005406/http://www.nsf.gov/statistics/seind12/pdf/c07.pdf>

<sup>59</sup> Alexa. The top 500 sites on the web. Available at: <https://www.alexa.com/topsites>

<sup>60</sup> Welbourne DJ, Grant WJ. Science communication on YouTube: Factors that affect channel and video popularity. *Public Underst Sci*. 2016; 25: 706-718.

drafted in the initial proposal then edited in the draft video to increase their readability.<sup>61</sup>

The video, lasting 1.28 minutes, was published on the following three video channels:

- <https://www.youtube.com/watch?v=73c9-qlgoH0> (17 January 2019)
- <https://vimeo.com/312030018> (21 February 2019)
- <https://www.researchsquare.com/article/rs-5817/v1> (20 September 2019)

The University of Adelaide Media Team issued a press release for this publication, which was covered locally, nationally and internationally in traditional media and online.

### ***Key findings***

1. Caries experience in adulthood was not related to previous orthodontic treatment. Although orthodontically treated participants had lower mean DMFT scores, this did not reach statistical significance.
2. A basic level of secondary education and brushing less than twice a day was associated with greater levels of decayed teeth.
3. Females, lower income earners, those with a basic level of education and regular dental attenders had more missing teeth.
4. Those who saw a dentist regularly had more filled and missing teeth.

### ***Implications***

1. As caries experience in adulthood is not determined by one's past orthodontic treatment, prospective patients who hold dental health expectations as a motivator for seeking treatment should be informed that brushing at least twice a day and visiting a dentist regularly are better predictors of future caries experience.
2. Communication through traditional and social media are effective ways to translate research knowledge to the general public.

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<sup>61</sup> Flesch R. A new readability yardstick. *J Appl Psychol.* 1948; 32: 221-233.

## Statement of authorship

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Contribution to the Paper	Data preparation, analysis and interpretation, performed all formal statistical analyses, prepared the original draft, critically reviewed and edited the manuscript. Corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	27.7.2020

## Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

- i. the candidate's stated contribution to the publication is accurate (as detailed above);
- ii. permission is granted for the candidate to include the publication in the thesis; and
- iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	David S. Brennan		
Contribution to the Paper	Conceptualisation and design, funding acquisition, data acquisition, data curation, supervision, analysis and interpretation and critically reviewed the manuscript.		
Signature		Date	27.7.2020

# The influence of orthodontic treatment on dental caries: An Australian cohort study

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## Abstract

**Objective:** To assess the influence of orthodontic treatment on long-term caries experience in 30-year-old South Australians. The research hypothesis that was tested was that those with previous orthodontic treatment would have lower caries experience.

**Methods:** In 2005-2006, a sample of 1859 30-year-olds from Adelaide, South Australia, who comprised 47% of participants who had previously taken part in an oral epidemiology study in 1988-1989, were traced from the Australian electoral roll and invited to participate in a cross-sectional study investigating long-term dental health outcomes. Participants completed a questionnaire that collected information on socio-demographic characteristics, dental health behaviours and receipt of orthodontic treatment. This was followed by clinical examination. The outcome variables were the summed decayed, missing and filled teeth (DMFT) score, and its individual components. Data were analysed using negative binomial regression.

**Results:** The response rate for the questionnaire was 34% (n = 632). There were no systematic differences between those who were followed up and those who were not followed up. Clinical data for 448 participants were available for analyses, representing 24% of the originally contacted individuals. By the age of 30, over a third of participants had received orthodontic treatment. Regardless of initial malocclusion classification, orthodontically treated participants had a lower DMFT score at age 30 but this did not reach statistical significance. Adjusted models controlling for socio-demographic, dental health behaviour and malocclusion status showed no associations between orthodontic treatment and decayed (Exp B: 1.00, 95% CI: 0.72-1.40), missing (Exp B: 1.00, 95% CI: 0.59-1.69), or filled teeth (Exp B: 1.18, 95% CI: 0.93-1.51) or overall DMFT (Exp B: 1.12, 95% CI: 0.88-1.41).

**Conclusion:** There was no difference in the long-term caries experience of South Australians aged 30 years based on past orthodontic treatment. Our study does not support the contention that those treated orthodontically have better dental health later in life.

## KEYWORDS

caries, malocclusion, oral health, orthodontics, outcomes

A Video Abstract to accompany this article is available at <https://vimeo.com/312030018>.



## 1 | INTRODUCTION

Oral health encompasses physiological functions (speech, smell, taste, mastication, deglutition) and psychologically linked capabilities (smile, convey emotions through facial expressions), all of which should occur confidently and in the absence of pain, discomfort or disease.<sup>1</sup> Malocclusions, which have multifactorial aetiology,<sup>2,3</sup> can preclude attainment of oral health.<sup>4</sup> They comprise varying characteristics and a wide spectrum of severity. Imbrication, an overlap of incisors and canines owing to crowding,<sup>5</sup> is considered a very mild type of malocclusion that requires little or no need for treatment.<sup>6</sup> On the other hand, an impacted tooth, which is one that cannot erupt due to a tooth-dental arch size discrepancy, ectopia or a physical obstruction,<sup>7</sup> is categorized as having a very great need for treatment,<sup>6</sup> with pressure resorption being one of its most important consequences that can occur without any clinical signs or symptoms and no immediately obvious detriment to oral health.<sup>8</sup>

Patients principally seek comprehensive orthodontic treatment (normally comprising a fixed appliance of wires, brackets, bands or attachments to multiple teeth) to resolve aesthetic concerns.<sup>9-12</sup> An individual's unease with their teeth, specifically, an awareness that anterior malocclusions mar their dentofacial appearance, can cause embarrassment and low self-esteem,<sup>13</sup> leading to concealment or avoidance of smiling in social situations.<sup>14</sup> Oral health cannot, therefore, be ascribed to patients demonstrating such behaviours. Furthermore, children also cite dental health concerns when seeking orthodontic treatment.<sup>12,15</sup> While tooth irregularity has been shown to have a positive and significant association with plaque accumulation, its amount is clinically insignificant when considering the incidence of caries.<sup>16</sup> Moreover, short-term improvements in oral hygiene standards have been reported in orthodontically treated children; this oral health gain is believed to stem from behavioural factors rather than orthodontic alignment per se.<sup>17</sup> No high-level evidence exists to support the association of dental crowding with caries.<sup>18</sup>

There are few studies investigating the long-term dental outcomes of orthodontic treatment. Those paying for orthodontic treatment usually regard it as an investment,<sup>10-12</sup> consequently expecting positive changes that will remain long after active orthodontic treatment has ended.<sup>19</sup> One of the expectations is fewer cavities based on the notion that teeth will become easier to brush following orthodontic treatment.<sup>20,21</sup> It is therefore important to understand whether orthodontic treatment can provide definite long-term dental health benefits for all patients, irrespective of initial malocclusion severity and receipt of orthodontic treatment.

The aim of this study was to assess the influence of orthodontic treatment on dental caries experience in a cohort of 30-year-old adults. The research hypothesis that was tested was that those with previous orthodontic treatment would have lower caries experience.

## 2 | METHODS

The sampling of the participants at baseline and data collection over the course of the study are fully presented elsewhere.<sup>22-25</sup> In 1988-1989, a total of 3925 13-year-old children who had not previously received orthodontic treatment were clinically examined in the School Dental Clinics in South Australia. Over the following 2 years, 3262 children participated in a short-term study concerning orthodontic treatment. In 2005-2006, 1859 of the short-term study participants, who were then aged 30 years, were identified through the electoral roll as still living in metropolitan Adelaide and they were contacted to take part in the long-term study. Ethical approval for the study was obtained from The University of Adelaide; informed consent was obtained at each stage of the study.

At age 13 years, a participant's baseline untreated malocclusion was assessed against the Dental Aesthetic Index (DAI),<sup>26</sup> which was developed "...specifically to measure dental aesthetics...that deviate from societally accepted norms..." by placing "an individual's dental appearance along a continuum that ranges from excellent (DAI score = 13) to very poor (DAI Score = 80 or higher)." As the authors did not originally suggest an "arbitrary score ... as a cut-off point...,"<sup>26</sup> for the purposes of our study, each participant was allocated to one of four ordinal categories;  $\leq$ DAI 25—"normal plus minor malocclusion"; DAI 26-30—"definite malocclusion"; DAI 31-35—"severe malocclusion";  $\geq$ DAI 36—"very severe malocclusion."<sup>27</sup> At age 30 years, trained and calibrated dentists collected clinical information concerning decayed, missing and filled teeth from each participant during an oral epidemiological examination, according to NIDR procedures,<sup>28</sup> and a questionnaire collected information on multiple factors including socio-demographic variables, dental health behaviours and whether the participants had received orthodontic treatment between the ages of 13 and 30.<sup>24</sup>

The principal dependent variables were the summed decayed, missing and filled teeth (DMFT) score, as well as the individual DMFT components. With the exception of baseline DAI at the age of 13 (DAI<sub>13</sub>), the remaining explanatory variables were derived from the questionnaire.

Sex and receipt of orthodontic treatment were coded dichotomously so that female and having received orthodontic treatment were the reference variables, respectively. Tooth brushing frequency was coded into "0-13 times/wk" and " $\geq$ 14 times/wk," the latter equating to brushing at least twice a day, which also served as the reference variable. Income per annum was coded as  $<$ \$AUD80 000 and  $\geq$ \$AUD80 000. Education level was grouped into tertiles, with the reference variable comprising tertiary level associate diploma, diploma or degree. Last dental visit was similarly grouped into tertiles, with " $\geq$ 10 years ago, or never" serving as the reference variable. DAI<sub>13</sub> was coded into the aforementioned categories.

Data analysis firstly involved descriptive statistics; frequency distribution and cross-tabulation. The associations between the main explanatory variable of orthodontic treatment and dental outcomes were then investigated for each  $DAI_{13}$  category. Negative binomial regression was adopted as Poisson regression showed over-dispersion. Effect size was calculated using an on-line computer program (<https://www.uccs.edu/lbecker/> Dr Lee A. Becker Effect size calculators, University of Colorado - Colorado Springs, USA). Next, all explanatory variables were introduced into the adjusted negative binomial regression models based on their statistical significance from multiple linear regression [forward] models ( $P < 0.05$ ), in addition to some being empirically important conceptual variables based on our knowledge of the literature. Statistical significance was set at  $P < 0.05$ . IBM SPSS Statistics,

Version 24 software (IBM Corp., Armonk, NY) was used for statistical analyses.

### 3 | RESULTS

Of the 1859 original study participants who were traced and invited to join the long-term study, 632 returned the postal questionnaire, giving a response rate of 34%. Four hundred and seventy-three participants attended for clinical examination; 25 were excluded due to invalid study identification numbers or were determined to have been erroneously traced as study participants. Clinical data for 448 participants (252 female) were available for analysis, representing 24% of the originally contacted individuals. Given this

**TABLE 1** Unadjusted associations of caries experience at age 30

	Distribution (n)	DMFT	Decayed teeth	Missing teeth	Filled teeth
		Unadjusted mean (SE)	Unadjusted mean (SE)	Unadjusted mean (SE)	Unadjusted mean (SE)
<b>Socio-demographic</b>					
<b>Sex</b>					
Male	196	4.5 (0.3)	0.8 (0.1)	0.2* (0.1)	3.5 (0.3)
Female	252	4.9 (0.3)	0.7 (0.1)	0.3 (0.1)	3.9 (0.2)
<b>Income level</b>					
<\$80 000	320	4.8 (0.2)	0.8 (0.1)	0.4*** (0.1)	3.6 (0.2)
≥\$80 000	116	4.6 (0.4)	0.6 (0.1)	0.02 (0.0)	4.0 (0.4)
<b>Education level</b>					
≤Year 11	62	5.2 (0.6)	1.5*** (0.3)	0.7*** (0.3)	3.1 (0.4)
Year 12 or certificate	189	5.0 (0.3)	0.8 (0.1)	0.4*** (0.1)	3.9 (0.3)
Associate diploma/ diploma/degree	194	4.3 (0.3)	0.6 (0.1)	0.1 (0.0)	3.7 (0.3)
<b>Dental health behaviour</b>					
<b>Last dental visit</b>					
<2 y ago	269	5.2** (0.3)	0.6* (0.1)	0.3* (0.1)	4.3*** (0.2)
2-<10 y ago	127	4.2 (0.3)	1.1 (0.2)	0.2 (0.1)	3.0 (0.3)
≥10 y ago, or never	51	3.6 (0.5)	1.1 (0.3)	0.1 (0.1)	2.3 (0.4)
<b>Tooth brushing frequency</b>					
0-13 times/wk	240	4.9 (0.3)	1.0*** (0.1)	0.3 (0.1)	3.6 (0.2)
≥14 or more times/wk	208	4.6 (0.3)	0.6 (0.1)	0.2 (0.1)	3.8 (0.3)
<b>Orthodontic variables</b>					
<b><math>DAI_{13}</math></b>					
≤ $DAI_{13}$ 25	196	4.8 (0.3)	0.6** (0.1)	0.2** (0.1)	4.0 (0.3)
$DAI_{13}$ 26-30	114	4.1 (0.4)	0.6** (0.1)	0.2* (0.1)	3.3 (0.3)
$DAI_{13}$ 31-35	62	5.4 (0.6)	0.9 (0.2)	0.5 (0.2)	4.0 (0.4)
≥ $DAI_{13}$ 36	69	4.8 (0.6)	1.3 (0.3)	0.4 (0.3)	3.2 (0.4)
<b>Receipt of orthodontic treatment</b>					
No	291	5.0 (0.3)	0.7 (0.1)	0.3 (0.1)	4.0 (0.2)
Yes	157	4.3 (0.3)	0.8 (0.2)	0.3 (0.1)	3.2 (0.2)

CI, Confidence Interval;  $DAI_{13}$ , Dental Aesthetic Index at baseline age 13; DMFT, Decayed, Missing, Filled Teeth; Ref., Reference variable.

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$

**TABLE 2** Caries experience at age 30 by orthodontic treatment and baseline malocclusion severity

Group	Predictive variable – orthodontic treatment	Distribution (n)	DMFT			Decayed teeth			Missing teeth			Filled teeth		
			Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r
≤DAI <sub>13</sub> 25	No treatment	143	5.0 (0.4)	0.67	0.04	0.6 (0.1)	0.76	-0.02	0.2 (0.1)	0.27	-0.04	4.2 (0.3)	0.48	0.07
	Treatment	53	4.6 (0.5)			0.7 (0.2)			0.3 (0.2)			3.7 (0.4)		
DAI <sub>13</sub> 26-30	No treatment	82	4.1 (0.4)	0.74	0.04	0.4 (0.1)	0.01	-0.17	0.2 (0.0)	0.18	-0.11	3.5 (0.4)	0.17	0.15
	Treatment	32	3.8 (0.6)			1.0 (0.4)			0.3 (0.1)			2.5 (0.5)		
DAI <sub>13</sub> 31-35	No treatment	35	6.1 (0.7)	0.20	0.20	1.0 (0.3)	0.48	0.06	0.4 (0.2)	0.47	-0.04	4.7 (0.6)	0.11	0.27
	Treatment	27	4.3 (0.9)			0.7 (0.4)			0.6 (0.4)			3.0 (0.5)		
≥DAI <sub>13</sub> 36	No treatment	26	5.4 (1.2)	0.41	0.11	1.5 (0.4)	0.22	0.12	0.9 (0.7)	0.00	0.15	3.0 (0.6)	0.84	-0.03
	Treatment	43	4.3 (0.5)			1.0 (0.4)			0.1 (0.1)			3.1 (0.5)		
Entire cohort	No treatment	291	4.9 (0.3)	0.24	0.07	0.7 (0.1)	0.33	-0.03	0.3 (0.1)	0.86	-0.003	3.9 (0.2)	0.07	0.11
	Treatment	157	4.3 (0.3)			0.9 (0.2)			0.3 (0.1)			3.2 (0.2)		

DAI<sub>13</sub>, Dental Aesthetic Index at baseline age 13; DMFT, Decayed, Missing, Filled Teeth; SE, standard error. P values are all from test of model of effect, negative binomial regression.

low participation rate, a comparison of participants in the follow-up study to the baseline cohort was undertaken (Table S1). There was no difference in the country of birth or occupation of the parents of participants between baseline and follow-up, or any differences in dental characteristics. However, there were significantly more participants at follow-up who were female, had both parents who were tertiary educated, or came from a household not having a health care card.

Approximately a third of participants had been orthodontically treated by the age of 30 (Table 1). Sixty per cent of participants reported that their last dental visit was less than 2 years previously, and 46% of all participants reported tooth brushing at least twice a day. Nearly three quarters of participants had an annual income <\$AUD80 000. Eighty-six per cent of all participants completed the highest level of secondary education with over half of them obtaining tertiary qualifications. All caries outcomes were significantly associated with last dental visit; dental visiting was associated with more missing teeth (MT) and filled teeth (FT), and a higher DMFT score. Brushing at least twice a day was associated with fewer decayed teeth (DT) and MT, the former being statistically significant ( $P < 0.001$ ). In addition to last dental visit, education level, tooth brushing frequency and DAI<sub>13</sub> were associated with DT. MT was significantly associated with all explanatory variables except tooth brushing frequency and receipt of orthodontic treatment. Though none of the caries outcomes were significantly associated with receipt of orthodontic treatment, orthodontically treated participants had more DT and MT, but fewer FT and a lower DMFT score. MT and FT were highest for those with a severe malocclusion at baseline (DAI<sub>13</sub> 31-35). Twelve orthodontically treated participants had one or more missing teeth, while it was 32 within the untreated participants (data not presented).

There was proportionally greater receipt of orthodontic treatment in the more severe DAI<sub>13</sub> categories; nearly two-thirds of participants with a malocclusion scored as ≥DAI<sub>13</sub> 36 had orthodontic treatment compared with over a quarter in the ≤DAI<sub>13</sub> 25 category (Table 2). Orthodontically treated participants in each DAI<sub>13</sub> category consistently had a lower mean DMFT score than untreated participants, but this did not reach statistical significance, and the effect size was small. There were significantly more DT among those with a definite malocclusion (DAI<sub>13</sub> 26-30) who were treated orthodontically ( $P = 0.01$ ). Also, there were more MT among all participants who had orthodontic treatment across all DAI<sub>13</sub> categories except for those with very severe malocclusion (≥DAI<sub>13</sub> 36); there were significantly more MT amongst the untreated participants ( $P < 0.001$ ). The effect sizes for these statistically significant differences were small.

In the adjusted models, there were significantly lower numbers of DT among those with a baseline "normal plus minor," or "definite malocclusion" (≤DAI<sub>13</sub> 25 and DAI<sub>13</sub> 26-30) ( $P < 0.001$ ) (Table 3). Additionally, fewer teeth were missing in male participants (Exp B: 0.51; 95% CI: 0.30-0.86), but more MT were observed for those with lower income (Exp B: 12.98, 95% CI: 2.90-51.90) as well as participants with basic secondary education (Exp B: 6.94, 95% CI: 3.21-14.99). Brushing less than twice daily was associated with more decayed teeth (Exp B: 1.46, 95% CI: 1.06-2.01), while a dental visit



**TABLE 3** Adjusted models of caries experience at age 30

	DMFT	Decayed teeth	Missing teeth	Filled teeth
	Exp B (95% CI)	Exp B (95% CI)	Exp B (95% CI)	Exp B (95% CI)
<b>Socio-demographic</b>				
<b>Sex</b>				
Male	0.89 (0.71, 1.11)	1.13 (0.82, 1.55)	0.51 (0.30, 0.86)*	0.91 (0.72, 1.14)
Female	Ref.	Ref.	Ref.	Ref.
<b>Income level</b>				
<\$80 000	0.98 (0.75, 1.28)	0.92 (0.63, 1.35)	12.28 (2.90, 51.90)**	0.94 (0.72, 1.23)
≥\$80 000	Ref.	Ref.	Ref.	Ref.
<b>Education level</b>				
≤Year 11	1.27 (0.90, 1.78)	2.80 (1.80, 4.35)***	6.94 (3.21, 14.99)***	0.93 (0.65, 1.33)
Year 12 or certificate	1.19 (0.93, 1.53)	1.11 (0.77, 1.59)	3.43 (1.72, 6.83)***	1.18 (0.92, 1.51)
Associate diploma/diploma/degree	Ref.	Ref.	Ref.	Ref.
<b>Dental health behaviour</b>				
<b>Last dental visit</b>				
<2 y ago	1.59 (1.10, 2.30)*	0.67 (0.41, 1.10)	16.32 (2.15, 124.12)**	1.80 (1.22, 2.66)**
2-<10 y ago	1.24 (0.83, 1.86)	1.35 (0.80, 2.28)	9.50 (1.21, 74.88)*	1.19 (0.78, 1.80)
≥10 y ago, or never	Ref.	Ref.	Ref.	Ref.
<b>Tooth brushing frequency</b>				
0-13 times/wk	1.09 (0.87, 1.36)	1.46 (1.06, 2.01)*	0.94 (0.55, 1.58)	1.03 (0.82, 1.29)
≥14 or more times/wk	Ref.	Ref.	Ref.	Ref.
<b>Orthodontic variables</b>				
<b>DAI<sub>13</sub></b>				
≤DAI <sub>13</sub> 25	0.98 (0.70, 1.34)	0.47 (0.30, 0.72)***	0.58 (0.30, 1.10)	1.21 (0.86, 1.69)
DAI <sub>13</sub> 26-30	0.81 (0.57, 1.15)	0.44 (0.27, 0.70)***	0.52 (0.25, 1.10)	0.96 (0.67, 1.38)
DAI <sub>13</sub> 31-35	1.06 (0.72, 1.57)	0.61 (0.37, 1.03)*	1.37 (0.66, 2.87)	1.16 (0.77, 1.75)
≥DAI <sub>13</sub> 36	Ref.	Ref.	Ref.	Ref.
<b>Receipt of orthodontic treatment</b>				
No	1.12 (0.88, 1.41)	1.00 (0.72, 1.40)	1.00 (0.59, 1.69)	1.18 (0.93, 1.51)
Yes	Ref.	Ref.	Ref.	Ref.

CI, Confidence Interval; DAI<sub>13</sub>, Dental Aesthetic Index at baseline age 13; DMFT, Decayed, Missing, Filled Teeth; Exp, Exponentiated; Ref., Reference variable.

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$

within the last 2 years was associated with a higher DMFT score (Exp B: 1.59, 95% CI: 1.10-2.30) reflecting more missing (Exp B: 16.32, 95% CI: 2.15-124.12) and filled teeth (Exp B: 1.80, 1.22-2.66).

## 4 | DISCUSSION

Our study showed that a little over a third of participants had received orthodontic treatment by the age of 30 years. There was also a consistent but non-significant lower DMFT score among orthodontically treated participants across all DAI<sub>13</sub> categories; there were no other consistent caries outcomes on the basis of past orthodontic treatment, which is in agreement with previous studies.<sup>19,29-31</sup> Socio-demographic variables and dental health behaviours had a greater

impact on long-term caries outcomes than the receipt of orthodontic treatment, regardless of initial malocclusion severity.

Our study only traced participants from the original study who lived in metropolitan Adelaide. This limitation, owing to a lack of resources, restricted the scope of the follow-up study and contributed to the permanent loss to follow-up of over half of the original cohort. Thus, 47% of the original participants were contacted, which is considered an adequate follow-up rate.<sup>32</sup> Data for the present study were derived from what was effectively a sub-sample of the original study population. Only a third of those traced and invited to the long-term study returned the questionnaire, of whom 71% had clinical and non-clinical data available for analysis. Thus, our final response rate from those contacted was 24%; those who did not respond or were not assessed were considered as missing completely at random (MCAR),<sup>33</sup>



particularly since the nature of our investigation was a prospective, observational one. While potential data from MCAR participants can be ignored,<sup>34</sup> we recognize that our analyses may consequently be statistically underpowered.<sup>35</sup> Although no difference in oral health status, including  $DAI_{13}$ , was found between the long-term study participants against the cohort's baseline characteristics,<sup>36</sup> the 2005-2006 study had proportionally more participants who had higher household income and whose parents had received tertiary education.<sup>36</sup> Therefore, our findings are generalizable to the residents of metropolitan Adelaide belonging to higher socio-economic status groups.

A second limitation of our study was that data on potential confounders that are known to promote dysbiosis of the oral biofilm and contribute to caries, such as diet and fluoride use,<sup>37</sup> were not collected. Nonetheless, tooth brushing, an important aspect of any participant's oral hygiene habits, was one of the important explanatory variables for decay alongside education level and a  $DAI_{13}$  of 30 or less. It is important to highlight that although a participant's oral hygiene habits may have changed between the ages of 13 and 30, oral hygiene is only one of several aetiological factors influencing caries experience.<sup>37</sup>

A third limitation of the study was the reliance on self-reported questionnaires, particularly regarding missing teeth. No dental records were available during the oral epidemiological examinations to corroborate the cause of a missing permanent tooth. We observed that while more participants amongst the  $\geq DAI_{13}$  36 category had received orthodontic treatment, they also proportionally had the lowest number of teeth lost to caries. This finding was contrary to the pattern within the remaining categories. An orthodontic treatment plan may include the extraction of teeth, so that the malocclusion is transformed into a stable and functional occlusion that is also dentofacially aesthetic. Variables considered when deciding whether and which teeth to extract have been classified as sagittal and vertical dentoskeletal and soft tissue relationships, transverse dental relationships, intra-arch and pathological conditions.<sup>38,39</sup> Where extractions are required, it is preferable to extract a tooth with a poor long-term prognosis, such as those that are pathologically compromised, rather than selecting healthy, unrestored teeth. Malformed, carious and unrestorable teeth, as well as those with periapical lesions, or complete veneer crowns are the most important conditions that can influence the choice for orthodontic extractions.<sup>39</sup> Therefore, it is possible that the number of teeth missing due to caries amongst this category is under-estimated and extractions were incorrectly remembered as being for orthodontic purposes. This may result from recall bias, poor clinician-patient communication at the time of extraction, or Hawthorne effect may have caused the participants to inaccurately report teeth missing for orthodontic reasons, whereas the carious status may have dictated their loss.

Elective orthodontic treatment is often sought by patients to ameliorate features of their dentofacial appearance that they find disagreeable. Amongst children, those who have more severe dental irregularities that are visible, as well as those who have been teased frequently about their teeth, often report dissatisfaction with their dental appearance and request

orthodontic treatment to resolve this.<sup>9,10</sup> The number of participants in our study who received orthodontic treatment by the age of 30 years was relatively fewer than in a similar study in the United Kingdom.<sup>40</sup> Over half of our participants with a  $DAI_{13}$  of 31 or more received orthodontic treatment, which is equivalent to findings from a study in New Zealand.<sup>29</sup>

When a patient presents requesting orthodontic treatment, it is essential that aside from identifying the features of malocclusions they present with, the clinician understands whether the particular patient will benefit from treatment. The dialogue between the clinician and patient, as well as their parent or guardian, must be a candid two-way conversation discussing treatment aims, the expected benefits and pertinent risks, as well as alternative approaches for treatment. Unrealistic patient expectations, such as seeking orthodontic treatment to reduce one's future experience of caries, needs to be carefully refuted, relying on high-level evidence. Confirming that a patient (or their guardian) has correctly understood the discussions held between them and the clinician is not only central to the shared decision-making process, but is paramount to obtaining valid and informed consent.<sup>41</sup>

## 5 | CONCLUSIONS

Within the study limitations, the caries experience of 30-year-old South Australian adults is not associated with orthodontic treatment earlier in life. Caries experience is related to education and income levels, frequency of tooth brushing as well as dental visiting. Orthodontic treatment does not provide better long-term dental outcomes in relation to caries. The research hypothesis that those with previous orthodontic treatment would have lower caries experience was not upheld. Therefore, future caries experience should not be proposed as an indication, or accepted as a justification, for the provision of orthodontic treatment.

## ACKNOWLEDGEMENTS

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**How to cite this article:** Dođramacı EJ, Brennan DS. The influence of orthodontic treatment on dental caries: An Australian cohort study. *Community Dent Oral Epidemiol.* 2019;47:210–216. <https://doi.org/10.1111/cdoe.12446>

**Supplemental table 1:**

**Sociodemographic and dental characteristics of participants examined at baseline and follow-up**

	<b>Baseline n=3293</b>	<b>Follow-up n=632</b>	<b>P value</b>
<b>Socio-demographic</b>			
Participant sex			
% Female	48.5	55.7	<0.01
Male parent			
% Australian-born	70.6	68.0	0.23
Education level			
Primary	7.8	7.9	
Secondary	71.1	62.8	
Tertiary	21.1	29.4	<0.01
Working in a job or business	90.5	93.4	0.03
Occupation			
Manager/administrator	29.4	29.6	
Professional	11.7	15.5	
Para-professional	8.2	9.3	
Tradesperson	19.7	19.4	
Clerks	5.9	5.6	
Sales/personal services	5.4	4.4	
Plant/machine operators	11.3	8.9	
Labourers	8.5	7.3	0.23
Female parent			
% Australian-born	74.3	76.1	0.53
Education level			
Primary	4.7	4.3	
Secondary	79.4	75.3	
Tertiary	16.0	20.4	0.03
Working in a job or business	61.0	62.8	0.32
Occupation			
Manager/administrator	15.7	12.9	
Professional	11.6	11.1	
Para-professional	8.2	9.5	
Tradesperson	3.3	2.4	
Clerks	26.4	32.4	
Sales/personal services	16.8	16.8	
Plant/machine operators	4.0	2.6	
Labourers	13.9	12.4	0.22
Household/family			
Covered by a health care card	32.3	26.6	<0.01
Weekly income: over \$500	42.7	49.4	0.05
<b>Dental variables</b>			
Mean DAI score (SE)	28.1 (0.2)	28.0 (0.3)	0.36
Mean DMFT score (SE)	2.1 (0.00)	2.0 (0.1)	0.90

DAI: Dental Aesthetic Index; DMFT: Decayed, Missing, Filled Teeth; SE: standard error



## RESEARCH PUBLICATION 6

### *The long-term influence of orthodontic treatment on adults' psychosocial outcomes: An Australian cohort study.*

Doğramacı EJ, Brennan DS.

Orthod Craniofac Res. 2019;22(4):312-320.

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#### **Contextual statement**

The presence of dentofacial characteristics that deviate from normal in prospective adolescent orthodontic patients is associated with increased incidence of bullying.<sup>62</sup> This may be a reason for patients (or their parents/carers) to seek orthodontic treatment, whereas others may wish to secure general improvements in their overall psychosocial functioning,<sup>63,64,65</sup> this view being supported by some general dental practitioners and orthodontists.<sup>66,67</sup> However, positive short- and long-term effects are yet to be demonstrated following orthodontic treatment.<sup>68,69,70</sup> Moreover, a prospective study was unable to show psychological disadvantage amongst adults who did not have orthodontic

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treatment where there was a need.<sup>69,70,71</sup> Therefore, the aim of the second study using the observational data from the *Oral Health of Adults Entering their Fourth Decade* research was to examine the influence of fixed orthodontic treatment on psychosocial outcomes in adulthood. The principal outcome variables were self-efficacy; the strength of a person's belief of their ability to respond to new or difficult situations and dealing with any associated setbacks or obstacles,<sup>72</sup> health competence; the extent that a person feels successful in managing their own health outcomes,<sup>73</sup> social support; the social support the responder believes they receive from family, friends and significant others,<sup>74</sup> and optimism.<sup>75</sup> These scales were used as they "...have been widely adopted in the literature, have well established psychometric properties and cover a broad range of psychosocial dimensions..."<sup>76</sup> The explanatory variables were essentially the same as in the first study, namely socio-demographic variables (sex, income and education level), dental health behaviour (last dental visit, tooth brushing frequency), and the orthodontic variables of baseline DAI (DAI<sub>13</sub>) and receipt of fixed orthodontic treatment. Cronbach's alpha was used to assess internal reliability for each outcome variable, and associations were assessed with unadjusted simple and adjusted generalised linear models.

The University of Adelaide Media Team coordinated a press-release of this research article, with the research subsequently covered locally, nationally and internationally in traditional media, including newspapers and live radio interviews with stations in three Australian states, as well as online coverage. This research article achieved a high Altmetric attention score and became the highest scoring paper ever published in

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### **Key findings**

1. Regardless of initial severity of malocclusion, previous orthodontic treatment was not related to better psychosocial outcomes in adulthood when compared to those who did not receive treatment. Higher psychosocial scores were found in untreated participants, this being significant for optimism.
2. Higher income earners had better psychosocial outcomes for all measures, whereas those with basic secondary level education had the lowest psychosocial scores.
3. Initial severity of malocclusion was not predictive of psychosocial outcomes in adulthood, although those with an initial definite malocclusion were most optimistic in adulthood.
4. Those practising optimal dental behaviours (brushing at least twice a day, regular dental visits) had higher psychosocial functioning.

### **Implications**

1. At a population level, there is no evidence that previous orthodontic treatment confers any psychosocial benefit in adulthood, regardless of the initial malocclusion severity. Patients seeking orthodontic treatment on this basis should have such expectations sensitively moderated, using the highest-level of evidence possible.
2. Lack of orthodontic treatment, regardless of initial malocclusion severity, does not diminish psychosocial functioning in adulthood.
3. Socio-demographic factors are more important predictors of psychosocial functioning, followed by dental health behaviours.

## Statement of authorship

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Name of Principal Author (Candidate)	Esma J Dođramacı		
Contribution to the Paper	Data preparation, analysis and interpretation, performed all formal statistical analyses, prepared the original draft, critically reviewed and edited the manuscript. Corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	27.7.2020

## Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

- i. the candidate's stated contribution to the publication is accurate (as detailed above);
- ii. permission is granted for the candidate to include the publication in the thesis; and
- iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	David S. Brennan		
Contribution to the Paper	Conceptualisation and design, funding acquisition, data acquisition, data curation, supervision, analysis and interpretation and critically reviewed the manuscript.		
Signature		Date	27.7.2020

# The long-term influence of orthodontic treatment on adults' psychosocial outcomes: An Australian cohort study

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## Abstract

**Objectives:** To assess the influence of orthodontic treatment on psychosocial outcomes in 30-year-olds. The research hypothesis tested was that participants previously treated orthodontically would have better psychosocial outcomes.

**Setting and Sample Population:** A prospective longitudinal cohort design was used to follow-up a sample of 1859 30-year-olds from Adelaide, South Australia, who had previously participated in an oral epidemiology study.

**Materials and methods:** Clinical examination in 1988-1989 recorded participants' malocclusion severity. In 2005-2006, participants were invited to complete a questionnaire collecting data on socio-demographic characteristics, dental health behaviours, receipt of orthodontic treatment and psychosocial factors. Data were analysed descriptively and by linear regression models.

**Results:** Data for 448 participants were available; 56% of participants were female. Over a third of participants had received orthodontic treatment. Higher income earners had the best psychosocial outcomes while participants with a basic level of secondary education had the lowest. Regardless of initial malocclusion severity, orthodontic treatment was not associated with better psychosocial outcomes. Instead, a pattern of better psychosocial outcome was observed amongst untreated participants, regardless of malocclusion severity, this being significant for optimism. Adjusted models controlling for socio-demographic, dental health behaviour and malocclusion severity showed no association between orthodontic treatment and self-efficacy, health competence or social support. There was, however, a strong association with optimism.

**Conclusion:** There was no difference in long-term psychosocial outcomes based on orthodontic treatment. Our study does not support the contention that orthodontic treatment produces better psychosocial functioning later in life.

## KEYWORDS

corrective/psychology, longitudinal studies, malocclusion/psychology, orthodontics, prospective studies, treatment outcome





## 1 | INTRODUCTION

Orthodontic treatment aims to resolve malocclusions, which have multifactorial aetiology.<sup>1,2</sup> The need for orthodontic treatment has traditionally been focused on clinical criteria assessing morphological features and ranking them in a hierarchy of severity. For example, imbrication, a mild type of malocclusion, is classified as requiring little or no treatment.<sup>3</sup> On the other hand, a very great need for treatment is ascribed for an impacted tooth,<sup>3</sup> which is one that is unable to erupt due to tooth-dental arch size discrepancy, ectopia or physical obstruction.<sup>4</sup> As severe pressure resorption, which is often asymptomatic, can negatively impact on the longevity of affected teeth,<sup>5</sup> malocclusions with such teeth require prompt management. Although clinical criteria are principally used for determining eligibility for orthodontic treatment, particularly for state-subsidized courses of care, they are not the only factors clinicians consider when deciding on the appropriateness of treatment. A patient's demonstration of and commitment to maintaining an excellent standard of oral hygiene is critical in order to avoid demineralization or periodontal disease during the course of treatment. Motivation for treatment and financial considerations are additional important factors.

Orthodontic treatment planning focusses on correcting features that deviate from normal, with orthodontists often guided by Andrew's six keys.<sup>6</sup> Treatment plans negotiated with patients, their parents or carers focus on the technical changes to the malocclusion, even though patients commonly cite aesthetic concerns as their principal motivation for seeking orthodontic treatment.<sup>7-10</sup> Thus, outcomes of treatment have typically emphasized aspects that can be technically achieved with certainty, with minimal attention given to patient-centred values. Psychosocial improvements may be cited by patients as expected outcomes of orthodontic treatment,<sup>10-12</sup> a view shared by some general dental practitioners and orthodontists.<sup>13,14</sup> This likely stems from the belief that a visible malocclusion can cause psychosocial problems in the affected individual, despite a lack of evidence to support this. Psychological or social factors, however, are not specifically identified by orthodontists for management within an orthodontic treatment plan. Prospective studies have reported that the presence of a malocclusion in childhood, or lack of orthodontic treatment amongst adults who needed orthodontic treatment earlier in life, does not produce any psychological disadvantage.<sup>15-17</sup> Positive psychosocial effects in the short-term or long-term after active orthodontic treatment has ended have yet to be demonstrated.<sup>16-18</sup>

In the absence of definitive evidence showing that orthodontic treatment can bring about positive psychological and social outcomes in patients, this study aimed to assess the role of orthodontic treatment on the long-term psychosocial outcomes in a cohort of 30-year-old adults in Adelaide, Australia. The research hypothesis tested was that participants who were previously treated orthodontically would have better psychosocial outcomes.

## 2 | MATERIALS AND METHODS

### 2.1 | Participants, setting and data collection

The data analysed were collected by the Australian Research Centre for Population Oral Health—The University of Adelaide over the course of the study. In 1988-1989, 3925 13-year-old children were clinically examined in the School Dental Clinics located in metropolitan Adelaide and regional centres of South Australia, Australia. None of the children had previously received orthodontic treatment. Over the next two years, 3262 of these children participated in a short-term study about orthodontic treatment. In 2005-2006, 1859 of the short-term study participants, then aged 30 years, were identified through the electoral roll as living in metropolitan Adelaide. They were contacted to participate in the long-term study titled "Oral Health of Adults Entering their Fourth Decade," a population oral health study focused on oral epidemiology. Participants were surveyed by a mailed self-complete questionnaire that collected data on self-reported socio-demographics, dental behaviour, receipt of fixed orthodontic treatment and psychosocial factors. Participants living in regional South Australia were not contacted for follow-up owing to limited resources at the follow-up phase. Full details of sampling of participants at baseline, as well as data collection over the course of the study, are presented elsewhere.<sup>19-21</sup> Ethical approval was obtained from the University of Adelaide (Human Research and Ethics Committee approval: H-04-2004), with informed consent obtained at each stage over progression of the study.

### 2.2 | Outcome measures

Psychosocial factors assessed were self-efficacy, health competence, social support and optimism.

#### 2.2.1 | Self-efficacy

The English version of the General Self-Efficacy Scale (GSES) was used to assess this outcome.<sup>22</sup> This 10-item scale assesses the strength of a person's belief of their ability to respond to new or difficult situations and dealing with any associated setbacks or obstacles. The GSES uses a 4-point Likert scale coded as 4 = exactly true, 3 = moderately true, 2 = hardly true and 1 = not at all true. All item responses are summed to produce a total score. The higher the score, the greater the individual's general sense of self-efficacy.

#### 2.2.2 | Health competence

The Perceived Health Competence Scale (PHCS) was used to measure this outcome.<sup>23</sup> This scale uses eight items to measure the extent that a person feels successful in managing their own health outcomes. The PHCS uses a 5-point Likert scale coded as 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree and 1 = strongly disagree. Four of the items are negatively worded, so agreement denotes low perceived competence. Therefore, these items are reverse-scored



prior to adding with the remaining four items to produce the overall PHCS score; higher values suggest greater confidence in self-management of health.

### 2.2.3 | Social support

The Multidimensional Scale of Perceived Social Support (MSPSS) was used to investigate this variable.<sup>24</sup> The 12-item scale subjectively captures the social support the responder believes they receive from family, friends and significant others. Responses are provided on a 5-point Likert scale, ranging from 5 = strongly agree to 1 = strongly disagree. Summing the responses to each item produces a total score with higher scores indicating increased levels of social support.

### 2.2.4 | Optimism

The Life Orientation Test (LOT) was used to assess optimism.<sup>25</sup> Specifically, there are eight items with equal numbers of positively and negatively worded items. Additionally, there are four filler items that act to conceal the underlying objective of the test. Participants indicate their response to each item on a 5-point Likert scale ranging from 5 = strongly agree to 1 = strongly disagree. Prior to calculating the sum total, filler items are excluded, and responses to negatively worded items are reversed. Higher scores demonstrate greater levels of optimism.

As all outcome measures were recorded on Likert scales, the scores were therefore treated as continuous variables.

## 2.3 | Explanatory variables

At age 13 years, a participant's baseline untreated malocclusion was assessed against the Dental Aesthetic Index (DAI<sub>13</sub>).<sup>26</sup> This index was published in 1986 and predates other indices, such as the Index of Orthodontic Treatment Need,<sup>3</sup> hence its selection for this study. It was developed "...specifically to measure dental aesthetics...that deviate from societally accepted norms..." by placing "an individual's dental appearance along a continuum that ranges from excellent (DAI score = 13) to very poor (DAI score = 80 or higher)." Each participant was then allocated into one of four nominal categories:  $\leq$ DAI<sub>13</sub> 25—normal plus minor malocclusion, DAI<sub>13</sub> 26-30—definite malocclusion, DAI<sub>13</sub> 31-35—severe malocclusion and  $\geq$ DAI<sub>13</sub> 36—very severe malocclusion.<sup>27</sup> Data for the remaining explanatory variables were derived from the self-completed questionnaire. As the study was focused broadly on population oral health, there was a single nested orthodontic question, whether the participant had received fixed orthodontic treatment or not. Due to the longitudinal and observational nature of the study, the incidental exposure to orthodontic treatment permitted natural division of the cohort according to either receipt or otherwise of treatment, thus creating a comparison group. Clinical factors such as the exact nature of orthodontic treatment received, achievement (or otherwise) of treatment objectives and retention/relapse were beyond the scope of this study. Sex and receipt of orthodontic treatment (ie fixed orthodontic treatment)

were coded dichotomously.<sup>28</sup> Tooth brushing was coded as "0-13 times per week" and "more than or equal to 14 times per week," with the latter being equivalent to brushing at least twice a day.<sup>28</sup> Income per annum was also coded dichotomously as  $<$ \$AUD80 000 and  $\geq$ \$AUD80 000. Education level and last dental visit were grouped into tertiles.<sup>28</sup>

## 2.4 | Statistical analysis

A comparison of characteristics of participants in the baseline and long-term study was performed in order to elucidate any difference in their representativeness.<sup>28</sup> Internal reliability for each outcome variable was measured using Cronbach's alpha. Data analysis initially comprised descriptive statistics, frequency distribution and cross-tabulation via simple linear regression models. Associations between the main explanatory variable of orthodontic treatment and each psychosocial outcome were then investigated for each DAI<sub>13</sub> category also using simple linear regression. Effect size was calculated using an online computer program (<https://www.uccs.edu/lbecker/> Dr Lee A. Becker Effect size calculations, University of Colorado—Colorado Springs, USA). Finally, all explanatory variables were introduced into the adjusted generalized linear models. Statistical significance was set at  $P < 0.05$ . All analyses were performed using IBM SPSS Statistics, version 25 software (IBM Corp. Armonk, NY).

## 3 | RESULTS

Of the 1859 original study participants invited to participate in the long-term study, 632 responded by returning the questionnaire; up to four follow-up mailings were sent to non-responders. This produced a response rate of 34%. After exclusion of invalid study identification numbers as well as individuals who were traced erroneously, data for 448 participants were available for analysis, representing 24% of the original study participants. There were significantly more female participants in the long-term study, as well as participants who came from a household not having a health care card, or where both parents were educated at tertiary level.<sup>28</sup> High internal consistency ratings were found for each of the instruments used to assess the psychosocial outcomes, with the coefficient alpha being: GSES, 0.88; PHCS, 0.85; MSPSS, 0.92 and LOT, 0.85.

Over a third of participants received orthodontic treatment by the age of 30 (Table 1). Sixty per cent had visited a dental health care professional (dental surgeon, dental specialist, hygienist, therapist and/or dental technician) within the previous two years. Almost half of the participants reported brushing their teeth at least twice a day. Socio-demographic variables, particularly income and education level, were strongly associated with every psychosocial outcome. Scores were highest amongst participants earning  $\geq$ \$AUD80 000, who comprised over a quarter of the study cohort, whereas the lowest scores for each outcome were always attained by participants with a basic level of secondary education ( $P < 0.05$ ). Tooth brushing at least twice a day was associated with higher scores for all



**TABLE 1** Unadjusted association of psychosocial outcomes at age 30

	Distribution (n)	Self-efficacy		Perceived health competence		Social support		Optimism	
		Unadjusted mean (SE)	P	Unadjusted mean (SE)	P	Unadjusted mean (SE)	P	Unadjusted mean (SE)	P
Socio-demographic									
Sex									
Male	196	32.63 (0.34)	0.63	29.40 (0.35)	0.03	49.28 (0.61)	0.00	21.40 (0.39)	0.09
Female	252	32.23 (0.24)	Ref.	30.11 (0.30)	Ref.	52.07 (0.48)	Ref.	21.74 (0.29)	Ref.
Income level									
<\$80 000	320	32.03 (0.24)	0.00	29.34 (0.26)	0.00	49.87 (0.47)	0.00	21.17 (0.28)	0.00
≥\$80 000	116	33.43 (0.38)	Ref.	31.10 (0.43)	Ref.	53.46 (0.60)	Ref.	22.74 (0.41)	Ref.
Education level									
≤Year 11	62	30.13 (0.68)	0.00	27.14 (0.61)	0.00	47.60 (1.21)	0.00	20.00 (0.77)	0.00
Year 12 or certificate	189	32.40 (0.29)	0.08	30.04 (0.34)	0.41	50.74 (0.59)	0.15	21.54 (0.36)	0.05
Associate diploma/ diploma/degree	194	33.07 (0.28)	Ref.	30.37 (0.33)	Ref.	51.84 (0.54)	Ref.	22.08 (0.33)	Ref.
Dental health behaviour									
Last dental visit									
<2 y ago	269	32.55 (0.27)	0.70	30.04 (0.29)	0.00	51.93 (0.46)	0.00	21.74 (0.30)	0.01
2-<10 y ago	127	32.16 (0.33)	0.99	30.08 (0.38)	0.00	49.42 (0.75)	0.15	21.50 (0.44)	0.03
≥10 y ago, or never	51	32.29 (0.71)	Ref.	27.66 (0.78)	Ref.	48.43 (1.31)	Ref.	20.93 (0.76)	Ref.
Tooth brushing frequency									
0-13 times/week	240	32.07 (0.29)	0.03	29.06 (0.31)	0.00	49.77 (0.53)	0.00	21.30 (0.33)	0.00
≥14 or more times/week	205	32.79 (0.28)	Ref.	30.64 (0.32)	Ref.	52.02 (0.55)	Ref.	21.92 (0.34)	Ref.
Orthodontic variables									
DAI <sub>13</sub>									
≤DAI <sub>13</sub> 25	196	32.66 (0.30)	0.44	30.11 (0.34)	0.08	51.28 (0.55)	0.32	21.88 (0.35)	0.01
DAI <sub>13</sub> 26-30	114	32.35 (0.41)	0.43	30.34 (0.40)	0.03	51.21 (0.70)	0.48	22.53 (0.44)	0.00
DAI <sub>13</sub> 31-35	62	31.67 (0.60)	0.17	28.79 (0.58)	0.55	49.25 (1.19)	0.13	20.81 (0.66)	0.98
≥DAI <sub>13</sub> 36	69	32.41 (0.44)	Ref.	28.96 (0.65)	Ref.	50.30 (1.09)	Ref.	19.95 (0.60)	Ref.
Receipt of orthodontic treatment									
No	291	32.58 (0.25)	0.26	30.05 (0.28)	0.08	51.08 (0.46)	0.27	22.03 (0.28)	0.01
Yes	157	32.08 (0.33)	Ref.	29.33 (0.38)	Ref.	50.36 (0.70)	Ref.	20.78 (0.41)	Ref.

Abbreviations: DAI<sub>13</sub>, Dental Aesthetic Index at baseline age 13; Ref., reference variable; SE, standard error.

psychosocial variables ( $P < 0.05$ ), and a dental visit within the previous two years was associated with higher health competence, social support and optimism scores ( $P < 0.05$ ). Orthodontic treatment was not related to better psychosocial outcomes. On the contrary, higher psychosocial outcomes were observed in participants who did not receive orthodontic treatment, this being significant for optimism ( $P < 0.05$ ). Participants with a baseline definite malocclusion had significantly higher health competence and optimism ( $P < 0.05$ ).

Stratified distribution of malocclusion with orthodontic treatment showed that those with increasing severity of malocclusion had proportionally greater receipt of orthodontic treatment (Table 2). Sixty-three per cent of participants in the  $\geq$  DAI<sub>13</sub> 36 category had orthodontic treatment against 27% in the  $\leq$  DAI<sub>13</sub> 25 category. Participants with a definite malocclusion (DAI<sub>13</sub> 26-30) who did not

receive treatment had higher psychosocial outcomes compared to those who received treatment; this was significant for self-efficacy and optimism ( $P < 0.05$ ). Participants with a very severe malocclusion ( $\geq$  DAI<sub>13</sub> 36) who received orthodontic treatment had higher health competence, social support and optimism, but this did not reach statistical significance, and the effect size was small. Untreated participants across the entire cohort had higher psychosocial outcomes; statistical significance was only reached for optimism ( $P < 0.05$ ).

The adjusted models confirmed the important unadjusted effects of socio-demographic and dental health behaviours on psychosocial outcomes (Table 3). Significantly, higher income earners had better psychosocial outcomes in all measures, whereas those with basic secondary level education had the lowest scores. Females were found to have higher scores for social support ( $P < 0.05$ ). Health



**TABLE 2** Psychosocial outcomes at age 30 by orthodontic treatment and baseline malocclusion

Group	Predictive variable—orthodontic treatment	Distribution (n)	Self-efficacy			Perceived health competence			Social support			Optimism		
			Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r	Unadjusted mean (SE)	P	Effect size r
≤DAI <sub>13</sub> 25	No treatment	143	32.38 (0.35)	0.18	0.11	30.40 (0.36)	0.05	-0.15	51.38 (0.60)	0.60	-0.04	21.80 (0.39)	0.83	-0.02
	Treatment	53	33.25 (0.47)			28.96 (0.70)			50.75 (1.09)			21.64 (0.63)		
DAI <sub>13</sub> 26-30	No treatment	82	33.35 (0.44)	0.01	-0.28	30.90 (0.45)	0.05	-0.20	51.07 (0.78)	0.76	-0.03	23.51 (0.44)	0.00	-0.33
	Treatment	32	30.91 (0.76)			29.16 (0.76)			50.63 (1.31)			20.34 (0.91)		
DAI <sub>13</sub> 31-35	No treatment	35	30.91 (1.19)	0.79	0.04	28.06 (1.16)	0.68	0.05	48.89 (2.09)	0.42	-0.10	19.71 (11.15)	0.69	0.05
	Treatment	27	31.33 (0.83)			28.67 (0.75)			46.48 (2.03)			20.33 (0.89)		
≥DAI <sub>13</sub> 36	No treatment	26	32.81 (0.69)	0.24	-0.15	27.46 (1.21)	0.39	0.09	49.23 (1.58)	0.55	0.08	19.73 (0.86)	0.87	0.02
	Treatment	43	31.74 (0.57)			29.65 (0.74)			50.56 (1.40)			19.93 (0.74)		
Entire cohort	No treatment	291	32.52 (0.27)	0.26	-0.06	29.99 (0.29)	0.08	-0.09	50.81 (0.47)	0.27	-0.05	21.84 (0.29)	0.02	-0.10
	Treatment	157	32.04 (0.31)			29.14 (0.37)			49.92 (0.70)			20.66 (0.38)		

Abbreviations: DAI<sub>13</sub>, Dental Aesthetic Index at baseline age 13; SE, standard error.

competence was highest amongst those who had a dental visit within the previous two years, as well as those brushing at least twice daily. The latter was also strongly associated with optimism. Orthodontic treatment was not found to predict better psychosocial outcomes; untreated participants had higher scores in all measures, this being significant for optimism ( $P < 0.05$ ). Generally, baseline malocclusion was not predictive of psychosocial outcomes, though participants with a definite malocclusion were most optimistic ( $P < 0.05$ ).

## 4 | DISCUSSION

This study reports on the longitudinal association between orthodontic treatment and psychosocial outcomes in 30-year-old Australians. The results demonstrate that orthodontic treatment is not associated with higher psychosocial outcomes in adulthood. Psychosocial measures were consistently better amongst those who did not receive orthodontic treatment. Also, untreated malocclusion, regardless of severity, was not associated with diminished psychosocial functioning in adults.

This longitudinal prospective, observational study followed participants from the age of 13-30 years. The human and financial resources required to establish and support such research precludes the widespread adoption of this type of study design in orthodontic research. Therefore, this study presents a unique opportunity to view the impact of orthodontic treatment, as one of multiple intervening factors, on psychosocial outcomes in adulthood. Notwithstanding the fact that every patient has an important role in preventing relapse, orthodontic treatment is undertaken with the expectation of changes remaining long-term. If patients anticipate these changes to also encompass psychosocial ones, it is valid to assess these outcomes at a time distant to completion of active orthodontic treatment. Age 30 falls in the middle of the second era of the life cycle, early adulthood.<sup>29</sup> The individual is in their peak biological form, has established an independent identity and is actively pursuing and realizing life goals linked to personal relationships, family, work and lifestyle. Although their psychosocial qualities have not fully matured, it is a period of life unlikely to have experienced the stresses and senescing observed in later eras of the life cycle, thus making it a suitable stage to investigate any predictive effect of biological change, namely earlier orthodontic treatment, on psychosocial outcomes.

Although no difference in psychosocial variables was evident between those that did or did not have orthodontic treatment, this is possibly attributable to a low response rate at follow-up. Over three-quarters of the participants were missing completely at random.<sup>28</sup> On account of a lack of resources, the follow-up study was limited to participants residing in metropolitan Adelaide, an area covering 2287.96 km<sup>2</sup>,<sup>30</sup> whereas the baseline study was conducted in the school dental clinics across South Australia; a land area of 983 482 km<sup>2</sup>, equivalent to the size of Egypt, or the combined area of France and Germany.<sup>31</sup> The high number of participants who could not be followed up may have contributed to a lack of power



**TABLE 3** Adjusted associations with psychosocial outcomes at age 30

	Self-efficacy		Perceived health competence		Social support		Optimism	
	Coefficient (SE)	P	Coefficient (SE)	P	Coefficient (SE)	P	Coefficient (SE)	P
Socio-demographic								
Sex								
Male	0.57 (0.39)	0.15	-0.49 (0.44)	0.27	-2.45 (0.76)	0.00	-0.34 (0.42)	0.42
Female	Ref.		Ref.		Ref.		Ref.	
Income level								
<\$80 000	-1.04 (0.45)	0.02	-1.36 (0.51)	0.01	-2.83 (0.88)	0.00	-1.16 (0.49)	0.02
≥\$80 000	Ref.		Ref.		Ref.		Ref.	
Education level								
≤Year 11	-2.34 (0.61)	0.00	-2.17 (0.69)	0.00	-2.69 (1.18)	0.02	-1.83 (0.66)	0.01
Year 12 or certificate	-0.43 (0.43)	0.32	0.14 (0.48)	0.76	-0.15 (0.82)	0.86	-0.39 (0.46)	0.40
Associate diploma/ diploma/degree	Ref.		Ref.		Ref.		Ref.	
Dental health behaviour								
Last dental visit								
<2 y ago	-0.11 (0.65)	0.87	1.62 (0.73)	0.03	2.26 (1.25)	0.07	1.02 (0.70)	0.14
2 - <10 y ago	-0.28 (0.70)	0.69	1.84 (0.79)	0.02	0.36 (1.36)	0.79	0.92 (0.76)	0.22
≥10 y ago, or never	Ref.		Ref.		Ref.		Ref.	
Tooth brushing frequency								
0-13 times/week	-0.26 (0.40)	0.51	-0.98 (0.44)	0.03	-1.07 (0.76)	0.16	-1.15 (0.42)	0.01
≥14 or more times/week	Ref.		Ref.		Ref.		Ref.	
Orthodontic variables								
DAI <sub>13</sub>								
≤DAI <sub>13</sub> 25	0.08 (0.58)	0.88	0.45 (0.65)	0.49	-0.36 (1.12)	0.75	0.90 (0.62)	0.15
DAI <sub>13</sub> 26-30	0.15 (0.63)	0.81	0.88 (0.70)	0.21	0.12 (1.21)	0.92	1.78 (0.67)	0.01
DAI <sub>13</sub> 31-35	-0.90 (0.70)	0.20	-0.46 (0.79)	0.56	-2.22 (1.36)	0.10	-0.18 (0.76)	0.81
≥DAI <sub>13</sub> 36	Ref.		Ref.		Ref.		Ref.	
Receipt of orthodontic treatment								
No	0.48 (0.42)	0.25	0.80 (0.47)	0.09	1.42 (0.81)	0.08	0.97 (0.45)	0.03
Yes	Ref.		Ref.		Ref.		Ref.	

Abbreviations: DAI<sub>13</sub>, Dental Aesthetic Index at baseline age 13; Ref., Reference variable; SE, Standard error.

in detecting statistically significant results. Thus, we caution that there may be a psychosocial effect as a result of orthodontic treatment, but our study was unable to detect this at a population level. Nonetheless, the results present an important contribution to a field with scarce research, particularly with respect to the provision of state-subsidized orthodontic treatment. Another limitation was differences in characteristics between the baseline and follow-up cohorts. Compared with the baseline cohort, the follow-up cohort had significantly more females, more participants with parents who were tertiary level educated and more participants who did not come from a household with a health care card. In other words, they were residents in a metropolitan capital city, mostly female, and belonging to higher socio-economic status groups. These characteristics therefore limit the generalizability of the results. Though it may be

suggested that data derived from female participants may influence the results, the use of adjusted models that controlled for sex helped to circumvent this issue.

Seminal research in this field was conducted in Wales in the same decades as our study.<sup>16,17</sup> Our Australian study had 25% more participants than the Welsh study, both had proportionally equal female participation (56%), but greater numbers received orthodontic treatment in the Welsh study.<sup>16,17</sup> Although our follow-up study participants represent higher socio-economic status groups, our study was inclusive of the diversity of the general South Australian population as there was no discrimination on grounds of ethnicity, place of birth or language background for participation. This differs from the Welsh study where participation was limited to Caucasians. Several of the key findings of this Australian study are in agreement



with those in Wales.<sup>16,17</sup> Shaw and colleagues were also unable to illustrate orthodontic treatment producing better psychosocial outcomes in 30-year-olds and 31-year-olds, or malocclusion severity predicting psychosocial outcomes in adulthood.<sup>17</sup> Our finding that untreated malocclusion, regardless of severity, is not related to poorer psychosocial outcomes also echoes their results; lack of orthodontic treatment does not appear to be a barrier to psychosocial functioning in adulthood. Both studies used GSES for examining self-efficacy. Despite no statistically significant difference in the scores between those who did or did not receive orthodontic treatment in either of the studies, the mean GSES score for participants in our study was greater than that in the Welsh study. Stratification of malocclusion severity in the Welsh study found no difference in GSES scores between those who did or did not receive orthodontic treatment, whereas our Australian study found participants with a definite malocclusion (DAI<sub>13</sub> 26-30) who did not receive orthodontic treatment had significantly greater self-efficacy scores. One may argue that the psychosocial variables of orthodontically treated patients were worse before treatment, following which it improved to produce levels similar to untreated participants. As our study did not obtain psychosocial measures from participants at baseline, we turn to the Welsh study in order to understand the context of our results. Shaw's analysis of covariance of orthodontic treatment, baseline malocclusion and self-esteem at both time points showed that self-esteem in adulthood was not predicted by previous orthodontic treatment; self-esteem in adulthood was strongly associated with self-esteem at baseline.<sup>17</sup> As we also explored the influence of other intervening factors, we found that socio-demographic factors are the most important predictors of psychosocial functioning in adulthood, followed by dental health behaviour. Consequently, the pattern of our results leads us to agree with the conclusions from Shaw and colleagues that suggests long-term variations in self-esteem cannot be ascribed to previous receipt of orthodontic treatment, regardless of malocclusion severity.<sup>17</sup>

The results of this study further support the view that orthodontic treatment cannot be justified on psychological or sociological grounds; there is no evidence to show it being predictive of higher psychosocial functioning in adulthood. Nonetheless, some orthodontists expect treatment to produce psychosocial improvements in their patients.<sup>14</sup> This may partially be explained by differences in orthodontic curriculum between institutions. The World Federation of Orthodontists (WFO) states specialist orthodontic graduates should be able to "evaluate psychological aspects of relevance to orthodontics."<sup>32</sup> In the United Kingdom (UK), graduates are expected to "understand psychological aspects relevant to orthodontics."<sup>33</sup> This may encompass knowledge about the psychology of patient motivation.<sup>34</sup> Thus, there is a noticeable difference in the level of cognitive knowledge regarding psychology relevant to orthodontics that is required. Adoption of WFO guidelines would produce a graduate functioning at the highest level of Bloom's taxonomy where they are not only able to identify, but can evaluate and make clinical judgements regarding psychological issues presented by their patients and its implications on orthodontic treatment.<sup>35</sup> On the other hand,

training under alternative guidelines might produce orthodontists who have an awareness and can identify pertinent psychosocial issues, but they may not have had the opportunity for higher order cognitive development.

During the initial consultation with patients, the orthodontist must clarify and identify the actual motivations for seeking orthodontic treatment. Treatment is justifiable in certain circumstances, for example, to reduce the risk of traumatic dental injury (TDI), as there is evidence demonstrating a strong association of TDI in patients with prominent or large overjets.<sup>36,37</sup> This malocclusion feature has consequently been categorized as having a very great need for treatment,<sup>3</sup> due to the significant effect of TDI affecting the longevity of affected teeth, amongst other factors.<sup>38</sup> On the other hand, orthodontic treatment cannot be justified with the purpose of improving psychosocial functioning or dental health; there is no evidence that untreated individuals, regardless of malocclusion severity, are at a disadvantage compared to treated patients.<sup>17,28,39</sup> It is therefore important that an orthodontist recognizes the limitations of orthodontic treatment, discusses these with patients and only proposes treatment for which they have been trained in and are competent at delivering. This implies practising within one's scope of knowledge and skills. If an orthodontist identifies psychological factors, which cannot be addressed through orthodontic treatment, as motivating factors for treatment, and if after explaining the limitations of orthodontic treatment the patient (or parent/carer) are still requesting treatment with expectations of better psychosocial results, the orthodontist could consider obtaining consent from the patient (or parent/carer) to refer them to their general medical practitioner or a psychologist for further assessment and management. This would also mean deferring orthodontic treatment until the patient's psychosocial concerns are investigated and resolved. In this way, any unrealistic expectations about orthodontic treatment could be modulated. Afterwards, the orthodontist could then focus on developing the aims and objectives of treatment, followed by a candid two-way discussion with patients (or parents/carers) about the exact nature of the treatment proposed, its inherent benefits and risks, and alternative treatment options. This is central to the shared decision-making process and is of utmost importance for obtaining valid and informed consent,<sup>40</sup> and should also help reduce the likelihood of dissatisfaction with treatment because of unmet expectations.

## 5 | CONCLUSION

Within the limitations of this study, particularly in light of the reduced sample available for follow-up, the psychosocial outcomes of 30-year-old Australians are not associated with orthodontic treatment earlier in life. Psychosocial outcomes are strongly related to education, income levels and dental health behaviours. The research hypothesis that participants who were previously treated orthodontically would have better psychosocial outcomes was not upheld. Therefore, better psychosocial functioning in adulthood should





not be proposed as a justification for the provision of orthodontic treatment.

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#### CONFLICT OF INTEREST

The authors do not have any interests to declare.

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## RESEARCH PUBLICATION 7

### *The long-term influence of orthodontic treatment on dental knowledge and behaviour: An Australian cohort study.*

Doğramacı EJ, Naini FB, Brennan DS.

J Dent. 2020;100:103345

DOI: [doi.org/10.1016/j.jdent.2020.103345](https://doi.org/10.1016/j.jdent.2020.103345)

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#### **Contextual statement**

Although the correction of malaligned anterior teeth is a key presenting concern of most patients seeking orthodontic treatment, benefits beyond aligned teeth are also expected by them. This includes improved dental health.

Patients may present with malocclusions with a great spectrum of severity, with the subsequent duration of comprehensive fixed orthodontics reflecting the complexity of treatment, ranging between 14 and 33 months,<sup>77</sup> which are punctuated with regular appointments of intervals ranging between every one to two weeks or up to every eight or ten weeks,<sup>78</sup> to monitor changes and adjust appliances until treatment goals are achieved. Considering the regular exposure that orthodontic patients have with dental professionals, particularly during a course of fixed orthodontic treatment, one may purport that this type of experience may influence their future dental attitudes and behaviours,<sup>79</sup> thus producing improved dental health.<sup>80,81</sup> Although the first study using data from the

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<sup>77</sup> Tsihlaki A, Chin SY, Pandis N, Fleming PS. How long does treatment with fixed orthodontic appliances last? A systematic review. Am J Orthod Dentofacial Orthop. 2016; 149: 308-318.

<sup>78</sup> Jerrold L, Naghavi N. Evidence-based considerations for determining appointment intervals. J Clin Orthod. 2011; 47: 379-383.

<sup>79</sup> Syrjälä AM, Knuuttila M, Syrjälä LK. Self-efficacy perceptions in oral health behaviour. Acta Odontol Scand. 2001; 59: 1-6.

<sup>80</sup> Shaw WC, Addy M, Ray C. Dental and social effects of malocclusion and effectiveness of orthodontic treatment: a review. Community Dent Oral Epidemiol. 1980; 8: 36-45.

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*Oral Health of Adults Entering their Fourth Decade* research was unable to demonstrate any difference in caries experience based upon receipt of orthodontic treatment,<sup>82</sup> it was hypothesised that given the previous frequent and regular exposure to dental professionals, participants who had previous orthodontic treatment would have better dental knowledge and thus better dental behaviours, compared to untreated participants. The aim of the third study using this observational data was to assess the influence of fixed orthodontic treatment on dental knowledge and behaviour in adulthood. The principal outcome variables were dental behaviour and dental knowledge. The first set of outcome variables representing the concept of dental behaviour comprised frequency of toothbrushing and flossing, last dental attendance and its purpose. The second set of outcome variables representing the concept of dental knowledge comprised responses to questions regarding self-care preventive behaviours, and responses to the visiting subscale of the Modified Dental Neglect Scale (MDNS-VS).<sup>83</sup> The explanatory variables were socio-demographic variables (sex, income and education level) and the orthodontic variables of baseline DAI (DAI<sub>13</sub>) and receipt of fixed orthodontic treatment. Cronbach's alpha was used to assess internal reliability for MDNS-VS. Unadjusted bivariate and adjusted multivariate binomial logistic regression were used to model dental behaviour and knowledge of self-care preventive behaviours, while unadjusted simple linear and adjusted multivariate generalised linear regression were used to model MDNS-VS.

The University of Adelaide Media Team was contacted regarding a press release for this research upon its acceptance for publication. Acceptance for release is pending, subject to the coronavirus disease (COVID-19) pandemic.

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<sup>82</sup> Dođramacı EJ, Brennan DS. The influence of orthodontic treatment on dental caries: An Australian cohort study. *Community Dent Oral Epidemiol.* 2019;47(3):210-216.

<sup>83</sup> Sanders AE, Spencer AJ, Slade GD. Evaluating the role of dental behaviour in oral health inequalities. *Community Dent Oral Epidemiol.* 2006; 44: 253-258.

### ***Key findings***

1. Oral hygiene behaviours, such as brushing and flossing, are not related to previous experience of orthodontic treatment. Proportionally more untreated participants brushed and flossed their teeth regularly, though this did not reach statistical significance.
2. Males, lower income earners and those with lower levels of educational attainment had poorer dental behaviour.
3. Those with a basic secondary education level and lower income earners were less likely to have had a recent dental visit. Those with a basic secondary education were most likely to attend for an emergency, rather than a scheduled dental visit.
4. Participants not treated orthodontically were more likely to give importance to myths, such as a calcium-rich diet preventing caries.
5. Participants with a baseline definite malocclusion had higher levels of knowledge regarding dental visiting compared to those with minimal or more severe malocclusions.

### ***Implications***

1. On a population level, previous experience of orthodontic treatment has limited impact on dental knowledge and may not affect dental behaviour in adulthood.
2. Socio-demographic factors are predictive of long-term dental knowledge and behaviour.
3. In addition to socio-demographic variables, childhood dental habits and social attitudes are likely to be important influencers of dental behaviour in adulthood.

## Statement of authorship

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## Principal Author

Name of Principal Author (Candidate)	Esma J Dođramacı		
Contribution to the Paper	Data preparation, analysis and interpretation, performed all formal statistical analyses, prepared the original draft, critically reviewed and edited the manuscript. Corresponding author.		
Overall percentage (%)	80%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	27.7.2020

## Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

- i. the candidate's stated contribution to the publication is accurate (as detailed above);
- ii. permission is granted for the candidate to include the publication in the thesis; and
- iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	David S. Brennan		
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Signature		Date	27.7.2020

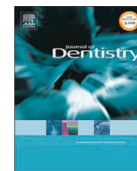
Name of Co-Author	Farhad B Naini		
Contribution to the Paper	Supervision, interpretation and critically reviewed the manuscript.		
Signature		Date	27.7.2020





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## The long-term influence of orthodontic treatment on dental knowledge and behaviour: An Australian cohort study



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### ABSTRACT

**Objectives:** Fixed orthodontic treatment (FOT) typically lasts 14–33 months, with regular appointments at short intervals to monitor changes, adjust appliances, and remotivate patients to maintain excellent oral hygiene standards to prevent dental disease. Past experiences are important influencers of dental attitudes and self-care dental behaviours in adulthood. Since FOT comprises a high frequency of appointments compared to other dental visiting, we hypothesised that previous FOT enhances dental knowledge and behaviour in later life.

**Methods:** This cohort study followed-up 30-year-old participants who originally took part in an oral epidemiological study when aged 13-years. Participants completed a questionnaire regarding sociodemographics, dental health behaviours, dental knowledge (prevention of caries and periodontal disease, including questions about popular myths) and FOT. Data analysis comprised un/adjusted binomial logistic regression and multivariate generalised linear regression.

**Results:** Data for 448 participants (56 % female, 35 % received FOT) were analysed; adjusted models controlled for sociodemographics and baseline malocclusion severity. There was no association between FOT and regular toothbrushing (Exp B: 1.35, 95% CI: 0.87–2.10), flossing (Exp B: 1.18, 95 % CI: 0.48–2.90), dental attendance within last 2 years (Exp B: 0.96, 95 % CI: 0.62–1.49) or a non-emergency dental visit (Exp B: 1.01, 95 % CI: 0.51–1.99). Non-FOT participants placed importance on a calcium-rich diet preventing caries (Exp B: 1.99, 95 % CI: 1.14–3.50,  $P < 0.05$ ), while those with a baseline definite malocclusion had higher levels of knowledge about dental visiting compared to those with minimal or more severe malocclusions ( $P < 0.05$ ).

**Conclusion:** Previous FOT appears to have limited impact on dental knowledge and may not affect long-term dental behaviours.

**Clinical significance:** This 17-year follow-up study examined the influence of previous fixed orthodontic treatment on dental knowledge and behaviour later in life. Although patients have numerous and regular appointments during the course of orthodontic treatment, this does not seem to impact on either dental knowledge or behaviour in adulthood.

### 1. Introduction

Contemporary, comprehensive orthodontic treatment usually involves the correction of multiple malocclusion features, often of multifactorial aetiology [1,2] using fixed appliances that remain in-situ for the full course of treatment, ranging between 14 and 33 months [3]. Treatment of complex malocclusions, particularly those requiring an inter-disciplinary approach, can be protracted [4–6].

Dental caries and periodontal disease are risks of orthodontic treatment [7]. Fixed appliances provide a favourable environment for plaque development on account of their rough and non-shedding surfaces [8], which influence the biological determinants of these diseases [9,10]. Thorough and regular mechanical cleaning of all tooth surfaces, principally with a toothbrush, is considered the most reliable means of controlling plaque [11], with those brushing frequently having a lower incidence of caries [12]. Consequently, the pre-treatment dialogue with

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patients (and parents/carers) as part of the shared-decision making process emphasises the risk of dental disease associated with treatment and includes key preventative strategies. Once treatment commences, regardless of initial malocclusion severity, it is punctuated with regular appointments, their intervals ranging from every one to two weeks, or up to every eight to ten weeks [13], in order to monitor changes and adjust appliances until all treatment goals are achieved. Patients are concurrently encouraged to continue optimal dental behaviours and receive professional hygiene and prophylaxis to help prevent dental disease [14,15].

Previous experiences are important influencers of dental attitudes and self-care dental behaviours in adulthood [16]. Given the regular exposure to dental professionals, coupled with reinforcement of oral hygiene and prophylactic measures over an extended period, and in the absence of any previous studies, we hypothesised that participants with previous orthodontic treatment would have better dental knowledge and behaviour compared to untreated participants. Therefore, the aim of this study was to assess the influence of fixed orthodontic treatment on long-term dental knowledge and behaviour in a cohort of 30-year-old adults.

## 2. Materials and methods

The Australian Research Centre for Population Oral Health, The University of Adelaide co-ordinated the study and collected data. Ethical approval was granted by The University of Adelaide's Human Research and Ethics Committee (H-04–2004) and informed consent obtained at each stage of the study's progression. In 1988–1989, 3925 13-year-old children who had no prior history of fixed orthodontic treatment were examined in School Dental Clinics located in metropolitan Adelaide and regional centres of South Australia, Australia. Participants' baseline untreated malocclusion was assessed by trained and calibrated assessors against the Dental Aesthetic Index (DAI<sub>13</sub>) [17]. Over the next two years, 3262 of these children participated in a short-term study about orthodontic treatment. In 2005–2006, 1859 of the short-term study participants, aged 30-years, were identified through the electoral roll as living in metropolitan Adelaide and were invited to participate in the long-term study titled "Oral Health of Adults Entering their Fourth Decade", a population oral health study focussed on oral epidemiology. Due to limited resources, participants in regional South Australia were not contacted. Invited participants were surveyed via a mailed self-completed questionnaire with up to four follow-up mailings to non-responders. Full details of sampling and data collection are presented elsewhere [18–20].

With the exception of DAI<sub>13</sub>, all variables were collected in the long-term study. The main explanatory variable was receipt of fixed orthodontic treatment, which was a single nested question within this oral health epidemiological study. Details about the exact nature of treatment, its complexity, whether treatment was completed or abandoned, and the type of provider of treatment were not collected as they were beyond the scope of the study. The observational and longitudinal nature of the study permitted natural division of the cohort. In response to the question "Had orthodontic bands or braces?", participants were requested to tick any number of rows that corresponded to each calendar year between 1990 and 2006, inclusive, that they had orthodontic treatment; each row corresponding to yearly intervals between the short-term study (when they were aged 13 years) and the present study (when they were aged 30 years). Responses were dichotomised so that participants indicating any number of years were coded as "yes" (= 1). Remaining variables were coded as per earlier work [21,22]: covariates of sex and income were coded dichotomously with the corresponding reference variables being female and  $\geq$  \$AUD80,000; education level was grouped into tertiles with tertiary level associate diploma, diploma or degree as the reference variable. Participants' DAI<sub>13</sub> scores were classified into quartiles, with each participant allocated to one of four ordinal categories:  $\leq$ DAI<sub>13</sub> 25–normal plus minor

malocclusion, DAI<sub>13</sub> 26–30–definite malocclusion, DAI<sub>13</sub> 31–35–severe malocclusion,  $\geq$ DAI<sub>13</sub> 36–very severe malocclusion; the latter being the reference variable.

The first set of outcome variables representing the concept of dental behaviour comprised: frequency of toothbrushing and flossing, last dental attendance and its purpose. Participants were asked to state how many times they brushed and flossed their teeth in the previous week. For ease of analysis and interpretation, responses were dichotomised, with brushing 14 times or more coded as being equivalent to at least twice daily, whereas responses for flossing 7 times or more were coded as equivalent to at least once daily. Next, participants indicated when their last visit to a dental professional occurred, which comprised the categories of dentist, dental specialist, dental hygienist, dental technician, dental mechanic, dentist or dental therapist. Options that participants could select from were "less than 12 months ago", "one to less than two years ago", "two to less than five years ago", "five to less than 10 years ago", "10 years or more", or "never attended". Responses were dichotomised, with those indicating "less than 12 months ago" and "one to less than two years ago" being combined and coded as "less than two years ago". The final component of dental behaviour required participants to indicate the main purpose for their last dental visit, which could be either "examination or check-up", "treatment (not for relief of pain)", or "emergency/relief of pain". Responses were dichotomised with all non-emergency visits coded as "scheduled visit". The second set of outcome variables represented the concept of dental knowledge and consisted of responses to questions regarding self-care preventive behaviours [23] and the visiting subscale of the Modified Dental Neglect Scale (MDNS-VS) [24]. In the former, participants rated the importance of six behaviours in preventing caries and periodontal disease, which also included two myths. The first myth concerned calcium in the diet for preventing caries and the second related to massaging of gums to harden them or to stimulate blood circulation in order to prevent periodontal disease. The response categories were "definitely important", "probably important", "neutral", "probably not important", and "definitely not important". Responses to statements were dichotomised by coding the categories of "definitely important" and "probably important" as "important". The MDNS-VS comprises 5-items concerning patient attitudes to dental visiting in specific circumstances, with participants recording their level of agreement or disagreement with each item on a 5-point Likert scale ranging from 5=strongly agree, to 1=strongly disagree. Three negatively worded items are reverse-scored prior to adding to the remaining items to produce an overall score for each participant that could range from 5 to 25. Therefore, the MDNS-VS was treated as a continuous variable, with higher values suggesting more favourable knowledge about dental visiting.

Internal reliability of MDNS-VS was measured using Cronbach's alpha. Descriptive statistics, distribution and cross-tabulation were used for preliminary data analysis. Results for dental behaviour and knowledge of self-care preventive behaviours were expressed as percentage of respondents, while those for MDNS-VS used unadjusted means. Bivariate analysis to assess statistical significance of categorical outcome measures used binomial logistic regression whereas simple linear regression was used for MDNS-VS. Multivariate binomial logistic regression was used to model dental behaviour and knowledge of self-care preventive behaviours according to the main explanatory variable of fixed orthodontic treatment, adjusted for the covariates of sex, income, education and DAI<sub>13</sub>. Multivariate generalised linear regression was used to model MDNS-VS. Fixed orthodontic treatment and all covariates were included in all models for maintaining consistency. Statistical significance was set at  $P < 0.05$ . All analyses were performed using IBM SPSS Statistics, version 26 software (IBM Corp., Armonk, NY).

## 3. Results

Of 1859 participants in the original study who were traced and

**Table 1**  
Unadjusted associations of dental behaviour and knowledge at age 30.

Socio-demographic variables	Distribution		Toothbrushing $\geq$ bd		Flossing $\geq$ od		Last dental visit $< 2$ years ago		Scheduled visit		Dental knowledge – importance of different factors in preventing dental disease		MDNS-VS	
	(n)	%	%	%	%	%	%	%	%	%	%	%	%	Unadjusted mean (SE)
Sex														
Male	196	40.0*	2.0**	60.2	88.5	77.9*	38.8	85.2	77.0*	47.4	54.6	12.31 (0.27)		
Female	252	50.8	9.2	60.2	87.2	85.3	66.3	82.9	84.9	50.6	59.1	12.69 (0.26)		
Income level														
< \$80,000	320	42.6**	5.3	56.9**	86.7	81.6	63.1	83.8	80.3*	48.9	55.0	11.97 (0.22)***		
$\geq$ \$80,000	116	57.9	8.7	72.2	92.1	86.1	69.8	85.3	88.8	51.7	65.5	14.06 (0.33)		
Education level														
$\leq$ Year 11	62	24.6***	0.0	50.0*	73.8***	70.5*	56.5	82.3	74.2	48.4	59.7	11.04 (0.59)***		
Year 12 or certificate	189	39.2***	4.3	57.7	86.6*	83.1	63.5	85.2	81.5	51.3	57.7	12.40 (0.28)		
Associate diploma/diploma/degree	194	59.4	9.4	65.8	93.7	84.5	67.0	83.0	83.5	46.6	55.2	13.10 (0.27)		
Orthodontic variables														
DAI <sub>13</sub>														
$\leq$ DAI <sub>13</sub> 25	196	47.9	5.6	61.7	89.0	79.1	65.8	86.2	81.6	51.0	58.2	12.65 (0.28)*		
DAI <sub>13</sub> 26 – 30	114	47.4	8.0	58.4	85.8	83.3	63.2	87.7	78.1	51.3	57.0	13.04 (0.36)*		
DAI <sub>13</sub> 31 – 35	62	42.6	6.6	58.1	90.3	88.5	64.5	80.6	82.3	46.8	53.2	12.24 (0.51)		
$\geq$ DAI <sub>13</sub> 36	69	43.5	2.9	60.9	85.3	81.2	60.9	76.8	84.1	42.0	59.4	11.62 (0.49)		
Receipt of FOT														
No	291	46.9	6.2	59.5	87.8	82.8	64.6	88.0**	82.1	49.5	57.0	12.47 (0.23)		
Yes	157	44.5	5.8	61.5	87.8	80.9	63.1	76.4	80.3	48.7	57.3	12.62 (0.33)		

Abbreviations: bd: twice daily; Ca<sup>2+</sup>: calcium; DAI<sub>13</sub>: Dental Aesthetic Index at baseline age 13; F: fluoride; FOT: fixed orthodontic treatment; MDNS-VS: visiting subscale of Modified Dental Neglect Scale; od: once daily; SE: standard error.

\*P < 0.05; \*\*P < 0.01; \*\*\*P < 0.001. Binomial logistic regression models were used for all except MDNS-VS, where simple linear regression models were used.



invited to participate, 632 returned the questionnaire. Exclusion of questionnaires with invalid study identification numbers and erroneously traced individuals left data for 448 participants (252 female) for analysis, representing 24 % of the original cohort, with significant participation by females, those who came from a household that did not have a health care card for government subsidised healthcare, as well as those from households where both parents were tertiary educated [21]. Cronbach's alpha for MDNS-VS was acceptable (0.76).

Over a third of participants received orthodontic treatment by the age of 30 (Table 1). Forty-six per cent had an annual income < \$AUD80,000 while 44 % were tertiary-level educated. Although oral hygiene behaviours were not significantly associated with orthodontic treatment, proportionally more untreated participants brushed and flossed their teeth regularly. Education had a very strong association with a range of dental behaviours. Among participants with a basic level of secondary education, a quarter brushed their teeth at least twice a day ( $P < 0.001$ ), half had seen a dentist within the last two years ( $P < 0.05$ ) and of these visits, over a quarter were emergency attendances ( $P < 0.001$ ). Fewer lower income earners brushed regularly or visited a dentist within the last two years ( $P < 0.01$ ). Forty per cent of males brushed twice a day ( $P < 0.05$ ) with 2% flossing daily ( $P < 0.01$ ). Knowledge of regular dental visits for the prevention of caries and periodontal disease were not considered important by as many participants with basic secondary education and lower income earners respectively, compared proportionally to the remaining participants ( $P < 0.05$ ). Knowledge about dental visiting was significantly lower amongst those with a basic level of secondary education as well as lower-income earners ( $P < 0.001$ ), whereas it was higher amongst participants with either a baseline definite malocclusion or normal plus minor malocclusion ( $P < 0.05$ ). Significantly, more females believed regular dental visits were important in the prevention of caries and periodontal disease ( $P < 0.05$ ), while a higher proportion of participants who had not received orthodontic treatment believed the myth that a calcium-rich diet is important in preventing caries ( $P < 0.01$ ).

The adjusted models confirmed the unadjusted effects of socio-demographic covariates on dental behaviour, and additionally orthodontic variables on dental knowledge (Table 2). Overall, previous orthodontic treatment was not associated with better dental behaviour. Males, lower income earners and those with lower levels of educational attainment had poorer dental behaviour. Males were more likely to have irregular toothbrushing and flossing behaviours. Those with lower education levels were least likely to brush regularly (Exp B: 0.25, 95 % CI: 0.13–0.49;  $P < 0.001$ ) or have a scheduled dental visit (Exp B: 0.17, 95 % CI: 0.07–0.41;  $P < 0.001$ ). Being a low-income earner was only significantly associated with a reduced likelihood of a recent dental visit (Exp B: 0.56; 95 % CI: 0.34–0.92;  $P < 0.05$ ). Concerning dental knowledge, participants who had not received orthodontic treatment were more likely to place importance on caries-preventing myths (Exp B: 1.99; 95 % CI: 1.14–3.50;  $P < 0.05$ ) while those with a baseline definite malocclusion were more likely to have higher levels of knowledge about dental visiting compared to those with minimal or more severe malocclusions (Coefficient: 1.29; SE: 0.60;  $P < 0.05$ ). Low income was strongly associated with lower levels of dental knowledge concerning general dental visiting, with low income earners being less likely to give importance to regular visits for preventing periodontal disease. Interestingly, they were less likely to believe the myth that massaging gums is important in the prevention of periodontal disease when compared to their higher earning counterparts (Exp B: 0.54; 95 % CI: 0.34–0.87;  $P < 0.05$ ). Males were least likely to believe that regular visits were important for preventing caries (Exp B: 0.55; 95 % CI: 0.32–0.92;  $P < 0.05$ ) and periodontal disease (Exp B: 0.50; 95 % CI: 0.30–0.85;  $P < 0.05$ ), while education level was significantly associated with lower levels of knowledge regarding dental visiting (Coefficient: -1.31; SE: 0.57;  $P < 0.05$ ).

#### 4. Discussion

This is the first study examining the influence of previous orthodontic treatment on long-term dental knowledge and behaviour of adults, thus making a substantial contribution to a field with scarce research. The hypothesis that orthodontically treated participants would have better dental knowledge and behaviour in later life was rejected. Regular contact with dental professionals for orthodontic treatment does not affect long-term dental behaviour, although dental knowledge about caries prevention amongst untreated participants is influenced by myths. Dental knowledge and behaviour are significantly associated with sociodemographic variables.

Health behaviours are predicted by the attitudes and beliefs of both patients and professionals [25], with social learning playing a key role in the development of attitudes [26]. Attitudes formed within one's household during childhood (and thus behaviours practised as habits therein), and peer norms are the principal influencers of toothbrushing [27,28]; participants commonly state personal hygiene and appearance as the motivating factors [27–29]. Thus, patients' attitudes to toothbrushing can be largely described as a health-related behaviour, where health is a secondary outcome, rather than a health-directed behaviour that is performed to prevent disease [30]. Although the attitudes and values of clinicians influences the likelihood of them participating in, and being positive about oral health promotion [31], traditional clinician-centred oral hygiene instruction to increase patient knowledge, in itself, is unlikely to affect optimal dental behaviour, particularly when intentions and attitudes behind actions like toothbrushing are not dental-health directed [27,30]. An individual's attitude about dental behaviours, i.e. performing them for reasons of hygiene, social situations or personal appearance, has a stronger effect on dental behaviour compared to the direct effect of dental knowledge [32]. Therefore, inherent attitudes, rather than knowledge and support received during orthodontic treatment, may account for the lack of difference in dental behaviours between the participants.

Patient perception is influential in predicting preventative health behaviours [33]. If oral health messages by the orthodontic team place strong emphasis on the increased risk of developing dental disease in the presence of fixed appliances, the patient may perceive that 1. they are only at risk during the course of treatment (because fixed appliances are plaque retentive and hamper toothbrushing), 2. the consequences of dental disease can be serious (inconvenience of adjunctive lifelong restorative treatment, possible tooth loss), 3. the recommended behaviours during orthodontic treatment bring benefits that outweigh the hassle of adopting them (prevent dental disease), 4. regular prompts from the orthodontic team to maintain optimal dental behaviour, at each appointment, throughout the course of treatment are worth complying with. Thus, patients may engage in favourable dental behaviour during active orthodontic treatment, while the risk is perceived to exist. At the end of active treatment, however, the patient may no longer feel at risk or sense the need to maintain optimal dental behaviours. This explanation is based on the assumption that patients seeking orthodontic treatment do not practise optimal dental behaviour until they are offered treatment but this is contrary to contemporary clinical practice. From the outset, aside from having high levels of motivation for treatment, prospective patients must demonstrate an excellent standard of oral hygiene, which must be sustained throughout treatment [14], which can be verified objectively by examining clinical markers of oral health, namely plaque and gingival indices. Since oral hygiene promotion pre- or peri-treatment does not produce significant changes in the short-term [34,35], continuation of orthodontic treatment in the presence of inadequate oral hygiene places the patient at risk of experiencing pertinent consequences of dental disease. Therefore, the responsible clinician would be obliged to terminate treatment prematurely and remove fixed appliances to avert such risks. Thus, it may be surmised that patients who undergo orthodontic treatment to completion are those who at the initial/pre-treatment consultation are



**Table 2**  
Adjusted associations of dental behaviour and knowledge at age 30.

Socio-demographic variables	Toothbrushing ≥ bd			Flossing ≥ od			Last dental visit <2 years ago			Scheduled visit			Dental knowledge – importance of different factors in preventing dental disease			MDNS-VS				
	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Exp B (95 % CI)	Coefficient (SE)		
Sex																				
Male	0.64 (0.42,0.97)*	0.23 (0.08,0.69)**	1.09 (0.72,1.63)	1.16 (0.61,2.18)	0.55 (0.32,0.92)*	0.82 (0.54,1.24)	1.01 (0.58,1.75)	0.50 (0.30,0.85)*	0.90 (0.61,1.33)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	0.80 (0.53,1.19)	Ref.	
Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	
Income level <\$80,000	0.70 (0.44,1.12)	0.77 (0.31,1.90)	0.56 (0.34,0.92)*	0.83 (0.37,1.87)	0.66 (0.35,1.25)	0.79 (0.48,1.29)	0.81 (0.43,1.55)	0.45 (0.23,0.89)*	0.81 (0.52,1.28)	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	0.54 (0.34,0.87)*	Ref.	
≥\$80,000	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	
Education level ≤ Year 11	0.25 (0.13,0.49)**	0.00 (0.00,0.00)	0.70 (0.38,1.29)	0.17 (0.07,0.41)**	0.49 (0.24,1.02)	0.85 (0.46,1.58)	1.15 (0.50,2.64)	0.78 (0.37,1.63)	1.46 (0.80,2.66)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	1.85 (0.99,3.46)	Ref.
Year 12 or certificate	0.49 (0.32,0.75)*	0.54 (0.22,1.35)	0.86 (0.55,1.33)	0.46 (0.21,1.01)	1.05 (0.59,1.88)	0.93 (0.60,1.46)	1.25 (0.69,2.27)	1.10 (0.62,1.94)	1.32 (0.86,2.03)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	1.34 (0.86,2.06)	Ref.
Associate diploma/ diploma/ degree	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Orthodontic variables																				
DAI <sub>13</sub> ≤ DAI <sub>13</sub> 25	0.89 (0.48,1.64)	1.51 (0.30,7.54)	0.95 (0.52,1.73)	1.34 (0.56,3.25)	0.66 (0.31,1.41)	1.09 (0.59,2.00)	1.40 (0.66,2.98)	0.58 (0.26,1.28)	1.40 (0.77,2.52)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	0.81 (0.44,1.48)	Ref.
DAI <sub>13</sub> 26 – 30	0.97 (0.50,1.87)	2.30 (0.45,11.88)	0.89 (0.46,1.70)	1.40 (0.53,3.66)	1.20 (0.51,2.82)	1.05 (0.54,2.01)	1.66 (0.71,3.88)	0.65 (0.28,1.51)	1.43 (0.75,2.70)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	0.82 (0.43,1.57)	Ref.
DAI <sub>13</sub> 31 – 35	0.81 (0.38,1.70)	2.10 (0.35,12.75)	0.79 (0.38,1.64)	1.58 (0.51,4.83)	1.86 (0.65,5.36)	1.14 (0.54,2.38)	0.97 (0.41,2.34)	0.90 (0.83,2.52)	1.22 (0.60,1.40)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	0.72 (0.65,1.54)	Ref.
≥DAI <sub>13</sub> 36	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Receipt of FOT																				
No	1.35 (0.87,2.10)	1.18 (0.48,2.90)	0.96 (0.62,1.49)	1.01 (0.51,1.99)	1.35 (0.77,2.37)	1.09 (0.70,1.69)	1.99 (1.14,3.50)*	1.45 (0.83,2.52)	0.92 (0.60,1.40)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	1.00 (0.65,1.54)	Ref.
Yes	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Abbreviations: bd: twice daily; Ca<sup>2+</sup>: calcium; CI: confidence interval; DAI<sub>13</sub>: Dental Aesthetic Index at baseline age 13; Exp: exponentiated; F<sup>-</sup>: fluoride; FOT: fixed orthodontic treatment; od: once daily. Ref.: reference variable; SE: standard error.

\*P < 0.05; \*\*P < 0.01; \*\*\*P < 0.001. Adjusted binomial logistic regression models were used for all except MDNS-VS, where adjusted generalised linear models were used.

found to already practise favourable dental behaviours, and would maintain these even after completion of treatment.

The lay public source health information from various sources: family, friends, encounters with health professionals and traditional/social media, though they are not always able to distinguish high quality and accurate content from unreliable information, including myths [36–38]. Key sources for dental information are dental clinics, print media and the Internet [23,39], with the latter having a significant association with self-reported dental behaviours including oral hygiene and regular dental attendance [39]. Previous work found females and those with lower education levels ascribing greater importance to dental myths [23], although this was not supported in our study. Participants who had not received orthodontic treatment believed that a calcium-rich diet staves off dental caries, while higher income earners gave importance to massaging the gums as a means of warding off periodontal disease. Though the influence of dental knowledge does not have as strong effect on dental behaviour as attitudes [27,32], misconceptions can potentially create conflict and distrust between clinicians and patients, particularly when lay theories are at odds with professional advice and evidence-based research [36,40]. Although a calcium-rich diet does not confer any protection against caries, this belief amongst untreated participants may illustrate that orthodontically treated participants had more accurate knowledge about caries-preventive factors. Establishment and maintenance of gateways of information, also known as clearinghouses, by professional dental associations, societies or organisations that dental professionals can refer their patients to, as well as the dental professions' engagement with media to promote accurate, evidence-based and up-to-date information about dental disease are some of the strategies that could be adopted to ensure effective knowledge translation from trustworthy sources to the lay public [36].

Certain limitations may restrict the generalisability of the findings to a wider population. A high number of participants could not be followed up, therefore, the findings are restricted to urban-dwellers. There may be differences in knowledge and behaviour between treated and untreated participants but our study was unable to detect these at the population level. Although the follow-up cohort comprised urban-dwelling residents who were mostly female and belonged to higher socioeconomic status groups compared to the baseline cohort, the adjusted models were able to control for these, despite these population groups having optimal health and behaviour. Data regarding knowledge and behaviour were not collected at other time-points over the course of this study, therefore, it was not possible to follow any changes in dental knowledge and behaviour within the cohort over time. As orthodontic treatment was a single nested question in the larger oral epidemiological study, no clinical details pertaining to the treatment were collected as they were beyond the scope of this study. Finally, data accuracy and validity may have impacted on the results, particularly as the questionnaire collected self-reported data that could not be otherwise independently verified. Oral hygiene practices such as toothbrushing are socially accepted behaviours. In this study, one of the questions participants responded to concerned toothbrushing frequency. Participant responses may have been distorted, as a result of the Hawthorne effect. Although participants are assured that all questionnaires are handled anonymously, participants may provide a response they believe study researchers expect, thus giving a socially desirable and conformist response, although this may not necessarily reflect their true dental behaviour. In spite of this possibility, the clinical dental health outcomes observed in the same participants and published elsewhere [21] were found to be compatible with the behaviours reported in this study.

## 5. Conclusion

Although previous and regular contact with dental professionals during the course of fixed orthodontic treatment may be thought to

have an influence on dental knowledge and behaviours in adulthood, our study showed that previous fixed orthodontic treatment appears to have limited impact on dental knowledge and may not affect long-term dental behaviours. Sociodemographic covariates of gender and income are more important predictors of dental knowledge and behaviour, with education additionally associated with dental behaviour.

## CRedit authorship contribution statement

**Esma J. Dođramacı:** Formal analysis, Investigation, Methodology, Validation, Visualization, Writing - original draft, Writing - review & editing. **Farhad B. Naini:** Supervision, Validation, Writing - review & editing. **David S. Brennan:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.jdent.2020.103345>.

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# DISCUSSION AND SUMMARY

## Infant behaviours and malocclusions

### *Key findings*

The multifactorial nature of malocclusions signifies that a child may present with a single or multiple features of malocclusions, detectable at any stage of dental development. NNSBs, a type of environmental factor, were strongly associated with different malocclusion features in the primary and mixed dentitions, with risk ratios consistently higher amongst children with a current or previous NNSB history. The risk for increased overjet was greater in digit versus pacifier suckers, with pacifier use strongly associated with posterior crossbite development. Anterior open bite was associated with all types of NNSBs, though was highly significant in digit sucking.

Use of a highly defined methodological approach produced the most precise and accurate results to date on the relationship between breastfeeding and malocclusions in the primary dentition. Although malocclusions were detected in children who breastfed optimally, their risk level was not comparable to children who breastfed sub-optimally. Nil or short duration of breastfeeding was significantly associated with anterior open bite, with the latter also significantly associated with a Class II canine relationship. Risk ratios for posterior crossbite were greater amongst children who were not exclusively breastfed, but not statistically significant, although all types of NNSB were highly and significantly associated with this malocclusion in the primary dentition.



Presently, there is scant Internet content targeting the lay public regarding breastfeeding and malocclusions, with the few websites identified having an overall moderate level of quality and the evidence level of supporting references being moderate to very low.

### ***Interpretation of key findings***

Breastfeeding exclusively in the first six months of life falls within the definition of optimal breastfeeding,<sup>84,85</sup> although less than half of all children globally are breastfeeding at six months and even fewer by the age of two.<sup>85</sup> NNSBs are usually introduced in infancy before any teeth have erupted into the oral cavity, persisting into the primary dentition, which is normally established at the age of three years, though these habits can continue for longer.

The position of teeth (i.e. dental equilibrium) is the result of four primary factors: 1. intrinsic forces (resting pressures) from the tongue, lips and cheeks, 2. extrinsic forces from habits and orthodontic appliances, 3. dental occlusion forces, and 4. forces from the periodontal membrane, with continuous forces having a stronger effect on tooth position compared to force magnitude.<sup>86</sup> Apart from differences in nourishment, NNSBs vary from breastfeeding as they are low magnitude forces engaged in for long periods of time, while breastfeeding involves suckling and swallowing with high force levels for short durations at a time. Pacifier use is also associated with shorter breastfeeding duration,<sup>87</sup> including shorter duration in exclusivity of breastfeeding.<sup>88</sup> Malocclusions are not part of normal dental development. Where they are not attributed to genetic factors, they are likely the result of environmental, pathological agents, that disrupt the normal dental equilibrium.

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<sup>84</sup> World Health Organization. UNICEF: Global Strategy for Infant and Young Child Feeding. Geneva, Switzerland: World Health Organization; 2003. Available at: <https://apps.who.int/iris/bitstream/10665/42590/1/9241562218.pdf?ua=1&ua=1>

<sup>85</sup> UNICEF. UNICEF Data: Monitoring the Situation of Children and Women. Infant and young child feeding. 2019 Available at: <http://data.unicef.org/nutrition/iycf.html>

<sup>86</sup> Proffit WR. Equilibrium theory revisited: factors influencing position of the teeth. Angle Orthod. 1978; 48: 175-186.

<sup>87</sup> Karabulut E, Yalçın SS, Özdemir-Geyik P, Karaağaoğlu E. Effect of pacifier use on exclusive and any breastfeeding: a meta-analysis. Turk J Pediatr. 2009; 51: 35-43.

<sup>88</sup> Buccini GDS, Pérez-Escamilla R, Paulino LM, Araújo CL, Venancio SI. Pacifier use and interruption of exclusive breastfeeding: systematic review and meta-analysis. Matern Child Nutr. 2017; 13: e12384.

One such agent is NNSBs, which may be the cause of malocclusions in both optimally and sub-optimally breastfed children. For example, NNSBs may be introduced to an infant after six months of exclusive breastfeeding. The significance of this time point is its co-occurrence with the commencement of eruption of the primary dentition into the oral cavity. Therefore, despite a type of optimal breastfeeding having previously occurred, this will be unlikely to convey any protective effect against the deleterious effects of NNSBs during the establishment of the primary dentition. Websites targeting laypeople about the relationship between breastfeeding and malocclusions are scant and do not detail evidence of the mechanisms involved for the apparent protective effect of breastfeeding. The research evidence used on these websites is mostly lower level.

### ***Limitations and recommendations***

Recall bias is an important issue that impacts on the accuracy of data collected from participants. Without independent verification, the data are at risk of being imprecise, particularly when a long period of time has elapsed between when a person's behaviour or activity occurred and when they (or parent/guardian) are asked to recall this information. Retrospective studies are particularly at risk of this type of bias. Although many of the component studies in the systematic reviews were cross-sectional, data regarding NNSB or breastfeeding are not always collected contemporaneously. One strategy to reduce recall bias involves the use of alternative study designs, such as a prospective observational approach, collecting data at pre-determined timepoints, at or close to the time when the behaviour is expected to occur. Longitudinal birth-cohort studies uniquely gather broad data on environmental and genetic determinants of infant and childhood development. Within the limitations of human and financial resources, nested studies at specified timepoints could research factors influencing oro-craniofacial development. When conducted in multiple different geographical areas, pooled results

may enable a better understanding of the determinants of malocclusions within a global context.

This PhD research did not aim to explore why or how malocclusion occurrence differs between optimally and sub-optimally breastfed children. This is an area requiring further research. Several component studies included in the systematic review and meta-analysis that focused on breastfeeding also reported data in relation to NNSB, however, owing to dissimilarities in the definitions, classification and types of outcome measures recorded and reporting methods, it was not possible to perform further analyses to separate the extent that NNSB impacts on malocclusion development in those who also have a history of optimal breastfeeding. Universal agreement and standardisation on the type of core outcome measures that should be collected and reported in orthodontic research could help overcome the problems of heterogeneity between studies in the future. This would also facilitate the application of network meta-analysis, rather than pairwise meta-analyses. In this way, data from multiple exposure-specific groups of participants could be used to obtain more precise estimates of effect for defined outcome measures.

Although it may be argued that a common risk factor approach in encouraging breastfeeding could help avoid malocclusion development while also being exposed to the other well-known benefits from breastfeeding,<sup>89</sup> the policy of “breast is best” is unlikely to dissuade the adoption and persistence of NNSBs, thus is unlikely to be an effective strategy for prevention of malocclusions of environmental (habit) origin, nor have any impact on the genetic determinants of malocclusion. Future community engagement directly with patients and indirectly via traditional and social media, as well as public

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<sup>89</sup> Sheiham A, Watt RG. The common risk factor approach: a rational basis for promoting oral health. *Community Dent Oral Epidemiol.* 2000; 28: 399-406.

health strategies, should emphasise the deleterious effects associated with NNSBs, including the higher risks for malocclusions and the consequences of malocclusions, per se, as well as their treatment. For example, committed digit suckers may develop an increased overjet, putting them at heightened risk for traumatic dental injury;<sup>90</sup> early interceptive orthodontic treatment can help reduce this risk.<sup>91</sup> However, orthodontic treatment is not without consequences, presenting a financial burden to the individual (or parent/carer), wider society, or both, and treatment also being associated with important iatrogenic risks.

## **Long-term outcomes of orthodontic treatment**

### ***Key findings***

Regardless of initial severity of malocclusion, previous receipt of fixed orthodontic treatment was not associated with caries experience, psychosocial outcomes, dental knowledge or dental behaviours in adulthood. Rather, socio-demographic variables were strongly predictive of these outcomes. Males, lower income earners and those with a basic level of secondary education had lower levels of knowledge about prevention of dental disease, infrequent oral hygiene behaviours, irregular dental visits that were often for emergencies, higher levels of caries experience, and poorer psychosocial outcomes.

### ***Interpretation of key findings***

The inequalities observed in this studied population were largely determined by levels of education and income. The lower the participant's level of educational attainment or income, the poorer their clinical and self-reported outcomes. Thus, gradients were

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<sup>90</sup> Arraj GP, Rossi-Fedele G, Dođramacı EJ. The association of overjet size and traumatic dental injuries – a systematic review and meta-analysis. *Dent Traumatol.* 2019; 35: 217-232.

<sup>91</sup> Batista KBSL, Thiruvengkatachari B, Harrison JE, O'Brien KD. Orthodontic treatment for prominent upper front teeth (Class II malocclusion) in children and adolescents. *Cochrane Database Syst Rev.* 2018 Mar 13; 3: CD003452.



observed that were socio-economic. Sex differences were also noted in several outcome measures. However, previous fixed orthodontic treatment was not identified as a determinant of long-term dental knowledge or behaviour, dental health or psychosocial outcomes.

A gradient was observed for oral hygiene behaviours, caries experience, attitudes to dental visiting and reported dental visiting. Lower levels of regular oral hygiene behaviours (toothbrushing and flossing) were observed amongst participants with basic education and low income levels, although this is in contrast to earlier work in Australia where no socio-economic differences were observed.<sup>92</sup> The finding of higher caries experience amongst participants with low income and educational attainment is consistent with previous work in Australia and other high-income countries that shows low socio-economic position is significantly associated with greater risk of untreated caries (decayed teeth) and previous caries experience (missing or filled teeth).<sup>92,93,94,95,96</sup> Significantly less favourable knowledge about dental visiting was found among participants with lower income and education levels, with fewer scheduled or regular visits made by lower income earners. This is in agreement with earlier work, which purports cost as the main barrier for accessing professional dental services.<sup>92,93</sup> Research in the United States has previously reported that people with lower levels of formal education had the least knowledge of fluoride preventing dental caries,<sup>97</sup> a finding mirrored in this PhD research.

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<sup>92</sup> Sanders AE, Spencer AJ, Slade GD. Evaluating the role of dental behaviour in oral health inequalities. *Community Dent Oral Epidemiol.* 2006; 34: 71-9.

<sup>93</sup> Brennan DS, Spencer AJ, Roberts-Thomson KF. Dental self-care and visiting behaviour in relation to social inequality in caries experience. *Community Dent Health.* 2011; 28: 216-221.

<sup>94</sup> Armfield JM, Mejia GC, Jamieson LM. Socioeconomic and psychosocial correlates of oral health. *Int Dent J.* 2013; 63: 202-209.

<sup>95</sup> Schwendicke F, Dörfer CE, Schlattmann P, Foster Page L, Thomson WM, Paris S. Socioeconomic inequality and caries: a systematic review and meta-analysis. *J Dent Res.* 2015; 94: 10-18.

<sup>96</sup> Lambert M, De Reu G, De Visschere L, Declerck D, Bottenberg P, Vanobbergen J. Social gradient in caries experience of Belgian adults 2010. *Community Dent Health.* 2018; 35: 160-166.

<sup>97</sup> Gift HC, Corbin SB, Nowjack-Raymer RE. Public knowledge of prevention of dental disease. *Public Health Rep.* 1994; 109:397-404.

All psychosocial outcomes were congruent with income and education, with the lowest scores observed amongst lower income earners and those with a basic level of education, increasing with higher education attainment. This is in agreement with research conducted in England where psychosocial values, including perceived social support, were aligned along a gradient of education and income; higher values were observed with increasing income and education,<sup>98</sup> though work in Italy alternatively found that social support did not follow a social gradient.<sup>99</sup>

Sex differences in oral hygiene behaviours that have been previously reported were confirmed in this PhD research,<sup>100</sup> with males brushing and flossing less often than females. However, no sex differences in recency of last dental visit or its purpose were observed, which is opposite to work in Finland where more males reported a greater period of time elapsing since their last dental visit.<sup>100</sup> This difference may be attributable to greater accuracy of their data as the researchers checked the self-complete questionnaire responses with each participant when they attended for clinical examination. In-person verification of questionnaire data was not undertaken in the *Oral Health of Adults Entering their Fourth Decade study*. In this PhD research, males had more untreated caries (decay), while females had more teeth missing or filled, the latter reflecting a higher DMFT score, with these findings being similar to work published from other Australian studies.<sup>101,102</sup> This corresponds with females having more frequent dental visits, with these largely being scheduled visits, whereby caries, or its consequences, can be identified and treated. Furthermore, this PhD research observed males having lower levels of knowledge regarding the prevention of dental diseases, a finding also consistent

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<sup>98</sup> Shields MA, Price SW. Exploring the economic and social determinants of psychological well-being and perceived social support in England. *J R Statist Soc A*. 2005; 168: 513-537.

<sup>99</sup> De Vogli R, Gnesotto R, Goldstein M, Andersen R, Cornia GA. The lack of social gradient of health behaviours and psychosocial factors in Northern Italy. *Soz Praventivmed*. 2005; 50: 197-205.

<sup>100</sup> Sakki TK, Knuutila MLE, Anttila SS. Lifestyle, gender and occupational status as determinants of dental health behaviour. *J Clin Periodontol*. 1998; 25: 566-570.

<sup>101</sup> Brennan D, Spencer J, Roberts-Thomson K. Dental knowledge and oral health among middle-aged adults. *Aust N Z J Public Health*. 2010; 34: 472-475.

<sup>102</sup> Armfield JM, Mejia GC, Jamieson LM. Socioeconomic and psychosocial correlates of oral health. *Int Dent J*. 2013; 63: 202-209.

with earlier work.<sup>101</sup> In agreement with research in England, males were also less likely to report positive psychosocial well-being or perceived social support.<sup>98</sup>

### ***Limitations and recommendations***

Owing to a lack of resources, over half of the original cohort from the baseline study in 1988-1989 was permanently lost as the follow-up study was limited to participants residing in metropolitan Adelaide. Thus, 1859 participants who comprised the remaining 47% of the original cohort from the baseline study were contacted to participate in the observational, cross-sectional study in 2005-2006. Six-hundred and thirty-two returned the postal questionnaire, giving a response rate of 34%. Of these, 473 attended for clinical examination, though 25 respondents were excluded due to invalid study identification numbers or they were deemed to have been traced erroneously. The final follow-up rate from the original 3925 participants at baseline was 24%, with those not responding or attending for assessments considered as missing completely at random.<sup>103</sup> A low response rate might be considered a limitation with respect to a decrease in the power of the analyses, however, many results across the three studies demonstrated statistically significant differences that were distributed by sex and along socio-economic gradients. One may assert that there is a possibility of bias in the results owing to differences between the original participants at baseline and those that participated in the follow-up, thus limiting the generalisability of the findings to a wider population. Although the follow-up participants largely represented females residing in metropolitan Adelaide who had a higher socio-economic position in society, data were analysed using multivariate models that controlled for education, income and sex.

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<sup>103</sup> Little RJA, Rubin DB. Chapter 1. Introduction. In: Little RJA, Rubin DB, Eds. *Statistical Analysis with Missing Data*. 2<sup>nd</sup> ed. Hoboken, NJ: John Wiley & Sons, Incorporated; 2002.

While potential data from participants missing completely at random can be ignored,<sup>104</sup> it is possible to project dental knowledge, behaviour, dental health and psychosocial outcomes of future South Australian populations using cross-sectional data from the follow-up study in 2005-2006 and additionally collecting new data at another time-point. The statistical technique for this is cohort-based modelling,<sup>105</sup> using a closed-type model with a single cohort whose participants would be homogenous for age (30-years-old) and residency (living in South Australia, Australia). Additionally, the target population would need to be fully representative of the South Australian population in terms of demographic and socio-economic variables. Data collection would be based upon clinical examination as well as administration of a survey based upon the one used in the *Oral Health of Adults Entering their Fourth Decade* study in 2005-2006. Rather than distributing the survey by traditional mail, an online survey software platform could be adopted. This method would present some advantages over traditional surveys that include: accessibility via any Internet-enabled device, automated reminders sent to participants, option for participants to stop providing responses mid-survey and resuming at a later time point, continuous data cleaning ensuring responses are considered and reliable (i.e. removal of responses where participants did not spend sufficient time prior to giving the response, only chose the same answer option per question, or skipped large portions of the survey), and exporting data electronically for statistical analyses. Participants can be pre-enrolled through traditional recruitment methods or alternatively, recruited via the firm hosting the online survey, recruiting until sufficient surveys have been completed that are representative of the target population. With the latter, fraudulent survey participation where participants complete the survey multiple times in order to benefit from financial compensation, as well as the use of programmed bots, have been reported.<sup>106</sup>

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<sup>104</sup> Siddiqui O, Flay BR, Hu FB. Factors affecting attrition in a longitudinal smoking prevention study. *Prev Med.* 1996; 25: 554-560.

<sup>105</sup> Ethgen O, Standaert B. Population-versus cohort-based modelling approaches. *Pharmacoeconomics.* 2012; 30: 171-181.

<sup>106</sup> Teitcheer JEF, Bockting WO, Bauermeister JA, Hofer CJ, Miner MH, Klitzman RL. Detecting, preventing, and responding to "fraudsters" in Internet research: ethics and tradeoffs. *J Law Med Ethics.* 2015; 43: 116-133.



Data accuracy and validity derived from the questionnaire may be contended to be inaccurate on account of it being self-reported. This is unlikely to be a problem for the outcome measures of dental caries, dental knowledge or psychosocial outcomes since clinical examinations by calibrated assessors established levels of active and treated caries, while questions regarding psychometrics and dental knowledge aimed to explore an individual's broader awareness and attitudes, at that moment in time, to issues that are related to oral health. However, future longitudinal studies could consider assessing dental knowledge and psychometrics at multiple time-points during the course of the study, which could glean insights into how attitudes and personal qualities change over time, in relation to static and dynamic socio-demographic variables, as well as other explanatory variables such as receipt of fixed orthodontic treatment.

Responses regarding dental behaviour might be considered to have been influenced by recall bias. Specifically, these are frequency of toothbrushing and flossing (quantitative facts – how often?), last dental attendance (quantitative fact – when?), and purpose of last dental attendance (qualitative fact – why?). Although this study did not have proxy validation of oral health behaviours of toothbrushing or flossing (i.e. spouse, housemate verification), the interval was one week and therefore not considered at high risk of recall error.<sup>107</sup> Moreover, the clinical dental health outcomes that were observed in the same participants were compatible with the behaviours reported. Since regular brushers have a lower incidence of caries,<sup>108</sup> when the unadjusted association of caries experience and toothbrushing for this cohort were compared, the level of active dental disease was found to be compatible with the toothbrushing reported. Furthermore, unadjusted and adjusted negative binomial regression to assess the association of self-reported toothbrushing with decayed teeth showed that those brushing less than twice a day had significantly more

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<sup>107</sup> Wagenaar WA. My memory: a study of autobiographical memory over six years. *Cogn Psychol.* 1986; 18: 225-252.

<sup>108</sup> Kumar S, Tadakmadla J, Johnson NW. Effect of toothbrushing frequency on incidence and increment of dental caries: a systematic review and meta-analysis. *J Dent Res.* 2016; 95: 1230-1236.

decayed teeth. When time interval increases, there is the possibility that the participant cannot remember non-repetitive events such as whether their last dental visit was within the last 12 months, last two years, two to less than five years ago, or five to less than ten years ago. In such circumstances, the participant might not only provide an answer that is based upon their best recollection, but one which is also a socially desirable response.<sup>109</sup> Although one of the strategies employed to overcome inaccuracy of recall of last dental visit was dichotomisation of last dental attendance using attendance less than two years ago (=yes) or not, future longitudinal studies could implement the use of diaries or electronic health passports to record when the visits occurred, or collecting data at multiple time-points with shorter intervals. These actions could also assist in recording precisely the reason for last dental attendance, even though attendance for relief of pain should be considered free of limitations of human recollection or recall bias as past studies have demonstrated high accuracy in recollection of pain-related behaviours.<sup>110</sup>

Overall, population studies that use self-reported questionnaires rely on the honesty of survey respondents. Socio-demographic variables of age and sex can be verified when the participant attends for clinical assessments, whereas income and education are harder to authenticate. Data analysis against national census data can help determine whether the distribution of explanatory variables in a study are representative of the target population and if not, could be verified with participants when they attend for clinical examinations.

A distinguishing feature of this study was the use of the Dental Aesthetic Index (DAI),<sup>111</sup> which was developed “specifically to measure dental aesthetics...that deviate from

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<sup>109</sup> Bradburn NM, Rips LJ, Shevell SK. Answering autobiographical questions: the impact of memory and inference on surveys. *Science*. 1987; 236: 157-161.

<sup>110</sup> Salovey P, Smith AF, Turk DC, Jobe JB, Willis GB. The accuracy of memory for pain. Not so bad most of the time. *APS Journal*. 1993; 2: 184-191

<sup>111</sup> Cons NC, Jenny J, Kohout FJ. DAI: The Dental Aesthetic Index. Iowa City: College of Dentistry, The University of Iowa; 1986.

societally accepted norms...” It precedes other orthodontic indices and was used in this study to determine the malocclusion severity of a participant, according to the public’s perceptions of dental aesthetics, with the presumption that dental aesthetics can be improved by orthodontic treatment. Although it may be criticised for not recording dental crowding as accurately in all areas of the dental arches, or that crowding is not weighted sufficiently, it nonetheless provides a useful means of objectively and reliably stratifying the population based on their malocclusion.<sup>112</sup> Although not an aim of this study, future longitudinal studies may wish to investigate the relationship between dental crowding and caries experience based upon the receipt of fixed orthodontic treatment. In situations where the DAI is adopted, this could perhaps be supplemented with the use of additional indices such as the Index of Orthodontic Treatment Need,<sup>113</sup> or Little’s Irregularity Index.<sup>114</sup>

Education, income and gender play a key role in shaping the biological factors, personal behaviours and psychosocial factors that influence individual health and well-being.<sup>115</sup> These have been coined “social determinants,”<sup>116</sup> and they contribute to the social gradients observed in health outcomes, including those found in this PhD research. Early childhood development and education, and elimination of gender biases, are stated as key areas that require targeted action as they can positively change the current life-course health patterns observed.<sup>115,116</sup>

In a clinical setting, prospective patients who hold expectations of improved dental health or psychosocial gains as a consequence of fixed orthodontic treatment should have these

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<sup>112</sup> Jenny J, Cons NC. Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale. *Aust Dent J.* 1996; 41: 43-46.

<sup>113</sup> Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. *Eur J Orthod.* 1989; 11:309-320.

<sup>114</sup> Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. *Am J Orthod.* 1975; 68: 554-563.

<sup>115</sup> Marmot M. Social justice, epidemiology and health inequalities. *Eur J Epidemiol.* 2017; 32: 537-546.

<sup>116</sup> Commission on the Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the commission on Social Determinants of Health. Geneva: World Health Organisation. 2008.

beliefs sensitively moderated, explaining, for example, that brushing at least twice a day, limiting cariogenic food and drinks to main meal times, and visiting a dentist regularly are more reliable actions that they can personally take to stave off dental disease. The expectation of psychosocial enhancement may currently be considered unrealistic, based on the results of this PhD research where lack of orthodontic treatment, regardless of initial malocclusion severity, on a population level, did not produce lower psychosocial functioning compared to treated participants. This is not synonymous with no psychosocial improvement at an individual, clinical level. Within the population studied, there were participants, both treated and untreated, who had high scores for the psychosocial outcomes measured, and equally those who had comparatively low scores. Thus, one may purport that some treated individuals, such as those with baseline DAI scores greater than 36, obtained high psychometric scores on account of their previous orthodontic treatment. However, this would be an erroneous deduction as the influence of other confounding variables, assessed through the use of adjusted models, should also be considered. Moreover, in the absence of baseline assessments, which is one of the limitations of this study, it is not possible to state how the participants' psychometric outcomes changed over time; whether orthodontic treatment enhanced their long-term psychosocial functioning. Nonetheless, evidence from a similar study in Wales showed that baseline psychosocial functioning, rather than receipt of orthodontic treatment, was predictive of psychosocial outcomes in adulthood.<sup>117</sup> Therefore, this study is confirmatory of earlier work; that the long-term psychosocial benefits of orthodontic treatment are yet to be shown.

State-subsidised orthodontic treatment is largely rationed on the basis of the presenting malocclusion's potential to carry a dental health impact on an individual. Features with a

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<sup>117</sup> Shaw WC, Richmond S, Kenealy PM, Kingdon A, Worthington H. A 20-year cohort study of health gain from orthodontic treatment: psychological outcome. *Am J Orthod Dentofacial Orthop.* 2007; 132: 146-157.



potentially more severe impact, such as a large overjet or an impacted tooth, which can be measured objectively, are classified as having a very great need for treatment,<sup>118</sup> owing to their increased risk for traumatic dental injury or impaction resorption.<sup>119,120</sup> As eligibility for state-subsidised treatment is usually assessed on the basis of meeting a minimum morphological threshold, the outcomes of the effectiveness of orthodontic treatment are currently reported in terms of morphological changes, using tools such as the Peer Assessment Rating that has reliability and validity,<sup>121,122</sup> to compare post-treatment occlusion with the initial presentation.

Assessment of the effectiveness of orthodontic treatment at enhancing psychological and social functioning, on an individual level, would require a longitudinal, multidisciplinary life-course approach, ideally nested in a parent epidemiological study, to not only be able to use the maximum amount of data for multiple health research areas, but also to avoid priming participants. With respect to orthodontics, data on socio-economic variables, psychological and social functioning, oral health, and initial (untreated) malocclusion, using quantitative and qualitative approaches, could first be obtained at pre-adolescence, with participants followed through at pre-determined time-points over various eras in the life cycle, additionally collecting further information related to receipt of orthodontic treatment, its nature, duration and morphological outcomes. However, the most important barriers to the widespread adoption of such methodologies are the immense human and financial resources required to support studies of this nature.

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<sup>118</sup> Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. *Eur J Orthod.* 1989; 11:309-320.

<sup>119</sup> Arraj GP, Rossi-Fedele G, Dođramacı EJ. The association of overjet size and traumatic dental injuries – a systematic review and meta-analysis. *Dent Traumatol.* 2019; 35: 217-232.

<sup>120</sup> Dođramacı EJ, Sherriff M, Rossi-Fedele G, McDonald F. Location and severity of root resorption related to impacted maxillary canines: a cone beam computed tomography (CBCT) evaluation. *Aust Orthod J.* 2015; 31: 49-58.

<sup>121</sup> Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD, Roberts CT, Andrews M. The development of the PAR index (Peer Assessment Rating): reliability and validity. *Eur J Orthod.* 1992; 14: 125-139.

<sup>122</sup> Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. *Eur J Orthod.* 1992; 14: 180-187.

Psychometric tools are not currently used routinely in clinical orthodontic practice for the purpose of assessing orthodontic treatment need or monitoring changes. Although specific tools could be proposed, the inherent differences in psychological and social characteristics at various eras of the life cycle, along with the potential of other confounding factors including socio-economic variables,<sup>123</sup> make the possibility for delineating any enhancements to psychosocial functioning as a consequence of orthodontic treatment challenging. Other considerations include the appropriateness of using psychosocial assessments to ration orthodontic treatment, incongruity between objective and subjective assessments with patient self-assessments, and the quandary of managing a patient whose malocclusion has been corrected morphologically, yet their psychosocial functioning has not achieved a minimum percentage change that may represent an improvement. The latter is a situation where pre-treatment assessment within an inter-disciplinary setting would help to correctly identify the salient health issues that can be predictably treated.

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123 Price J, Whittaker W, Birch S, Brocklehurst P, Tickle M. Socioeconomic disparities in orthodontic treatment outcomes and expenditure on orthodontics in England's state-funded National Health Service: a retrospective observational study. *BMC Oral Health*. 2017; 17: 123.

## CONCLUSION

This research aimed to examine the association of environmental factors during childhood on the development of malocclusions, and to discern the long-term outcomes of previous orthodontic treatment.

Results of this research demonstrate that children in the primary dentition with a history of optimal breastfeeding have a lower risk for developing various malocclusion features compared to sub-optimally breastfed children. The most biologically plausible explanation is that when NNSBs are adopted, optimal breastfeeding ends, and the deleterious effects of NNSBs can develop and their effects can be observed in the dentition. When NNSBs continue beyond the primary dentition, certain malocclusion features can persist into the mixed and secondary dentitions. Breastfeeding should therefore be considered as preventing the acquisition and perpetuation of NNSBs, and breastfeeding does not, in itself, reduce the occurrence of malocclusions.

Comprehensive fixed orthodontic treatment is focussed on correcting the intra- and inter-maxillary relationships of teeth to normal in patients in the secondary dentition. Although long-term occlusal outcomes can be easily and objectively measured, non-occlusal outcomes are seldom investigated. At a population level, there is no evidence that previous orthodontic treatment confers better dental health or psychosocial outcomes, regardless of initial malocclusion severity, in adulthood. Moreover, there is limited difference in the level of dental knowledge, and no difference in performance of ideal dental behaviours based on one's past experience of comprehensive fixed orthodontic treatment. Therefore, orthodontic treatment should not be proposed or justified on the grounds of reducing caries risk or improving psychosocial functioning in later life. However, based on the limitations in data collection already described, further investigation is required.

## APPENDICES

### Appendix 1: Course attendances during PhD candidature

Date(s)	Course title	Organiser/Host, Venue	Format	Hours
30.11- 4.12.15	Comprehensive Systematic Review Training Programme	The Joanna Briggs Institute, The University of Adelaide.	Structured training program	18
21.3.16	Authorship issues - Australian Code for the Responsible Conduct of Research	The University of Adelaide	Online course	2
21.3.16	Management of data and primary materials - Australian Code for the Responsible Conduct of Research	The University of Adelaide	Online course	2
21.3.16	Publication and dissemination of research findings - Australian Code for the Responsible Conduct of Research	The University of Adelaide	Online course	2
29.9.16	Florey Postgraduate Research Conference	Faculty of Health and Medical Sciences, The University of Adelaide. National Wine Centre of Australia, Adelaide	Conference	6
21- 25.4.17	117 <sup>th</sup> Annual Session: Navigating orthodontics: the art, the science, the business	American Association of Orthodontists, San Diego, US.	Conference, including oral presentation	10
18.9.17	Introduction to SPSS for statistics	CaRST – The University of Adelaide	Workshop	6
25.9.17	Session chair: Oral Session – Translation of research into clinical dental practice, 57 <sup>th</sup> International Association of Dental Research – Australia and New Zealand Divisional Meeting	International Association of Dental Research, Adelaide Health and Medical Sciences Building - The University of Adelaide	Conference	3
20.11.17	Thriving in your life as an HDR	CaRST – The University of Adelaide	Workshop	2
27.11.17	Reviving your life while doing an HDR	CaRST – The University of Adelaide	Workshop	2
4.12.17	The self-reflective HDR	CaRST – The University of Adelaide	Workshop	2
14.2.18	Emerging leader: leading others	CaRST – The University of Adelaide	Workshop	2



23.5.18	Commercialisation 101	CaRST – The University of Adelaide	Workshop	1
14.6.18	HDR workshop: ethics and integrity in research with humans	University of South Australia, Flinders University, The University of Adelaide	Workshop	6
21.6.18	Clinical research: establishing investigator initiated	CaRST – The University of Adelaide	Workshop	3
25.9.18	Florey Postgraduate Research Conference: presenting a poster	Faculty of Health and Medical Sciences, The University of Adelaide	Poster presentation	3
25.9.18	Florey Postgraduate Research Conference: symposium	Faculty of Health and Medical Sciences, The University of Adelaide. Wine Centre of Australia, Adelaide	Conference	2
26.9.18	Media training for scientists	CaRST – The University of Adelaide	Workshop	2
10.10.18	Engaging with industry	CaRST – The University of Adelaide	Workshop	2
25.10.18	Animate your science	The University of Adelaide	Workshop	2
31.10.18	Altmetric explorer for researchers	CaRST – The University of Adelaide	Workshop	2
1.5.19	Presenting your research with confidence	CaRST – The University of Adelaide	Workshop	2.5
10.5.19	Qualtrics web survey software – an introduction	Adelaide Business School, The University of Adelaide	Workshop	3
12.6.19	Emotional intelligence: understanding ourselves and others	CaRST – The University of Adelaide	Workshop	6
30.10.19	Defeating self sabotage	CaRST – The University of Adelaide	Workshop	2.5
13.11.19	Workforce skills workshop	CaRST – The University of Adelaide	Workshop	3
11.3.20	Leadership and the art of influence	CaRST – The University of Adelaide	Workshop	2

Abbreviation: CaRST: Careers and Research Skills Training

**Appendix 2: Certificate of attendance – Comprehensive Systematic  
Review Training Program – The Joanna Briggs Institute.**



### Appendix 3: Conference/lecture presentations of PhD research

Date	Title	Host, Venue	Format
13.12.16	Breastfeeding and malocclusions	Australian Society of Orthodontists, SA Branch. General Meeting. Amaro Restaurant, Adelaide, Australia	Oral
23.4.17	Malocclusions in young-children – does breastfeeding really reduce the risk?	Oral Research Presentations - American Association of Orthodontists 117 <sup>th</sup> Annual Session. San Diego, US.	Oral
25.9.17	What's worse for a child's teeth: non-nutritive sucking behaviours (NNSB) or sub-optimal breastfeeding?	Translation of research into clinical dental practice - 57 <sup>th</sup> International Association of Dental Research – Australia and New Zealand Divisional Meeting. The University of Adelaide – Adelaide Health and Medical Sciences Building, Adelaide, Australia.	Oral
2.7.18	Malocclusions – from infancy to adulthood. Do infant behaviours reduce their occurrence and what are the consequences of malocclusions later in life?	University of Malaya – Faculty of Dentistry. Kuala Lumpur, Malaysia.	Oral
5.7.18	Malocclusions – from birth to adulthood	Updates in endodontics and orthodontics: refreshing our knowledge. Universiti Sains Malaysia –School of Dental Sciences. Kota Bharu, Malaysia.	Oral
25.9.18	“Breastfeed for straight teeth!” Fact or fiction?	Florey Postgraduate Research Conference. The University of Adelaide - Faculty of Health and Medical Science. National Wine Centre of Australia, Adelaide, Australia.	Poster
4.5.19	Outcomes of orthodontic treatment – The Australian story	38 <sup>th</sup> Australian Dental Congress. Adelaide, Australia	Oral
4.9.20	What are the outcomes of orthodontic treatment later in life?	Colgate Research Day virtual poster competition – senior division. Adelaide Dental School, The University of Adelaide, Australia.	Digital poster
30.9.20	Do braces make you better-off in adulthood?	Florey Postgraduate Research Conference. The University of Adelaide - Faculty of Health and Medical Science. Virtual conference.	Digital poster

7.10.20- 3.11.20	Does previous fixed orthodontic treatment predict dental behaviour and knowledge in adulthood?"	9 <sup>th</sup> International Orthodontic Congress – Virtual Meeting.	Digital poster
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## Appendix 4: Survey – Oral Health of Adults Entering their Fourth Decade



# ORAL HEALTH OF ADULTS ENTERING THEIR FOURTH DECADE

**Australian Research Centre for Population Oral Health**  
**Dental School, Faculty of Health Sciences**  
**The University of Adelaide SA 5005**  
**Phone: (08) 8303 4046**  
**Fax: (08) 8303 4858**  
**Email: dentalstudy@adelaide.edu.au**

### Instructions

Thank you for participating in our survey. Your responses are very important to us and will help us to better understand the relationship between dental health and use of dental services.

Please consider each question and answer to the best of your ability. Circle the number or tick the box that best matches your answer, or write your answers where spaces are provided.

### Section 1. *Section 1 asks about the number of teeth you have.*

A1 Do you have any of your own natural teeth?  
 Yes, I have some or all of my natural teeth       No, I have none of my natural teeth

A2 There are 16 teeth, including wisdom teeth, in the **UPPER** jaw. How many of these 16 teeth do you have remaining in your upper jaw? **Do not count false teeth. If you have no teeth in your upper jaw, write 'nil'.**

I have ..... (number) natural teeth in my upper jaw

A3 There are 16 teeth, including wisdom teeth, in the **LOWER** jaw. How many of these 16 teeth do you have remaining in your lower jaw? **Do not count false teeth. If you have no teeth in your lower jaw, write 'nil'.**

I have ..... (number) natural teeth in my lower jaw

**Go on to questions A4 and A5 below**

A4 Do you wear a denture or false teeth in your **UPPER** jaw? Dentures (plates) are artificial teeth that can be removed.  
 Yes       No

A5 Do you wear a denture or false teeth in your **LOWER** jaw? Dentures (plates) are artificial teeth that can be removed.  
 Yes       No

**Section 2.**

*Section 2 asks about your dental visits.*

B1 How recent was your last visit to a dental professional? **Tick one box only.**  
*(Includes dentist, dental specialist, dental hygienist, dental technician, dental mechanic, denturist or dental therapist).*

<input type="checkbox"/> Less than 12 months ago	<input type="checkbox"/> Five to less than ten years ago
<input type="checkbox"/> One to less than two years ago	<input type="checkbox"/> Ten years or more
<input type="checkbox"/> Two to less than five years ago	<input type="checkbox"/> Never attended (go to question B7)

B2 What was the main reason for your last dental visit? **Tick one box only.**

Examination or check-up

Treatment (not for relief of pain)

Emergency/Relief of pain

B3 Where do you **usually** go for dental treatment? **Tick one box only.**

Private dental practice

Public dental clinic (inc. dental hospital, community clinic)

Other site (please specify) .....

B4 We would like to know about your dental visits in the last **12 months**

**For each question, please write the appropriate number in the space provided. If the answer is nil, please write 'nil'. Do not leave any of the spaces blank.**

How many:	In the last 12 MONTHS
a) Dental <i>visits</i> have you made?	.....
b) Dental <i>examinations</i> have you had?	.....
c) <i>Clean and scale</i> procedures have you had?	.....
d) <i>Fillings</i> have you had?	.....
e) Teeth have you had <i>extracted</i> (removed)?	.....

B5 Have you had any other treatment in the last 12 months? **Tick the relevant box(es).**

<input type="checkbox"/> No other treatment in the last 12 months	<input type="checkbox"/> Gum treatment (periodontal treatment)
<input type="checkbox"/> Professional <i>fluoride</i> application	<input type="checkbox"/> Adjustment, reline or rebase <i>denture(s)</i>
<input type="checkbox"/> New <i>denture(s)</i> prepared or fitted	<input type="checkbox"/> Orthodontics
<input type="checkbox"/> Other <i>oral</i> surgery (besides extraction)	<input type="checkbox"/> Crown or bridge treatment
<input type="checkbox"/> Other treatment (please specify) .....	

B6 How often on average would you seek care from a dental professional? **Tick one box only.**

More than two times a year

Two times a year

Once a year

Once in two years

Less often than once in two years

B7 Imagine you had an appointment to go to the dentist tomorrow, how would you feel about it? **Tick one box only.**

I would look forward to it as a reasonably enjoyable experience

I wouldn't care one way or the other

I would be a little uneasy about it

I would be afraid that it would be unpleasant and painful

I would be very frightened of what the dentist might do

B8 Do you need to make a dental visit now?  Yes  No

B9 What do you need a dental visit for? **Tick the relevant box(es).**  
 Check-up  
 Treatment (not for relief of pain)  
 Emergency/Relief of pain

B10 How soon do you think you need a check-up or treatment? **Tick one box only.**  
 In less than a week  
 From one week to less than a month  
 From one month to less than three months  
 From three months to less than six months  
 Six months or more

B11 Do you think you will receive treatment or a check-up within this time?  
 Yes  No

B12 If you said that you needed treatment, what treatment do you need? **Tick the relevant box(es).**  
 Clean and scale  Denture(s) made or repaired  
 Filling(s)  Gum treatment  
 Extraction(s)  Dental crown or bridge  
 Other treatment (please specify) .....

**Section 3.** Section 3 asks about your dental behaviours and dental knowledge.

**Please respond to the following questions. If your answer to a question is nil, please write 'nil' in the space provided. Do not leave the space blank.**

C1 In the last week, how many times did you **brush** your teeth? .....

**If you said that you brushed your teeth at least once in the last week, circle the best response:**

C2	In the last week, <b>how long</b> on average did you usually spend on each occasion brushing your teeth?	Less than 1 minute	About 1 minute	About 1½ minutes	About 2 minutes	About 2½ minutes	About 3 minutes	More than 3 minutes
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C3 In the last week, how many times did you use an **electric** toothbrush? .....

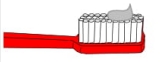
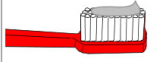
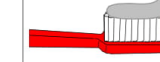
C4 In the last week, how many times did you use **dental floss**? .....

C5 a) In the last week, how many times did you use a **mouth rinse** or mouth wash? .....

b) If you used a mouth rinse or mouth wash in the last week, write the name of the product you used here:.....

**The following questions ask about your exposure to fluoride in childhood when your adult teeth were developing.**

D1	Up to the time you started school how often did you use <b>toothpaste</b> when brushing your teeth?	Less than once a day	Once a day	Twice a day	More than twice a day	Don't know
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D2	Up to the time you started school, what did you do immediately <b>after toothbrushing</b> ?	Just swallow	Rinse and swallow	Rinse and spit	Just spit	Don't know	
D3	Up to the time you started school, what <b>amount of toothpaste</b> did you usually apply to the toothbrush?	 Small <input type="checkbox"/> 1	 Medium <input type="checkbox"/> 2	 Large <input type="checkbox"/> 3			
D4	Up to the age of 8 years, did you ever take <b>fluoride tablets or drops</b> ?	Yes	No (Go to E1)	Don't know (Go to E1)			
D5	Up to the age of 8 years, how often did you take <b>fluoride tablets or drops</b> ?	More than once a day	Once a day	A few times a week	Once a week	Less than once a week	Don't know

*These questions are about professional and home dental care. Please read each statement then **circle one number only to indicate your level of agreement/disagreement with EACH statement.***

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
E1	It is good practice to have regular dental check-ups.	1	2	3	4	5
E2	I avoid seeking dental care even when I think I have a dental problem.	1	2	3	4	5
E3	I generally make dental appointments for check-ups even when I believe there is no problem.	1	2	3	4	5
E4	When I have a dental problem, it is not a high priority.	1	2	3	4	5
E5	If I had toothache, I would deal with it myself for at least a week.	1	2	3	4	5

**In your opinion, how important is each of the following in preventing TOOTH DECAY?**  
*Circle the number that best fits your answer to EACH statement.*

		Definitely important	Probably important	Neutral	Probably not important	Definitely not important
F1	Seeing a dentist regularly	1	2	3	4	5
F2	Drinking water with fluoride	1	2	3	4	5
F3	Sufficient calcium in the diet	1	2	3	4	5

**In your opinion, how important is each of the following in preventing GUM DISEASE?**  
*Circle the number that best fits your answer to EACH statement.*

		Definitely important	Probably important	Neutral	Probably not important	Definitely not important
F4	Seeing a dentist regularly	1	2	3	4	5
F5	Drinking water with fluoride	1	2	3	4	5
F6	Massaging the gums	1	2	3	4	5



**Section 4.** Section 4 asks you about the impact of your dental health on your daily life.

Each of the following questions begins by asking how your **teeth, mouth or dentures** have affected your daily living during the past year. We would like you to complete these questions even if you have good dental health.

**Please circle one response only that best fits your case for EACH statement.**

**HOW OFTEN** during the **PAST YEAR...**

		Very Often	Fairly Often	Occasion-ally	Hardly Ever	Never
G1	...have you had trouble <i>pronouncing any words</i> because of problems with our teeth, mouth or dentures?	1	2	3	4	5
G2	...have you felt that your <i>sense of taste</i> has worsened because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G3	...have you had <i>painful aching</i> in your mouth?	1	2	3	4	5
G4	...have you found it <i>uncomfortable to eat any foods</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G5	...have you been <i>self-conscious</i> because of your teeth, mouth or dentures?	1	2	3	4	5
G6	...have you <i>felt tense</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G7	...has your <i>diet been unsatisfactory</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G8	...have you had to <i>interrupt meals</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G9	...have you found it <i>difficult to relax</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G10	...have you been a bit <i>embarrassed</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G11	...have you been a bit <i>irritable with other people</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G12	...have you had <i>difficulty doing your usual jobs</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G13	...have you felt that life in general was <i>less satisfying</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5
G14	...have you been <i>totally unable to function</i> because of problems with your teeth, mouth or dentures?	1	2	3	4	5

**Section 5.** Section 5 asks about broader life issues that may impact upon your dental health.

The next ten statements seek views on levels of self-efficacy. **Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Not at all true	Hardly true	Moderately true	Exactly true
H1	I can always manage to solve difficult problems if I try hard enough.	1	2	3	4
H2	If someone opposes me, I can find means and ways to get what I want.	1	2	3	4
H3	It is easy for me to stick to my aims and accomplish my goals.	1	2	3	4
H4	I am confident that I could deal efficiently with unexpected events.	1	2	3	4
H5	Thanks to my resourcefulness, I know how to handle unforeseen situations.	1	2	3	4
H6	I can solve most problems if I invest the necessary effort.	1	2	3	4
H7	I can remain calm when facing difficulties because I can rely on my coping skills.	1	2	3	4
H8	When I am confronted with a problem, I can usually find several solutions.	1	2	3	4
H9	If I am in trouble, I can usually think of something to do.	1	2	3	4
H10	No matter what comes my way, I am usually able to handle it.	1	2	3	4

The next five statements seek views on levels of life satisfaction. **Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I1	In most ways my life is close to my ideal.	1	2	3	4	5
I2	The conditions of my life are excellent.	1	2	3	4	5
I3	I am satisfied with my life.	1	2	3	4	5
I4	So far I have acquired the important things I want in life.	1	2	3	4	5
I5	If I could live my life over, I would change almost nothing.	1	2	3	4	5

**Each of the following statements is about managing your general health. Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
J1	I take responsibility in caring for my health.	1	2	3	4	5
J2	No matter how hard I try my health doesn't turn out the way I would like.	1	2	3	4	5
J3	It is difficult for me to find effective solutions to the health problems that come my way.	1	2	3	4	5
J4	I succeed in the projects I undertake to improve my health.	1	2	3	4	5
J5	I'm generally able to achieve my goals with respect to my health.	1	2	3	4	5
J6	I am usually unsuccessful in making changes to things about my health that I don't like.	1	2	3	4	5
J7	Generally, my plans for my health don't work out well.	1	2	3	4	5
J8	I am able to do things for my health as well as most other people.	1	2	3	4	5

**Each of the following statements is about social support. Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
K1	There is a special person who is around when I am in need.	1	2	3	4	5
K2	There is a special person with whom I can share joys and sorrows.	1	2	3	4	5
K3	My family really tries to help me.	1	2	3	4	5
K4	I get the emotional help and support I need from my family.	1	2	3	4	5
K5	I have a special person who is a real source of comfort to me.	1	2	3	4	5
K6	My friends really try to help me.	1	2	3	4	5
K7	I can count on my friends when things go wrong.	1	2	3	4	5
K8	I can talk about my problems with my family.	1	2	3	4	5
K9	I have friends with whom I can share my joys and sorrows.	1	2	3	4	5
K10	There is a special person in my life who cares about my feelings.	1	2	3	4	5
K11	My family is willing to help me make decisions.	1	2	3	4	5
K12	I can talk about my problems with my friends.	1	2	3	4	5

**Each of the following statements is about self-esteem. Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Strongly disagree	Disagree	Agree	Strongly agree
L1	I feel that I'm a person of worth, at least on an equal plane with others.	1	2	3	4
L2	I feel that I have a number of good qualities.	1	2	3	4
L3	All in all, I am inclined to feel that I am a failure.	1	2	3	4
L4	I am able to do things as well as most other people.	1	2	3	4
L5	I feel I do not have much to be proud of.	1	2	3	4
L6	I take a positive attitude toward myself.	1	2	3	4
L7	On the whole, I am satisfied with myself.	1	2	3	4
L8	I wish I could have more respect for myself.	1	2	3	4
L9	I certainly feel useless at times.	1	2	3	4
L10	At times I think I am no good at all.	1	2	3	4

**Each of the following statements is about life-orientation. Please circle one number only to indicate your level of agreement/disagreement with EACH statement.**

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
M1	In uncertain times, I usually expect the best.	1	2	3	4	5
M2	It's easy for me to relax.	1	2	3	4	5
M3	If something can go wrong for me, it will.	1	2	3	4	5
M4	I always look on the bright side of things.	1	2	3	4	5
M5	I'm always optimistic about my future.	1	2	3	4	5
M6	I enjoy my friends a lot.	1	2	3	4	5
M7	It's important for me to keep busy.	1	2	3	4	5
M8	I hardly ever expect things to go my way.	1	2	3	4	5
M9	Things never work out the way I want them to.	1	2	3	4	5
M10	I don't get upset too easily.	1	2	3	4	5
M11	I'm a believer in the idea that "every cloud has a silver lining".	1	2	3	4	5
M12	I rarely count on good things happening to me.	1	2	3	4	5



The next items are about the activities that you spend your time on, like work, study and volunteering. If you are taking extended leave, we would still like you to respond to the items below.

N1 Are you employed full-time or part-time in a job, business or farm?

Yes, I work ..... hours per week  No

N2 What is your current occupation? **Please give the full title** (e.g., Childcare aide, maths teacher, pastry-cook, apprentice toolmaker).  
**If you have more than one job, we are interested in your main job only.**

.....

N3 What are the main tasks that you usually perform in your stated occupation? (e.g., looking after children at a day-care centre, teaching secondary school students, making cakes and pastries). For managers, state main activities managed.  
**Please give full details.**

.....

N4 Are you currently studying full-time or part-time at a University, College or TAFE?

Yes, full-time  Yes, part-time  No, I am not studying

N5 Are you currently regularly volunteering your time at an organisation, school, charity or club?

No  
 Yes, I volunteer approximately ..... hours per month.

**If you answered 'NO' to questions N1, N4, AND N5, GO TO SECTION 6 on the next page.**

For this group of statements, paid work, study and volunteering are considered 'work'. Circle one number only to indicate your level of agreement/ disagreement with EACH statement.

		Often		Never	
O1	Do you have a choice in deciding HOW to do your work?	1	2	3	4
O2	Do you have a choice in deciding WHAT you do at work?	1	2	3	4
O3	Others take decisions concerning my work.	1	2	3	4
O4	I have a good deal of say in decisions about my work.	1	2	3	4
O5	I have a say in my own work speed.	1	2	3	4
O6	My working time can be flexible.	1	2	3	4
O7	I can decide when to take a break.	1	2	3	4
O8	I have a say in choosing with whom I work.	1	2	3	4
O9	I have a great deal of say in planning my work environment.	1	2	3	4

**Section 6.** Section 6 asks you about sociodemographic characteristics.

P1 Are you:  Male  Female

P2 How old are you? ..... (years)

P3 What country were you born in?  Australia  
 Other (please specify).....

P4 Are you of Aboriginal and/or Torres Strait Islander origin?  Yes  
 No

P5 What is the main language you speak at home?  English  
 Other (please specify) .....

P6 What is the **highest** level of education you have completed? **Tick one box only.**  
 Year 7 or less  
 Year 8  
 Year 9  
 Year 10 (Intermediate)  
 Year 11 (Leaving)  
 Year 12 (Matriculation, Leaving Honours)  
 Certificate (please specify) .....

P7 Are you covered by any Government Health Concession cards? (**NOT including a Medicare card**).  
 No  
 Yes (please specify) .....

**Income is important in understanding oral health, as it influences access to dental health services.**

P8 Could you please indicate the category of the **total** (gross or before-tax) yearly income of your household? We only require an approximation. **Tick one box only.**  
 Up to \$12,000 per year  
 From \$12,001 to \$20,000 per year  
 From \$20,001 to \$30,000 per year  
 From \$30,001 to \$40,000 per year  
 From \$40,001 to \$50,000 per year  
 From \$50,001 to \$60,000 per year  
 From \$60,001 to \$70,000 per year  
 From \$70,001 to \$80,000 per year  
 More than \$80,000 per year

P9 Including yourself, how many people in your household are **aged 15 years and over**? .....

P10 How many dependent children in your household are **younger than 15 years** of age? .....

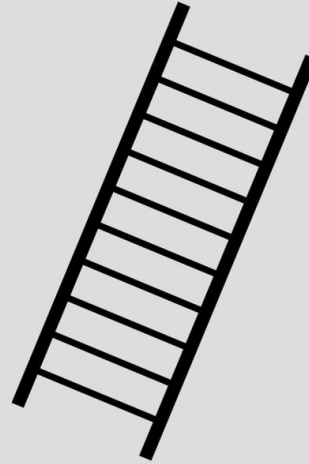
**If you answered '0' or 'NIL' to question P10, GO TO QUESTION P12.**

P11 What is the age of **each child** younger than 15 in your household?  
**(Leave one or more boxes blank if there are fewer than 5 children under 15)**  
.....  
Age of child 1      Age of child 2      Age of child 3      Age of child 4      Age of child 5

Think of the ladder below as representing where people stand in society. At the top are the people who are best off – have the most money, most education and the best jobs. At the bottom are the people who are worst off – with the least money, least education and the worse jobs or no job. The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to the bottom.

P12 **Where would you put yourself on the ladder?**

**Please place a large 'X' on the rung where you think you stand.**



**Best off**  
Most education  
Most money  
Best jobs

**Worst off**  
Least education  
Least money  
Worst jobs or no job

**Section 7.** Section 7 asks about your fluoride and dental history.

We wish to estimate your lifetime exposure to fluoridated water supplies. To do this we need to know where you lived in each year from 1975 or later if you were born after 1975.

**INSTRUCTIONS**

- For each year from 1975 onwards please indicate the city or town in which you lived.
- If you were born after 1975, please begin recording your details from the year in which you were born.
- For Australian capital cities, simply tick the capital city column (A–H) for each year that you lived there.
- For other Australian cities or towns please write the name (column I) and postcode (column J) of the city or town.
- If you lived overseas for 12 months or more please write the name of the country in column K.

**EXAMPLE** This person was born in 1976 and began recording from that year onwards, living in Sydney in 1976 and 1977, Ballarat in 1978, the United States in 1982 and then in Melbourne from 1983.

	A	B	C	D	E	F	G	H	I	J	K
	Place a tick for each year lived in a capital city								Name the area	Write postcode	Name the country
	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin	Other Australian city or town	Postcode (only required for non-capital cities)	Country (if not Australia)
1975											
1976	✓										
1977	✓										
1978									Ballarat	3612	
1979									Ballarat	3612	
1980									Ballarat	3612	
1981									Ballarat	3612	
1982											United States
1983		✓									
1984		✓									
1985		✓									
1986		✓									

EXAMPLE ONLY

**Please indicate on this page all places in which you lived for 12 months or longer from 1975 to now. Tick a capital city (A–H) OR write name & postcode of a non-capital city (I–J) OR name the country (K).**

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>	<b>I</b>	<b>J</b>	<b>K</b>
	<i>Place a tick for each year lived in a capital city</i>								<i>Name the area</i>	<i>Write postcode</i>	<i>Name the country</i>
	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin	Other Australian city or town	Postcode <i>Only required for non-capital cities</i>	Country <i>(if not Australia)</i>
<b>1975</b>											
1976											
1977											
1978											
1979											
<b>1980</b>											
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<b>2005</b>											
2006											



We wish to learn about your dental history going back to when you were a teenager. For each year please indicate whether any of the listed dental events happened by placing a tick against the year in the appropriate column.

**EXAMPLE**

In the example below, this person had orthodontic bands during 1990 and 1991, made an emergency dental visit for relief of pain in 1997, and smoked 20 cigarettes per day in 1995. This person has not had any teeth extracted, hence the column for “Had a tooth extracted?” was left blank.

	Had an emergency visit for relief of pain?	Had orthodontic bands or braces?	Had a tooth extracted? (Not counting wisdom teeth)	Smoked daily or occasionally?	Number of cigarettes per day?
<b>1990</b>		✓			
1991		✓			
1992					
1993					
1994					
<b>1995</b>				✓	20
1996					
1997	✓				

EXAMPLE ONLY

	Had an emergency visit for relief of pain?	Had orthodontic bands or braces?	Had a tooth extracted? (Not counting wisdom teeth)	Smoked daily or occasionally?	Number of cigarettes per day?
<b>1990</b>					
1991					
1992					
1993					
1994					
<b>1995</b>					
1996					
1997					
1998					
1999					
<b>2000</b>					
2001					
2002					
2003					
2004					
<b>2005</b>					
2006					

**Section 8.** Section 8 asks about life events that you may have experienced and their impact.

	Have you experienced these events?	Please circle: Y for Yes, or N for No, or n/a for not applicable			If yes: How long ago was the most recent time?	What impact did it have on your life at the time the event occurred?						
		Extremely negative	No impact			Extremely positive						
1	Marriage	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
2	Trouble with the boss	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
3	Major change in financial state (e.g. a lot worse off or a lot better off than usual)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
4	Death of spouse/partner	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
5	Major change in sleeping habits (a lot more or a lot less sleep, or change in part of day when asleep)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
6	Death of a close family member	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
7	Major change in eating habits (a lot more or a lot less food intake, or very different meal hours or surroundings)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
8	Foreclosure on a mortgage or loan	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
9	Revision of personal habits (dress, manners, associations, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
10	Death of a close friend	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
11	Minor violations of the law (e.g. traffic tickets, jay walking, disturbing the peace, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
12	Outstanding personal achievement	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
13	(a) Male: Wife/girlfriend pregnancy	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
	(b) Female: Pregnancy	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
14	Major changes in the health or behaviour of a family member	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
15	Major change in working hours or conditions	Y	N	n/a		-3	-2	-1	0	+1	+2	+3

Continued...

Have you experienced these events?		Please circle: Y for Yes, or N for No, or n/a for not applicable			If yes: How long ago was the most recent time?	What impact did it have on your life at the time the event occurred?						
		Extremely negative	No impact			Extremely positive						
16	Taking on a mortgage greater than \$10,000 (e.g. purchasing a home, business, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
17	Major changes in number of family get-togethers (e.g. a lot more or a lot less than usual)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
18	Changing to a new school	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
19	Gaining a new family member (e.g. through birth, adoption, oldster moving in etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
20	Change in residence	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
21	Major personal injury or illness	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
22	Marital separation from mate	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
23	Taking on a mortgage or loan less than \$10,000 (e.g. purchasing a car, TV, freezer, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
24	Marital reconciliation with mate	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
25	Being fired from work	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
26	Divorce	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
27	Changing to a different line of work	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
28	Major change in the number of arguments with spouse/partner (e.g. either a lot more or a lot less regarding childrearing, personal habits etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
29	Major change in responsibilities at work (e.g. promotion, demotion, lateral transfer)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
30	Change in spouse/partner's work (beginning work, ceasing work, loss of job, beginning new job, retirement, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3
31	Major change in social activities (e.g. clubs, dancing, movies, visiting, etc.)	Y	N	n/a		-3	-2	-1	0	+1	+2	+3

**Section 9.** *Section 9 asks about your time preferences for your dental check-up.*

As explained in the cover letter and information sheet, we would like you to participate in a dental check-up. You will not be given any x-rays and the check-up will be at no cost to you. The check-up will take about 20 minutes to complete. No treatment will be done but a statement will be given to you outlining any treatment needs that are identified during the check-up. A dentist registered by the SA Dental Board will perform the check-up. We would like some information in order to organise the most convenient dental check-up time.

*Please indicate your preferred time(s) to attend a dental check-up, numbering your preferences from most preferred to least preferred.*

**Preferred time(s):**

	<b>Morning (9am-12pm)</b>	<b>Afternoon (12pm-5pm)</b>	<b>Evening (5pm-7.30pm)</b>
<b>Monday</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tuesday</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Wednesday</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Thursday</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Friday</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Saturday</b>	<input type="checkbox"/>		

We will arrange for the check-up to be conducted at a South Australian Dental Service clinic near you, or at the Adelaide Dental Hospital.

*Please tick the box(es) indicating your preferred location for the dental check-up.*

**Preferred location(s):**

Adelaide Dental Hospital, Frome Rd, Adelaide

A Government dental clinic in your area

**Your contact details:**

**Phone:** Home .....

Work .....

Mobile .....

**Email address:** .....

**Any comments?**

.....

.....

.....

**Thank you very much for your time. Please check that you have answered each question and return your completed questionnaire in the reply paid envelope provided. You will be contacted soon to arrange your dental check-up.**

--	--	--	--	--	--	--	--



## Appendix 5: Evidence of presentation of PhD research

### 2016 – Australian Society of Orthodontists, SA Branch



Australian Society  
of Orthodontists

### Notice of General Meeting

A General Meeting of the Australian Society of Orthodontists, South Australian Branch, is to be held:

**Tuesday, 13<sup>th</sup> September 2016**

Amaro Restaurant  
173 Hutt Street,  
Adelaide SA 5000  
Phone: (08) 8232 3281

6:15 pm for 6.45 pm

Guest Speakers

Dr Esmá Dogramaci

"Breastfeeding and malocclusions"

And

Dr Pat Hanna, Ms Michelle Cutler (ASO CEO) & Mr John Peacock (Associations Forum)

"ASO Governance"

RSVP: Dr James Moses by Tuesday 6<sup>th</sup> September

Ph: 0432852806

Email: [jbmoses@hotmail.com](mailto:jbmoses@hotmail.com)

Please specify any dietary requirements

AGENDA

- 1 Apologies
- 2 Minutes of the previous meeting
- 3 Business arising from previous meeting
- 4 Correspondence in/out
- 5 Business arising from correspondence
- 6 Treasurer's report
- 7 Federal Councillor's report
- 8 General Business
- 9 ASO Governance
- 10 Close

Maurice Meade  
ASO SA Branch Secretary

## 2017 – American Association of Orthodontists 117<sup>th</sup> Annual Session



American  
Association of  
Orthodontists®

My Life. My Smile. My Orthodontist.®

117<sup>th</sup> Annual Session

Navigating Orthodontics  
The Art ▪ The Science ▪ The Business

San Diego, California ■ April 21-25, 2017

**DeWayne B. McCamish, DDS, MS**  
President



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Secretary-Treasurer



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April 23, 2017

Malocclusions in young children – does breastfeeding really reduce the risk?

Esma J. Dođramacı, et al.  
Adelaide, Australia

Dear Dr. Dođramacı,

Thank you for participating as an Oral Research Presenter at the American Association of Orthodontists (AAO) 2017 Annual Session in San Diego, CA.

The Planning Committee recognizes that the real success of the Annual Session is active involvement by individuals in programs such as this. Your Oral Research presentation was an important contribution. We appreciate the time spent in preparing your scientific information and trust other attendees benefited from your presentation.

Again, thank you for your participation in this momentous event. The AAO looks forward to your continued participation at the 2018 AAO Annual Session in Washington, DC.

Sincerely,

Dr. Jeffrey C. Nickel, DMD, MSc, PhD  
Chair, Council on Scientific Affairs

# 2017 – 57<sup>th</sup> International Association of Dental Research – Australia and New Zealand Divisional Meeting, Adelaide, Australia

## Abstracts

### Oral Session 1 - Translation of research into clinical dental practice 1

What's worse for a child's teeth: non-nutritive sucking behaviours (NNSB) or sub-optimal breastfeeding?

E. J. Dogramaci, G. Rossi-Fedele

The University of Adelaide, Adelaide, South Australia, Australia

**Objectives** Establish whether NNSB or sub-optimal breastfeeding are associated with malocclusions in the primary dentition, and compare the associations they may have.

**Methods** The systematic review of association (etiology) methodology, developed by the Joanna Briggs Institute (JBI), was followed. The criteria of population, exposure and outcome were used to generate the review questions. Studies with healthy participants in the primary dentition and no history of orthodontic or surgical treatment were considered for inclusion. Studies with participants with a cleft lip/palate; other craniofacial deformities; any syndrome; or maxillofacial trauma were excluded. Studies evaluating 1 or more of the following types of exposures were considered for inclusion: NNSB; pacifier or digit sucking; breastfeeding; exclusive/non-exclusive; short/long duration. Increased overjet, sagittal relationship (canine/molar teeth), posterior crossbite (x-bite), and anterior open bite (AOB) were assessed as outcomes. Prospective and retrospective (cohort) studies, case-control studies and analytical cross-sectional studies were considered for inclusion. Reviews, text- and opinion-based articles, conference abstracts, case reports, case-series, and descriptive cross-sectional studies were excluded. A 3-step search strategy was used that included electronic searches across MEDLINE, EMBASE, SCOPUS and CINAHL. Full-text articles were assessed, and data extracted independently and in duplicate by 2 JBI-trained and accredited reviewers, using standardised instruments from JBI SUMARI. Meta-analyses were performed when there were sufficient number of studies with homogenous exposure and outcome measures. Across-study heterogeneity precluded use of a single systematic review with sub-group analyses to synthesise the results of the component studies. Therefore, two separate reviews were conducted.

**Results** 20 studies were included across 2 separate systematic reviews. 2 were prospective; the remainder were cross-sectional in design. There is evidence to indicate that NNSBs carry a greater risk for the development of posterior x-bite and AOB in the primary dentition when compared to absence of breastfeeding.

**Conclusions** NNSB is associated with greater prevalence and risk for development of posterior x-bite and AOB compared to absence of breastfeeding.



# Certificate of Appreciation

This certificate is awarded to

Dr Esma J Doğramacı

for being the guest speaker for the lecture entitled;

**MALOCCCLUSIONS – FROM INFANCY TO ADULTHOOD. DO INFANT BEHAVIOURS REDUCE THEIR OCCURRENCE AND WHAT ARE THE CONSEQUENCES OF MALOCCCLUSIONS LATER IN LIFE?**

on:

July 2nd, 2018

at:

Faculty of Dentistry  
University of Malaya



PROF. DATO' DR. ZAINAL ARIFF ABDUL RAHMAN  
DEAN, FACULTY OF DENTISTRY  
UNIVERSITY OF MALAYA



2018 – Universiti Sains Malaysia, Kota Bharu, Malaysia



## *Certificate of Appreciation*

This certificate is awarded to

**Dr Esma J Dogramaci**

as a **SPEAKER**  
in the

### **UPDATES IN ENDODONTICS AND ORTHODONTICS: REFRESHING OUR KNOWLEDGE**

organized by:  
School of Dental Sciences  
Universiti Sains Malaysia  
Usains Tech Services Sdn. Bhd.

on 5th July 2018

at Universiti Sains Malaysia, Health Campus, Kubang Kerian, Kelantan



.....  
**PROFESOR DR. ADAM BIN HUSEIN**  
Dean  
School of Dental Sciences  
Universiti Sains Malaysia

.....  
**DR. TAHIR YUSUF NOORANI**  
Chairman





# “BREASTFEED FOR STRAIGHT TEETH!” Fact or fiction?

Esma J. Doğramaci,<sup>1,2</sup> Giampiero Rossi-Fede<sup>1</sup>

<sup>1</sup> Adelaide Dental School, <sup>2</sup> Australian Research Centre for Population Oral Health (ARCPHO)  
Faculty of Health and Medical Sciences  
Email: esma.dogramaci@adelaide.edu.au

## Background

- Malocclusions (deviation of a person's bite and tooth arrangement from normal) are the result of a complex interaction of genotype and environmental factors.
- Environmental factors (e.g. non-nutritive sucking behaviours) can cause malocclusions (Fig. 1).<sup>1</sup> Modifying them can prevent malocclusions and avoid orthodontic treatment.
- Dental crowding, which the lay public commonly refer to as “crooked” or “unstraight teeth”, is the result of dentofacial disproportion; the space in the jaws being too small to allow all teeth to neatly line up next to each other. While genetics plays a key role, environmental factors such as early loss (extraction) of deciduous teeth because of untreatable decay, are important mediators.
- Optimal breastfeeding (breastmilk, exclusively, for the first 6 months of life, then continued breastfeeding up to the age of 2 years or beyond) has innumerable health benefits.<sup>2</sup> Recent media headlines reported “breastfeeding for straight teeth” and “breastfeeding may help build a better bite.”<sup>3</sup> Euphistic headlines have the potential to mislead or cause confusion, or both, particularly amongst the lay public.
- Nearly ¼ of adult Internet users look online for health information;<sup>4</sup> to fill a knowledge gap, verify existing personal knowledge, get reassurance, obtain alternative opinions or avoid professional consultations.<sup>5,6</sup> Over 50% of first-time mothers use general Internet searches to seek information about breastfeeding.<sup>7</sup> The lay public may not always be able to discriminate between good quality information from spurious claims, or be aware if information is incorrect, biased or out-of-date. Reliance on poor-quality Internet information for self-diagnosis and subsequent self-treatment, particularly if it is false, inaccurate or incomplete, can be detrimental.<sup>8</sup>
- No study has evaluated Internet information targeting the lay public about breastfeeding and malocclusions.
- No high-level evidence exists into whether breast-feeding really reduces the risk for malocclusion development, particularly in children ≤6 years old.



## Aims

- Assess the quality of Internet information targeting the lay public about the relationship between breastfeeding and malocclusions.
- Determine the level of evidence of scientific articles cited on websites for the lay public.
- Investigate whether breastfeeding decreases the risk of malocclusions in healthy children ≤6 years old in the deciduous dentition.

## Methods

**Assessment of quality of Internet information:** A keyword term (“breastfeeding and crooked teeth”) and a natural language term (“does breastfeeding protect against crooked teeth”) were each entered into 4 search engines. Consecutive sampling of every website was performed until 5 websites were identified per search engine, that fulfilled the inclusion criteria, to produce 40 websites for evaluation.<sup>9</sup> The LIDA Instrument,<sup>10</sup> and the Joanna Briggs Institute (JBI) Levels of Evidence,<sup>11</sup> were used to assess quality of the information.

**Systematic Review and Meta-Analysis:** The title and protocol were prospectively registered, peer-reviewed, and approved by the JBI.<sup>12</sup> The JBI methodology for reviews of association (etiology) was followed;<sup>13</sup> Population, Exposure and Outcome were used to generate the review questions for identifying the risk of developing different malocclusion features in the deciduous dentition in children who have:

- breastfed vs. those not breastfed.
- exclusively breastfed vs. those not exclusively breastfed.
- breastfed for long duration (≥12 months) vs. those breastfed for short duration (<12 months).

A 3-step search strategy was used that included 4 bibliographic databases. After excluding duplicates, titles and abstracts of articles were screened and selected independently by 2 JBI-trained and accredited reviewers, who then assessed methodological quality of full-text articles using JBI Critical Appraisal tools. Data from included articles were extracted with tools from JBI SUMARI. The random-effects model was used for all meta-analyses, with supplementation with the fixed-effects model in situations where statistical heterogeneity was ≤50% (assessed using the I<sup>2</sup> statistic).

## Results

### Internet information

>1.5 million URLs retrieved.  
508 websites screened.

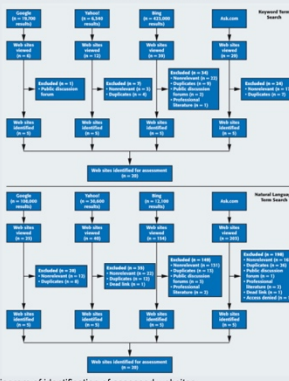


Fig 2: Flow diagram of identification of assessed websites.

High accessibility, moderate usability & reliability.  
Overall quality - moderate.

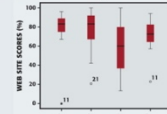


Fig 3: Box plots of the distribution of the component and overall LIDA scores of websites.

Commercial organisations own most websites.  
Dental websites - highest quality information.

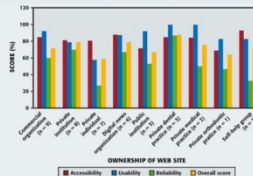


Fig 4: Distribution of median LIDA scores according to the category of ownership of the websites.

<1/2 websites cite articles to support content.  
Commercial organisations cite very low evidence.

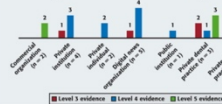


Fig 5: Number of citations of articles on websites, according to level of evidence.

### Systematic review and meta-analysis

860 articles identified.  
6 included in meta-analyses.

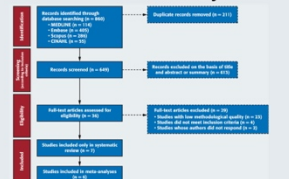


Fig 6: Flow diagram of study selection.

## Results (cont'd)

Higher risk ratios for malocclusions amongst sub-optimally breastfed children.

EXPOSURE	CLASS II CANINE RELATIONSHIP	POSTERIOR CROSSBITE	ANTERIOR OPEN BITE
	No. of Studies	No. of Studies	No. of Studies
Breastfeeding	2	2	3
Not breastfeeding	1	1	1
Sub-optimally breastfed	1	1	1
Longer duration of breastfeeding	2	2	2
Shorter duration of breastfeeding	2	2	2
Never breastfed	3	3	3
Never breastfed + longer duration	1	1	1
Never breastfed + shorter duration	1	1	1
Never breastfed + never breastfed	1	1	1
Never breastfed + longer duration + shorter duration	1	1	1
Never breastfed + longer duration + never breastfed	1	1	1
Never breastfed + shorter duration + never breastfed	1	1	1
Never breastfed + longer duration + shorter duration + never breastfed	1	1	1
Total	20	20	20

Table 1: Summary of meta-analyses comparing different exposures with specific malocclusion features in the primary dentition.

Very significant association between shorter breastfeeding & Class II canine relationship.

Study or Subgroup	Events	Total	Events	Total	Weight (%)	RR, M-H, Random, 95% CI
Werner and Wilkins, 2002	18	20	2	20	2.0	0.27 (0.09 to 0.75)
Arora and Chugh, 2014	30	30	1	30	1.0	0.13 (0.01 to 2.42)
Total events	48	50	3	50		
Total studies	2		2			
Total events	340		110			
Total studies	10		10			
Test for overall effect: $I^2 = 0.00$ , $P = 0.49$ , $RR = 0.27$						

Fig 7: 1.65 times increased risk for Class II canine relationship in those who breastfed for shorter duration.

Significant association between no breastfeeding & anterior open bite.

Study or Subgroup	Events	Total	Events	Total	Weight (%)	RR, M-H, Random, 95% CI
Werner and Wilkins, 2002	18	20	1	20	2.0	0.57 (0.09 to 3.21)
Arora and Chugh, 2014	30	30	1	30	1.0	0.13 (0.01 to 2.42)
Total events	48	50	2	50		
Total studies	2		2			
Total events	482		108			
Total studies	10		10			
Test for overall effect: $I^2 = 0.00$ , $P = 0.82$ , $RR = 1.46$						

Fig 8: 1.46 times increased risk for anterior open bite in those who never breastfed.

Strong & highly significant association between shorter breastfeeding & anterior open bite.

Study or Subgroup	Events	Total	Events	Total	Weight (%)	RR, M-H, Random, 95% CI
Werner and Wilkins, 2002	18	20	1	20	2.0	0.57 (0.09 to 3.21)
Arora and Chugh, 2014	30	30	1	30	1.0	0.13 (0.01 to 2.42)
Total events	48	50	2	50		
Total studies	2		2			
Total events	482		108			
Total studies	10		10			
Test for overall effect: $I^2 = 0.00$ , $P = 0.53$ , $RR = 3.58$						

Fig 9: 3.58 times increased risk for anterior open bite in those who breastfed for shorter duration.

## Summary

- The scant Internet information about breastfeeding and malocclusions is moderate in quality, with greatly variable reliability. Only 2 high-quality websites were identified.
- Less than 1/2 of websites cite scientific articles to support their content, ranging between moderate to mostly very low level evidence.
- This systematic review provides the highest-level evidence into breastfeeding and malocclusions in children ≤6 years.
- Very few high quality studies were identified; none investigated crooked teeth as a malocclusion outcome related to breastfeeding.
- Sub-optimally breastfed children have higher prevalence and risk of developing certain malocclusion features. This should not be misinterpreted as breastfeeding decreasing malocclusion occurrence.
- The crucial role of genetics in malocclusions was supported in studies into geographically isolated, non-urban and genetically homogenous populations where children who were optimally breastfed and who did not have deleterious habits still developed malocclusions.
- It is not possible to confirm that breastfeeding leads to correct development of dentofacial structures. The contention made in media headlines that breastfeeding will lead to straight (non-crooked) teeth could not be upheld.
- Rather than advocating optimal breastfeeding for malocclusion prevention, it should instead be encouraged for helping avert the acquisition of non-nutritive sucking behaviours, which are recognised as having a direct causal relationship for certain malocclusions.<sup>1</sup>

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13. *Statista*. 2018. Available at: <https://www.statista.com/statistics/454843/health-information-searches/>.

## Acknowledgements

KG Peres & MA Peres supervised the Internet study. G Rossi-Fede was the second reviewer for the systematic review and meta-analysis. CW Dreyer reviewed the manuscript for the systematic review and meta-analysis. The research was supported by an Australian Government Research Training Scholarship.



**MAIN SCIENTIFIC PROGRAM**

**Saturday, 4th May 2019**

• = Recorded sessions

Program information is subject to change. Visit the website or Congress App for updates.

**Stream 1 | Hall C**

Mucogingival procedures around dental implants to enhance longevity.  
Presented by Dr Sascha Jovanovic.  
Sponsored by *Nobel Biocare*

8:15am - 9:00am

Endodontics: A rational approach to root canal irrigation.  
Presented by Prof Giampiero Rossi-Fedele.

9:05AM - 9:50AM

**MORNING TEA IN THE EXHIBITION**

Modern Dentistry: It's all about adhesion, compression and preservation.  
Presented by Prof Richard Young.  
Sponsored by *J.Morita, Kuraray & Noritake*

10:30AM - 11:15AM

New restorative developments to ensure stable crestal bone and gingival margins.  
Presented by Dr Sascha Jovanovic.  
Sponsored by *Nobel Biocare*

11:20AM - 12:05PM

**LUNCH IN THE EXHIBITION | LUNCHEON SESSIONS\***

Endodontics: what to do when things go wrong.  
Presented by Dr Geoffrey Young.

1:45PM - 2:30PM

Is it really toothache? Odontogenic vs Non-Odontogenic pain.  
Presented by Prof Asgeir Sigurdsson.

2:35PM - 3:20PM

**AFTERNOON TEA IN THE EXHIBITION**

Oral manifestation of systemic disease.  
Presented by Prof Tony Pogrel.

3:25PM - 3:55PM

Prosthodontic Soft Tissue Manipulation.  
Presented by Dr Aldo Leopardi.

4:00PM - 4:45PM

Considerations in treatment planning for Immediate Implant Placement.  
Presented by Dr Tony Strangio

4:50PM - 5:35PM

Say Ahhh - What do GPs, pharmacists and dentists do about bad breath?  
Presented by Prof Ivan Darby

**Stream 2 | Hall D**

OMGI What's that lesion on this OPG!  
Presented by Dr Sarah Constantine.

Pink, Aesthetic Substitute.  
Presented by Dr Aldo Leopardi.

9:55AM - 10:25AM

Managing Dental Anxiety and Dental Phobia.  
Presented by Dr Avanti Karve.

Links between sexual assault and dental appointments: patient management guidelines.  
Presented by Dr Sharonne Zaks.

Infection Control - important updates and current recommendations.  
Presented by A/Prof Sharon Liberali.

Record Keeping: essential knowledge to avoid pitfalls.  
Presented by Dr Elizabeth Millford.

The Aesthetic evaluation and the Invisalign restorative interface.  
Presented by Dr Bharat Agrawal.  
Sponsored by *Invisalign*

Relationship Counselling: you, the patient, the Dental Board and the Law.  
Presented by Dr Gerard Clausen.

Interproximal Reduction (IPR) - When? Why? How?  
Presented by Dr Morris Rapaport.

ADHF & Volunteering Action  
Presented by Dr David Digges and Mr David Owen

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38TH AUSTRALIAN DENTAL

**CONGRESSES**

**Certificate of Appreciation**

Presented to

**DR ESMA DOGRAMACI**

For your invaluable contribution as a Local Speaker at the  
38th Australian Dental Congress held in Adelaide, 1st - 4th May 2019

Dr Carmelo Bonanno  
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Australian Dental Association

Dr Karin Alexander  
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38<sup>th</sup> Australian Dental Congress



**2020 – Abstract. Colgate Research Day virtual poster competition. Adelaide, Australia.**

## **WHAT ARE THE OUTCOMES OF ORTHODONTIC TREATMENT LATER IN LIFE?**

### **Introduction**

Patients mostly seek orthodontic treatment to correct crowding. Further expectations include increased dental knowledge, reduced caries risk, and higher psychosocial functioning.

### **Aim**

To identify any differences in dental knowledge, behaviour, caries and psychosocial outcomes between adults based upon previous orthodontic treatment.

### **Methods**

In 1988-1989, 3925 13-year-olds in South Australia had their baseline malocclusion recorded. In 2005-2006, 1859 of these participants, aged 30-years, were invited to the long-term observational, cross-sectional study. The University of Adelaide granted ethical approval. A self-completed questionnaire collected data on socio-demographics, dental health practices/knowledge, psychometric outcomes, past orthodontic treatment. Clinical examinations recorded DMFT scores. Data analysis comprised descriptive statistics, frequency distribution, cross-tabulation, unadjusted bivariate and adjusted multivariate models using negative binomial regression, simple linear regression, generalised linear regression and multivariate binomial logistic regression.

### **Results**

Of 632 respondents, 448 (252 female) had valid questionnaire/clinical data. 73% earned <\$80,000p.a., 44% held tertiary qualifications, 60% had a recent dental visit, 46% brushed twice daily, 35% were treated orthodontically. Adjusted models showed no



association between orthodontic treatment and regularity of oral hygiene measures, knowledge about or actual dental visits, or DMFT scores, regardless of baseline malocclusion. Untreated participants were more optimistic (Coefficient: 0.97; SE: 0.45), believing calcium prevents decay (Exp B: 1.99; 95%CI: 1.14-3.50). Lower-income earners had significantly lower disease prevention knowledge, poorer dental visiting attitudes (Coefficient: -1.88; SE: 0.43), more missing teeth (Exp B: 12.28; 95%CI: 2.90-51.90), and low scores for social support (Coefficient: -2.83; SE: 0.88) and optimism (Coefficient: -1.16; SE: 0.49). Basic education was associated with infrequent toothbrushing (Exp B: 0.25; 95%CI: 0.13-0.49), poorer dental visiting attitudes (Coefficient: -1.31; SE: 0.57), fewer non-emergency visits (Exp B: 0.17; 95%CI: 0.07-0.41), more decayed (Exp B: 2.80; 95%CI: 1.80-4.35) and missing teeth (Exp B: 6.94; 95%CI: 3.21-14.99), lower self-efficacy (Coefficient: -2.34; SE: 0.61), perceived health competence (Coefficient: -2.17; SE: 0.69), social support (Coefficient: -2.69; SE: 1.18) and optimism (Coefficient: -1.83; SE: 0.66). Males brushed (Exp B: 0.64; 95%CI: 0.42-0.97) and flossed (Exp B: 0.23; 95%CI: 0.08-0.69) infrequently, gave less importance to regular dental visits (Exp B :0.55; 95%CI: 0.32-0.92), and had lower social support (Coefficient: -2.45; SE: 0.76).

## **Conclusion**

Orthodontic treatment is not associated with better dental knowledge, behaviour, caries levels or psychosocial functioning in adulthood.





# Do braces make you better-off in adulthood?

Esma J. Doğramacı,<sup>1,2</sup> Farhad B. Naini,<sup>3</sup> David S. Brennan<sup>2</sup>

1. Adelaide Dental School - Orthodontics, 2. Adelaide Dental School - Australian Research Centre for Population Oral Health (ARCPOH), 3. Kingston and St George's Hospitals, Department of Orthodontics, London, UK.  
Email: [esma.dogramaci@adelaide.edu.au](mailto:esma.dogramaci@adelaide.edu.au)

## Background

- Oral health can be impacted by malocclusions by hindering speech, chewing or psychologically-linked acts (e.g. smiling).
- Braces straighten crooked teeth and tuck back sticky-out teeth, to prevent dental trauma.
- Braces treatment can take up to 3 years, with frequent appointments averaging every 6-8 weeks.

## Questions

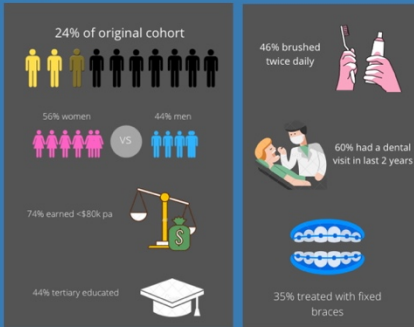
- Are there any other, long-term, benefits of braces?
- Does past braces make you take better care of your teeth?
- Will you have fewer cavities if you have straight teeth?
- Will you feel more positive about yourself after braces?

## Methods

- In 1988-1989, 3925 13-year-olds had their teeth checked in South Australian School Dental Clinics.
- In 2005-2006, 1859 of the original participants, aged 30 and living in Adelaide, were invited to the cross-sectional, observational study.
- A self-completed questionnaire collected data on:
  - Income
  - Dental knowledge
  - Education
  - Psychosocial experiences + behaviours
  - Dental habits
  - If they had braces in the past
- Teeth were clinically checked for past or active decay.
- In addition to descriptive statistics, frequency distribution, and cross-tabulation, un/adjusted bivariate and multivariate models analysed the data.

## Results

- 632 • Returned the postal questionnaire.
- 34% response rate.
- 473 • Attended for clinical exam.
- 25 excluded (in valid study ID, traced erroneously).
- 448 • Valid questionnaire and clinical data.



There was no difference between treated and untreated participants in:

- Regularity of oral hygiene habits.
- Level of past or active decay.
- Regularity or purpose of dental visits.
- Psychosocial behaviour/functioning (except optimism).
- Dental visiting attitudes.

### Social determinants predicted all outcomes along a socioeconomic gradient.

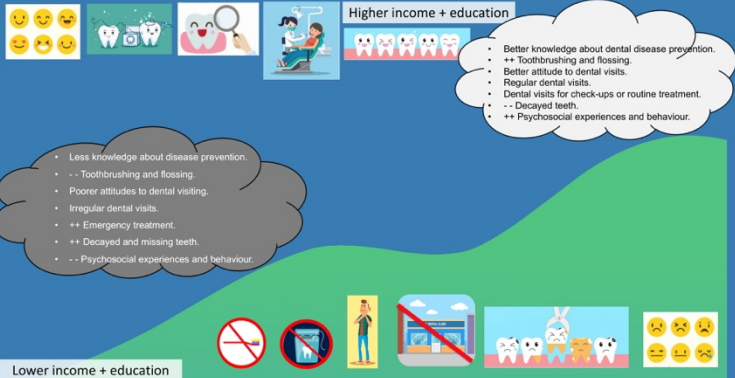


Table: Adjusted associations of dental behaviour, knowledge, caries experience and psychosocial outcomes at age 30.

	Toothbrush >bd	Floss >od	Last dental visit <2 yrs ago	Scheduled visit?	Dental knowledge - preventing decay			Dental visiting attitudes	DMFT	Decayed teeth	Missing teeth	Filled teeth	Self-efficacy	Perceived health competence	Social support	Optimism
					Regular visits	F water	Ca <sup>2+</sup> in diet									
	Exp B (95% Confidence Interval)															
No-braces	1.35 (0.87,2.10)	1.18 (0.48,2.90)	0.96 (0.62,1.49)	1.01 (0.51,1.99)	1.35 (0.77,2.37)	1.09 (0.77,2.37)	1.99 (1.14,3.50)	-0.16(0.40)	1.12 (0.88,1.41)	1.00 (0.72,1.40)	1.00 (0.59,1.69)	1.18 (0.93,1.51)	0.48 (0.42)	0.80 (0.47)	1.42 (0.81)	0.97 (0.45)*
Yes-braces	Ref.															

Abbreviations: bd twice daily; Ca<sup>2+</sup> calcium; Exp: exponentiated; F: fluoride; od, once daily; Ref: reference variable; SE: standard error. \* P<0.05

## Conclusions

- No evidence that braces: prevents decay, instills regular oral hygiene or dental visiting habits, or guarantees higher psychosocial behaviour or functioning in later life.
- Social determinants (sex, education, income) predicted all health outcomes along a socioeconomic gradient.
- Until further research is published, braces should not be proposed or justified for improving long-term dental or psychosocial outcomes.

## Publications

- Doğramacı EJ, Brennan DS. The influence of orthodontic treatment on dental caries: An Australian cohort study. *Community Dent Oral Epidemiol.* 2019;47(3):210-216.
- Doğramacı EJ, Brennan DS. The long-term influence of orthodontic treatment on adults' psychosocial outcomes: An Australian cohort study. *Orthod Craniofac Res.* 2019;22(4):213-220.
- Doğramacı EJ, Naini FB, Brennan DS. The long-term influence of orthodontic treatment on dental knowledge and behaviour: An Australian cohort study. *J Dent. Online ahead of print.* 24 April 2020. doi:10.1016/j.jdent.2020.102254.

## Acknowledgements

The PhD was supported by an Australian Government Research Training Scholarship. Ethical approval: 14-04-2004 - The University of Adelaide Human Research and Ethics Committee. Research funding: National Health and Medical Research Council - 299057, The Commonwealth Department of Community Services and Health - Research and Development Grant, South Australian Health Commission. Images from freepik.com.

**DOES PREVIOUS FIXED ORTHODONTIC TREATMENT PREDICT DENTAL BEHAVIOUR AND KNOWLEDGE IN ADULTHOOD? AN AUSTRALIAN LONGITUDINAL STUDY.**

Introduction

Fixed orthodontic treatment (FOT) typically lasts <2 years, with regular appointments at short intervals to monitor changes, adjust appliances, and periodic patient remotivation and education to maintain excellent oral hygiene standards to prevent dental disease. Although longitudinal studies show past FOT not affording better long-term dental health or psychosocial outcomes, the increased frequency of FOT appointments versus other dental visiting might influence a patient's dental behaviour and knowledge in later life.

Objectives

Assess the influence of FOT on dental behaviour and knowledge.

Aims

The research hypotheses tested was previous FOT enhances dental behaviour and knowledge.

Methods

1859 30-year-olds who participated in an oral epidemiological study when aged 13-years were invited to a cross-sectional study investigating long-term oral health. Participants self-completed a questionnaire regarding socio-demographics (gender, income, education), dental health behaviours (oral hygiene habits, dental attendances), dental knowledge (prevention of caries and periodontal disease) and FOT. Data analysis comprised un/adjusted binomial logistic regression.

Results

Data for 448 participants (56% female, >1/3 received FOT) were analysed; adjusted models controlled for socio-demographics and malocclusion severity. There was no association between FOT and twice daily toothbrushing (Exp B: 1.35, 95%CI: 0.97-2.10), daily flossing (Exp B: 1.18, 95%CI: 0.48-2.90), dental attendance within last 2 years (Exp B: 0.96, 95%CI: 0.62-1.49) or a non-emergency dental visit (Exp B: 1.01, 95%CI: 0.51-1.99). Concerning dental knowledge, non-FOT participants believed a calcium-rich diet prevents caries (Exp B: 1.99, 95%CI: 1.14-3.50, P<0.05).

Conclusions

Previous FOT does not enhance long-term dental behaviour, non-FOT participants were inclined to believe caries-staving myths.

## Appendix 6: Media Release - Publication 5

The University of Adelaide Media release:

<https://www.adelaide.edu.au/news/news104442.html>

Media coverage, originally printed in *The Adelaide Advertiser* newspaper.



19 Jan 2019

Adelaide Advertiser, Adelaide

Author: Brad Crouch • Section: General News • Article Type: News Item  
Audience : 149,005 • Page: 35 • Printed size: 275.00cm<sup>2</sup> • Region: SA • Market: Australia  
ASR: AUD 5,628 • words: 320 • Item ID: 1065720652

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Page 1 of 1

# Brace yourself - bands won't prevent decay

**BRAD CROUCH**  
HEALTH REPORTER

BRACES may straighten teeth but they won't protect them from decay.

Dr Esma Dogramaci and Professor David Brennan from the University of Adelaide's Adelaide Dental School were prompted to examine the issue after coming across a "a commonly held belief among the general public that orthodontic treatment will prevent future tooth decay".

Their study published in the journal *Community Dentistry and Oral Epidemiology* found that paying a fortune for a perfect Hollywood smile – or just paying for work to fix crooked teeth – did not confer immunity against decay.

The researchers looked into the long-term dental health of 448 South Australians to the age of 30 – about one-third had worn braces. "There was no difference in the long-term caries (decay) experience of South Australians aged 30 based on past orthodontic treatment," it concluded.

Dr Dogramaci said patients often complain about crooked teeth and want braces to make them straight so they can "avoid problems like decay in the future."



**SMILE:** Student Tam Nguyen with orthodontist Dr Esma J Dogramaci at the University of Adelaide. Picture: MATT LOXTON

Their research paper quotes two other studies which conclude that: "One of the expectations (of paying for braces) is fewer cavities based on the notion that teeth will become easier to brush following orthodontic treatment".

"It is also anecdotal," Dr Dogramaci told *The Advertiser*. "I work as a specialist orthodontist and I often have teens and their parents asking for braces because they feel their teeth would be healthier and they would have less prob-

lems, such as decay, if they are straightened with braces.

"This is not the case. There is a misconception among patients that orthodontic treatment prevents tooth decay.

"Evidence from the research clearly shows that people cannot avoid regularly brushing their teeth, good oral hygiene and regular dental check-ups to prevent decay in later life.

"Having your teeth straightened does not prevent tooth decay in later life."



## Appendix 8: Media Release - Publication 6

The University of Adelaide Media release:

<https://www.adelaide.edu.au/news/news107242.html>

3AW Radio interview:

<https://www.3aw.com.au/dental-work-doesnt-buy-happiness-study-finds/>

Media coverage, originally printed in *The Adelaide Advertiser* newspaper.



13 Jun 2019

Adelaide Advertiser, Adelaide

Author: Brad Crouch • Section: General News • Article Type: News Item  
Audience : 112,097 • Page: 3 • Printed size: 569.00cm<sup>2</sup> • Region: SA • Market: Australia  
ASR: AUD 8,464 • words: 265 • Item ID: 1132723546



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Page 1 of 1



STRAIGHT TALK: Orthodontist Dr Esma Dogramaci and dental student Alex Furlan say having braces doesn't boost positivity. Picture: MIKE BURTON/AAP

### BRAD CROUCH HEALTH REPORTER

BRACE yourself – despite the cost and inconvenience, straightening your teeth won't always bring happiness.

New University of Adelaide research debunks the belief that turning crooked teeth into a Hollywood smile automatically boosts self-confidence.

The Australian-first study, by Dr Esma Dogramaci and Professor David Brennan from the Adelaide Dental School, followed 448 South Australian students aged 13 in 1988 and 1989.

By the time they turned 30,

more than a third had received orthodontic treatment.

"There was a pattern of higher psychosocial scores in people who did not have orthodontic treatment, meaning people who hadn't had braces were significantly more optimistic than the ones that did," Dr Dogramaci said.

"Those who didn't have braces had varying levels of crooked teeth, just like those who had braces treatment, ranging from mild to very severe."

The study looked at how

well people felt they coped with new or difficult situations and setbacks, the support they believed they received from their personal network and their own level of optimism.

Dr Dogramaci said many people were convinced braces would make them feel more positive.

However, she said the study confirmed other factors played a role and "braces as a youngster was not one of them".

Fourth-year dental student Alex Furlan has never had braces despite his orthodontist

recommending he have them.

"I'm quite happy without them," he said.

"I've never felt the need to straighten my teeth. I can get on in life without having perfectly straight teeth."



# CURRICULUM VITAE

## Education and training

---

- 2020 Doctor of Philosophy – Dentistry, The University of Adelaide.
- 2019 Postgraduate Certificate - Learning and Teaching in Higher Education, The University of London.
- 2014 Certificate of Completion of Specialist Training – Orthodontics, General Dental Council, UK.
- 2013 - Master of Science – Orthodontics, with Merit, King's College London.  
- Diploma of Membership in Orthodontics, The Royal College of Surgeons of England.
- 2007 Diploma of Membership of the Faculty of Dental Surgery, The Royal College of Surgeons of England.
- 2004 Certificate of Completion of Dental Vocational Training, UK Committee of Postgraduate Dental Deans and Directors.
- 2003 Bachelor of Dental Surgery, The University of Manchester.
- Undergraduate honours:
- 2000 Immunology, Microbiology.
- 2001 Biomaterials Science.
- 2002 - Oral Health & Development (Paediatric Dentistry, Orthodontics, Dental Public Health).  
- Oral & Maxillofacial Sciences (Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology).
- 2003 Final BDS examination.

## Current academic and clinical appointments

---

### Adelaide Dental School, The University of Adelaide.

Jan 2019 - present Senior Lecturer

May 2015 - Dec 2018 Lecturer

### South Australian Dental Services.

March 2017 - present Senior dental specialist - orthodontics

July 2015 - June 2016

### The University of London.

Nov 2019 - present Worldwide recognised tutor

### Faculty of Dental Surgery, The Royal College of Surgeons of England.

Oct 2009 - present Lecturer

2007 - 2009 Tutor

## Peer-reviewed publications

---

2020 **Doğramacı EJ.**

Breastfeeding and malocclusions. A current opinion.

*Primary Dental Journal*. Accepted: 28.10.2020.

**Doğramacı EJ**, Littlewood SJ.

Removable orthodontic retainers: practical considerations.

*British Dental Journal*. Accepted: 28.10.2020.

An invited article for an issue focused on orthodontic retainers scheduled for publication in 2021.

**Doğramacı EJ**, Rossi-Fedele G.

Chairside manipulation of chlorhexidine solutions.

*American Journal of Orthodontics and Dentofacial Orthopedics*. Accepted: 18.9.2020.

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The long-term influence of orthodontic treatment on adults' psychosocial outcomes. Reflections and critique on a recent commentary.

*Orthodontics and Craniofacial Research*. Early online: <http://dx.doi.org/10.1111/ocr.12432>

PMID: 33105069.

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The long-term influence of orthodontic treatment on dental knowledge and behaviour: An Australian cohort study.

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Canullo L, Rossi-Fedele G, Camodeca F, Marrucchella G, **Doğramacı EJ**, Scarano A.

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*The International Journal of Oral and Maxillofacial Implants*. 35: 585-590. PMID: 32406657

2019 **Doğramacı EJ**, Brennan DS.

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*Orthodontics and Craniofacial Research*. 22: 312-320. PMID: 31132228

Altmetric attention score: 49. <https://wiley.altmetric.com/details/61288664>

This paper is in the top 5% of all research ever tracked by Altmetric and has the highest score of any paper published in *Orthodontics and Craniofacial Research*.

Arraj GP, Rossi-Fedele G, **Doğramacı EJ**.

The association of overjet size and traumatic dental injuries – a systematic review and meta-analysis.

*Dental Traumatology*, 35: 217-232. PMID: 31062510

Altmetric attention score: 57. <https://wiley.altmetric.com/details/60070232>

This paper is in the top 3% of all research outputs ever tracked by Altmetric and has the highest score of any paper published by *Dental Traumatology*.

Top downloaded paper in *Dental Traumatology* in 2018-2019.

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This paper is in the top 5% of all research outputs ever tracked by Altmetric and was selected for the continuing education programme of the American Dental Association.

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*The JBI Database of Systematic Reviews and Implementation Reports*, 15: 1856-1866. PMID: 28708750

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2014 **Doğramacı EJ**, Rossi-Fedele G, McDonald F.

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*Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology*, 118: e205-209 PMID: 25457895

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Rossi-Fedele G, **Dođramacı EJ**, Steier L, de Figueiredo JAP.

Interactions between chlorhexidine embedded gutta-percha points and some chlorine-containing endodontic irrigating solutions.

*International Endodontic Journal*, 46: 675-680 PMID: 23331158

2012 **Dođramacı EJ**, Naini, FB.

Impacted maxillary canines: contemporary management and review of the literature.

*Faculty Dental Journal*, 3: 210-217 DOI: 10.1308/204268512X13466824724715

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Antagonistic interactions between sodium hypochlorite, chlorhexidine, EDTA and citric acid.

*Journal of Endodontics*, 38: 426-431 PMID: 224114823

2011 Rossi-Fedele G, Guastalli AR, **Dođramacı EJ**, *et al.*

Influence of pH changes on chlorine-containing endodontic irrigating solutions.

*International Endodontic Journal*, 44: 792-799 PMID: 21658076

Rossi-Fedele G, **Dođramacı EJ**, Steier L, de Figueiredo JAP.

Some factors influencing the stability of Sterilox®, a super-oxidised water.

*British Dental Journal*. 210: e23 PMID: 21372834

## Professional prizes, awards and scholarships

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- 2020 Fellowship – Faculty of Dental Surgery of the Royal College of Surgeons of Edinburgh.  
Elected *without examination*. This is the highest award by Britain's oldest and largest Royal Surgical College, in recognition of clinical, teaching and research contributions to dentistry, particularly in orthodontics.
- 2018 Learning Enhancement and Innovation Grant.  
Awarded by The University of Adelaide to support the development of an e-resource to teach cephalometry to dental students. \$2500. Resource introduced as blended-flipped learning in 2020.
- 2017 JL Eustace International Travel Award.  
Awarded by the Adelaide Dental School. Recommended by the School's scholarship committee to support a student of the school who is of outstanding merit to present their research findings at an international scientific conference. \$2200.
- 2015 - Australian Government Research Training Program Scholarship.  
This scholarship carries a full tuition fee subsidy for the Higher Degree by Research (Doctor of Philosophy).
- 2013 King's College London Research Support Fund.  
Administered by the External Strategy Committee. £600.
- 2003 Laurence Usiskin Student Elective Prize winner.  
Awarded by the British Orthodontic Society. Scholarship awarded to pursue an elective in orthodontics where the project should involve a significant travel component with the prize-winner expected to spend time in an overseas centre. £1000.
- Farrar Prize in Oral Surgery.  
Awarded by The University of Manchester Dental School on the basis of the best performance in Oral Surgery during the 2nd, 3rd and 4th years of the BDS course and the results of the 4th BDS (Part II); special account being taken of performance in Oral Surgery. £50.
- British Dental Association – Research Elective Prize.  
Administered by British Medical and Dental Students' Trust. £250.
- Wesley Johnson Travel Fund.  
Administered by The University of Manchester Dental School. £350.
- 2002 Dental Student Award 2002 winner  
Awarded by Wrigley's Oral Healthcare in Action, in conjunction with the British Dental Association, for designing the winning leaflet titled "Safer snacking for healthy teeth". Competed for by student dentists, therapists and hygienists at dental schools in the UK and Ireland. £500. Cheque for £500 also awarded to The University of Manchester Dental School.

## Committees and professional memberships

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- 2020 - Affiliate member - Adelaide Education Academy, The University of Adelaide.
- 2020 - Fellowship – Dental Surgery, The Royal College of Surgeons of Edinburgh.  
Elected *without examination*.
- 2019 - Member - Communities of Practice for learning and teaching: virtual reality, The University of Adelaide.
- 2019 - Member – Allied Health Practice and Science Programs Board, The University of Adelaide.
- 2019 - Member – Lex Salus, Adelaide Law School, The University of Adelaide.
- 2019 Staff representative – Adelaide Dental School Program Board, The University of Adelaide.
- 2018 - 2019 Academic Lead–Innovation and e-learning. Adelaide Dental School Program Board, The University of Adelaide.
- 2018 - Member – Higher Education Academy (UK).
- 2018 - Information Technology and Digital Services Reference Group - Division of Research and Innovation –The University of Adelaide.
- 2016 - 2017 Local organising committee - 57<sup>th</sup> IADR Australia and New Zealand Division meeting.
- 2015 - 2017 BDS4 Joint Year Co-ordinator – Adelaide Dental School, The University of Adelaide.
- 2015 - 2016 Dental School Academic Advisory Committee, The University of Adelaide.
- 2013 - Membership in Orthodontics – The Royal College of Surgeons of England.
- 2008 - National Trainee Representative – e-Den Executive Group.  
<https://www.e-lfh.org.uk/programmes/dentistry/>
- 2007 Membership of the Faculty of Dental Surgery – The Royal College of Surgeons of England.