# Food Insecurity and Dental Caries Prevalence in Children and Adolescents

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*DOI:*
10.1111/ipd.13041

# Food Insecurity and Dental Caries Prevalence in Children and Adolescents: A Systematic Review and Meta-analysis

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## Abstract

**Aim:** This study aimed to investigate the relationship between food insecurity (FI) and dental caries prevalence in children and adolescents.

**Design:** MEDLINE (via PubMed), EMBASE, SCOPUS, ISI web of knowledge, Cochrane, and ProQuest Dissertations & Theses databases (up to April 19th, 2022) as well as reference lists were searched. Eligible studies compared dental caries prevalence in food-secure and food-insecure individuals younger than 19 years. Two independent reviewers performed study selection, data extraction, and risk of bias assessment using a modified Newcastle-Ottawa Scale. Meta-analysis was done, and the pooled odds ratio (OR) was calculated at 95% confidence interval (95% CI).

**Results:** Among the 1350 retrieved records, 10 cross-sectional reports were selected for systematic review. Six studies involving 8,631 participants were included in the meta-analysis. More than half of the reports were published within the period 2019-2021. All studies except one were judged as low risk of bias. Overall, the prevalence of dental caries was greater among the food-insecure children and adolescents (OR: 2.01, 95% CI: 1.52-2.65, $P < .001$, $I^2$: 73.5%). Similarly, all three categories of FI showed significant association with caries experience (marginal FI: OR: 1.88, 95%CI: 1.56-2.27, $P < .001$, $I^2$: 0.0%; low: OR: 2.42, 95%CI: 1.42-4.14, $P = .001$, $I^2$: 74.4%; very low FI: OR: 2.37, 95%CI: 1.88-3.00, $P < .001$, $I^2$: 0.0%).

**Conclusion:** The results showed a significant association between FI status and dental caries in both childhood and adolescence; however, there was a lack of longitudinal studies for better understanding of this association. Health policies leading to reduction of FI may also aim to reduce dental caries.

**Keywords:** Adolescent; Child; Dental caries; Food security; Food supply; Meta-analysis

## INTRODUCTION

Dental caries remains a major public health problem globally despite the overall decline in more developed countries, imposing a considerable economic burden on health care services.[1-3] This biofilm-mediated, diet-modulated and multifactorial disease significantly affects disadvantaged social groups and is prevalent among school-aged children.[1, 3] Dental caries, if it remains untreated, causes pain and infection and therefore may affect physical and psychological developments. Dental caries reportedly affect educational and personal achievements in children.[4]

Dental caries is a preventable disease, resulting from the imbalance between pathological and protective factors.[5] A number of factors, including biological, environmental, and socio-behavioral may contribute to development and progression of dental caries.[2] Diet and nutrition, for example, affect the structure of the tooth before and after its eruption, making the teeth susceptible/resistant to caries.[6, 7] Socioeconomic circumstances also influence dental caries through primary determinants of caries, that is cariogenic biofilm, dietary fermentable carbohydrates, and susceptible teeth/hosts,[7, 8] with those experiencing poverty in at least one stage of their life from childhood through adolescence, and those coming from low-income and low educational level families experiencing significantly greater prevalence/worse levels of dental caries.[8, 9]

Food insecurity (FI) is a health and social issue affecting a wide range (7-97%) of households with children in developed countries.[10] The United States Department of Agriculture (USDA) describes FI as "a household-level economic and social condition of limited or uncertain access to adequate food" that may lead to hunger, [11] with low income and poverty being its main determinants.[10] This condition may lead to some serious health, developmental and social consequences through changing children's dietary intakes.[10] Several cross-sectional studies have also suggested the association between FI and childhood dental caries, albeit with some inconsistencies.[12-15] Moreover, with the ongoing battle with COVID-19, there has been an increases in FI, affecting vulnerable households globally.[16] It seems that this inevitably affects oral health [17] and therefore, investigating the impact of FI on dental caries is timely and worthy of attention.

Despite some previous attempts to summarise the evidence on the impact of FI on dental caries[18], no systematic review or meta-analysis has critically examined such a relationship among children and adolescents. Our research aims to answer whether the prevalence of dental caries among children aged 19 and younger varies between food-secure and food insecure households.

In addition, we address the following questions:

a) Are dental caries and FI associated based on age group, tooth type, definition of caries, and country?

b) Are other factors, including socioeconomic and dietary factors, associated with dental caries in eligible studies?

The latter was qualitatively evaluated whenever the data was available.

## METHODS

The reporting of this systematic review and meta-analysis is guided by the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[19] The protocol of the study was registered in the PROSPERO (International Prospective Register of Systematic Reviews) database (CRD42021246379).

### Eligibility criteria

The inclusion criteria for the present systematic review are defined according to the following PECOS format: a) Population: participants of less than 19 years of age from the general population, b) Exposure: (different categories of) household and/or child FI, c) Comparison: food security (FS), d) Outcome: coronal dental caries evaluated by clinical examination, e) Study design: observational (both longitudinal and cross-sectional designs).

FI/FS status must be directly assessed by a specific questionnaire in eligible studies. The exclusion criteria were: a) recruitment of participants specifically from special healthcare need populations, orthodontic patients, or individuals with dental anomaly, b) other study designs, and c) full-text reports in languages other than English.

To be included in the meta-analysis, a study must report the number of food-secure and food-insecure participants, as well as the prevalence of dental caries in each of these groups.

### Information sources and search strategy

The following electronic bibliographic databases were independently searched up to April 19th, 2022 by two members of the research team (X and Y) without any language and publication date limitations: MEDLINE (via PubMed), EMBASE, SCOPUS, ISI web of knowledge (all databases), Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews, and ProQuest Dissertations & Theses Database Global (Appendix 1). In addition, handsearch search was performed on the cited reference lists of included reports and relevant systematic reviews.

**Study selection, data extraction, and risk of bias assessment**

Initial study selection was independently performed by two other members of the research team (Y and Z) using the EndNote software (EndNote™ 20 (Clarivate Analytics, Philadelphia, Pennsylvania)). The final decision was arrived at after independent full-text evaluation, and following consensus between the two authors. Any disagreements at this phase were resolved through discussion with a third research team member (W).

Data extraction from the included reports and the risk of bias assessment of individual studies were performed independently by the same two reviewers (Y and Z). Following consensus between them, the third reviewer (W) checked and finalized the extracted data. Missing data required for statistical synthesis were requested by emailing the correspondent authors.

The following data regarding the study characteristics were tabulated: first author and year of publication, country under study, setting, study design, sample size and sampling method, dental caries definition and scoring system, FI assessment tool and status, other factors affecting dental caries (including socioeconomic and dietary factors), and relationship between FI/other factors and dental caries.

The risk of bias assessment of included studies was conducted using a Newcastle-Ottawa Quality Assessment Scale adapted for cross-sectional studies.[20] This 7-item scale is organized into three domains: selection (representativeness of the sample, sample size, non-respondents, and ascertainment of exposure), comparability, and outcome (assessment of outcome, and statistical test).[20] The risk of bias of each study was rated based on the total score as low (7-10), moderate (5-6), and high (0-4).

**Synthesis methods and reporting bias assessment**

Meta-analysis was conducted using Stata software, version 11.0 (Stata Corp, College Station, TX, USA). FI was considered both as a dichotomized variable and a categorical variable for statistical analysis. Heterogeneity among the included studies was determined based on $I^2$ statistics, with values >50 indicating substantial heterogeneity. The random-effect model was employed to calculate pooled odds ratio (OR) and its corresponding 95% confidence interval (95% CI) using sample size and caries prevalence in the included studies. Moreover, the potential sources of heterogeneity (i.e., year of study, sample size, age of participants, tooth type, caries assessment criteria, and country under study) were investigated using subgroup analyses and meta-regression. Egger's regression test was applied to detect the publication bias. The level of statistical significance was set at *P* value < .05.

## RESULTS

**Study selection**

Overall, 1350 records were identified through electronic search. After duplicate removal and screening of a total of 995 remaining records, 24 records were selected for full-text evaluation. Excluding 14 reports mainly because they did not assess dental caries/health through clinical examination (Appendix 2)[21-34], nine journal articles (eight studies)[12, 14, 15, 35-40] and one thesis[13] meeting the inclusion criteria were included in the present systematic review. Except four journal articles (one duplicate report of the same study[39], one with the same data source[38], and two with insufficient required data[36, 40]), the other six reports were all considered for meta-analysis. Two studies independently reported outcomes for each study sub-group; therefore, they were separately incorporated in the systematic review and meta-analysis.[13, 15] Of these, only the data from one sub-group were dependent (two different outcomes from one single population).[13]

Handsearching of the bibliographic references of the included studies and relevant systematic reviews[18, 41] did not yield any additional studies fulfilling the eligibility criteria of our study (Figure 1).

**Study characteristics**

Table 1 shows the characteristics of the included studies in the systematic review. The majority of reports were published within the period 2019-2021 (publication year range: 2008-2021).[12, 14, 15, 35, 38, 40] While only one study analyzed data collected in the last five years,[12] half of the reports analyzed data from the past 10 years (data collection year range: 2001-2016).[12, 15, 35, 38, 40] Five reports were from the United States (US),[12, 13, 35, 36, 38] three reports (two studies) were from Brazil,[14, 37, 39] one from Canada [15] and one from South Korea.[40] Eight studies were cross-sectional[12-14, 35-40] and one study stated that the paper was nested in the Baby Teeth Talk Study,[15] a community-based early childhood caries (ECC) randomized controlled trial.[42] Nonetheless, the analyses of this report on FI and child oral health were based on the second-year post-parturition data, making it also cross-sectional.[15] Five studies analyzed the data from the US and South Korea National Health and Nutrition Examination Survey,[13, 35, 36, 38, 40] while the rest (four studies) were either sub-projects[15, 37] or independent studies.[12, 14, 39]

Sample size of the eligible studies varied from 82 to 4822 individuals. Three studies included children not older than five years old,[12, 15, 40] and five articles selected children and/or adolescents aged five years and older.[14, 35-37, 39] However, samples of two studies comprised individuals both under and over five years of age.[13, 38] Regarding the tooth type, four studies assessed caries experience in both primary and permanent teeth,[13, 36-38] three articles only in primary teeth[12, 15, 40] and two reports (one study) only in permanent teeth.[14, 39] Bahanan et al. did not specify the tooth type.[35] For the purpose of our meta-analysis, with regard to the age of the participants in the latter study, it was assumed that the authors considered both primary and permanent teeth.

Assessment of FI in all studies except one[15] was performed by administering the USDA questionnaires or their versions validated for other populations. For dichotomization of FI categories in these studies, three reports considered score 0 as FS and score ≥1 as FI.[13, 14, 39] We used this measure for the dichotomizing FI variable in the other three studies included in the meta-analysis.[12, 37, 38] The study by Kim et al. (not included in the meta-analysis), however, selected a different cut-off point: score 0-2: FS and score ≥3: FI.[40] On the other hand, Tsai and Lawrence used an under-validation one-item tool modified from the WHO's Adverse Childhood Experiences (ACE) International Questionnaire for assessing FI.[15] Overall, three studies considered child FI for their statistical analysis.[13, 15, 38]

In terms of caries experience, cut-off points in all studies but one were presence (≥1) or absence (= 0) of any caries affected teeth. Tsai and Lawrence selected a disparate cut-off and considered severe-ECC as having dmft >9.[15] Four studies only incorporated the data on untreated caries experience (decayed teeth component in decayed, missing and filled teeth index) into their statistical analysis.[14, 35-37, 39] Regarding the definition of dental caries, three studies classified non-cavitated lesions or white spots as caries besides cavitated lesions.[12, 15, 35] One study included only active caries in its assessments.[38]

**Risk of bias in studies**

All studies were judged as low risk of bias, except one, which was judged as moderate risk of bias, mainly because it achieved lower scores for three items (representativeness of the sample, comparability of subjects, and statistical test) compared with most of the studies. None of the studies was free from risk of bias (Appendix 3).

**Individual studies**

Tables 1 and 2 summarize the results of studies on the relationship between dental caries and FI, and between dental caries and socioeconomic/dietary factors, respectively. Other factors having an association with child/adolescent dental caries were as follows (only adjusted values are presented):

*Child/adolescent-related variables*: health insurance coverage (for DMFT: $P$ = .038)[13], dental visit in the last year ((for ECC: other visit: OR: 11.4, 95%CI: 3.86-33.71, and no visit: OR: 0.52, 95%CI: 0.29-0.95; for dft: $P$ < .001; for DMFT: $P$ = .028)[13] (OR: 0.29, 95%CI: 0.23-0.37, $P$ < .0001)[35]), number of school lunches eaten per week (for dft: $P$ = .045),[13] and caries experience in the primary teeth ((for DMFT: $P$ = .014)[13] (for dt: r = 0.710)[40])

*Mother-related variables*: nutritional status (mothers' number of nutrients with an index of nutritional quality less than 1 (NINQ): for dft: r = 0.091, $P$ < .05 and for dt: r = 0.088, $P$ < .05; mothers' mean nutritional adequacy ratio (MAR): for dft: r =-0.094, $P$ < .05),[40] psychosocial well-being (perceived stress for on-reserve population: OR: 2.48, 95%CI: 1.40–4.37, $P$ = .002; sense of control for off-reserve population: OR: 0.17, 95%CI: 0.03–0.95, $P$ = .04),[15] and alcohol consumption during pregnancy (for off-reserve population who stopped or currently drinking: OR: 0.09, 95%CI: 0.01–0.90, $P$ = .04)[15]

*Household/Family-related variables*: household overcrowding (for on-reserve population: OR: 1.89, 95%CI: 1.06–3.38, $P$ = .03),[15] household smoking exposure (for ECC: OR: 2.60, 95%CI: 1.50-4.50, $P$ < .001)[13]

**Statistical synthesis**

Considering FI as a dichotomous variable, the meta-analysis of nine comparisons from six studies (five with low risk of bias, involving a total of 8,631 participants) demonstrated greater prevalence of dental caries in food insecure children and adolescents (OR: 2.01, 95%CI: 1.52-2.65, $P < .001$ ).[12-15, 35, 37] Heterogeneity among these studies was high ($I^2$: 73.5%, $P < .001$) (Figure 2).

*Subgroup analysis based on country (Figure 2-A):* Three studies (five data subsets)[12, 13, 35] were from the US. Pooled OR of experiencing dental caries in food insecure US children and adolescents was 1.86 (95% CI=1.30-2.66, $P = .001$) as compared to those with FS. The heterogeneity of this analysis was high ($I^2$: 82.3%, $P < .001$). Two studies[14, 37] from Brazil and one study[15] from Canada, each with two data subsets, were meta-analyzed. Pooled OR of dental caries experience in food insecure Brazilian and Canadian populations compared with their food secure counterparts was 2.27 (95% CI=0.87-5.92, $P = .095$, $I^2$: 76.5%) and 3.09 (95% CI=1.75-5.44, $P < .001$, $I^2$: 0.0%), respectively.

*Subgroup analysis based on age of participants (Figure 2-B)*: Four comparisons from three studies and five comparisons from four studies were used for subgroup analyses of populations under[12, 13, 15] and over five years old[13, 14, 35, 37], respectively. Both analyses demonstrated greater odds of dental caries experience in food insecure individuals (pooled OR for population under five years: 2.48 (95%CI: 1.82-3.37, $P < .001$, $I^2$: 3.6%), and pooled OR for population over five years: 1.75 (95%CI: 1.22-2.51, $P = .002$, $I^2$: 83.1%)).

*Subgroup analysis based on caries assessment criteria (Figure 2-C)*: Two subgroup analyses (each with one included study) [13, 15] of different cut-offs of caries experience showed inconsistent results (pooled OR for caries experience (DMFT/dft/dmfs) > 0: 1.61, 95%CI: 0.89-2.92, $P = .118$, $I^2$: 88.8%, and pooled OR for caries experience (dmft) > 9: 3.09, 95%CI: 1.75-5.44, $P < .001$, $I^2$: 0.0%). Four studies were included in subgroup analysis of untreated caries. [12, 14, 35, 37]

This analysis demonstrated a greater prevalence of untreated caries in food insecure individuals (pooled OR: 2.15, 95%CI: 1.50-3.09, $P < .001$, $I^2$: 59.2%).

*Subgroup analysis based on tooth type (Figure 2-D)*: Three and two different studies were included in subgroup analyses of the primary,[12, 13, 15] and both primary and permanent dental caries,[35, 37] respectively. The results of the meta-analyses for both comparisons were consistent, showing higher prevalence of dental caries among the food insecure children (pooled OR for primary tooth caries: 2.38 (95%CI: 1.92-2.95, $P < .001$, $I^2$: 0.0%), and pooled OR for primary and permanent dental caries: 2.47 (95%CI: 1.30-4.72, $P = .006$, $I^2$: 60.2%)). Data from two studies were meta-analyzed to evaluate caries experience in the permanent teeth.[13, 14] This analysis showed no differences in dental caries prevalence among food secure and food insecure individuals (pooled OR: 1.14, 95% CI: 0.67-1.94, $P = .639$, $I^2$: 76.4%).

Considering FI as a categorical variable, a total of four studies were included in this part.[12, 13, 35, 37] All studies except one were assessed as low risk of bias. All three categories of FI showed significant association with caries experience in both children and adolescents (marginal FI: OR: 1.88, 95%CI: 1.56-2.27, $P < .001$, $I^2$: 0.0%; low: OR: 2.42, 95%CI: 1.42-4.14, $P = .001$, $I^2$: 74.4%; very low FI: OR: 2.37, 95%CI: 1.88-3.00, $P < .001$, $I^2$: 0.0%) (Figure 3).

**Reporting biases**

The results of meta-regression of the association between dental caries and FI based on year of study ($P = .17$), sample size ($P = .5$), country ($P = .75$), and age of participants ($P = .9$) were not significant (Figure 4). The Egger's test showed no significant publication bias for all outcomes in the meta-analysis ($P = .47$) (Figure 5).

**DISCUSSION**

This systematic review and meta-analysis found significant association between FI and both childhood and adolescent dental caries. This relationship was more significant among preschool children as compared to adolescents which is indicated by the greater OR for primary tooth decay. These results were similar to those of a previous systematic review that found an association between the cumulative history of oral health problems (including untreated dental caries, restorations and use of prosthesis, and extractions) and FI; however, it is suggested that examination of the role of FI in dental/oral health should be conducted through longitudinal, rather than cross-sectional, studies involving clinical examinations and dietary analyses.[18]

The association between FI and dental caries, on the one hand, may be related to the dietary behaviors of low socio-economic households, aiming to meet the energy needs of their children, including adherence to diets high in readily fermentable carbohydrates.[12] In fact, when food needs compete with non-food basic needs, these households are less likely to choose more expensive healthy diets rich in fruits and vegetables. Instead, they opt for a cheaper unhealthy and highly cariogenic diet, which is often high in fat and sugar, and likely to be highly processed. [18] Hence, frequent sugar consumption; a known risk factor for tooth demineralization, may be associated with the greater prevalence of dental caries and consequent extractions in food-insecure individuals.[18, 43] On the other hand, decayed teeth resulting from FI may interfere with mastication and restrict the type and variety of foods an individual ingests, with decreased intake of proteins, fiber, micronutrients (e.g., vitamins A, B and C, folic acid), minerals (e.g., calcium, zinc, iron) and increased consumption of fats and carbohydrates, and thus, worsen the problem.[18] Moreover, nutritional deficiencies can lead to more permanent tooth susceptibility to caries, which is another determinant of tooth loss.[44]

The relationship between FI and dental caries could also be attributed to the interaction between FI and poverty. The FI could be an indication of a bigger issue of poverty in which the decision making is influenced by the stress of limited resources. Accordingly, for poor households with numerous competing demands, purchasing of dental hygiene products or attending regular preventive dental visits may not be a priority.[12, 45] Dietary habits and access to dental hygiene supplies were not analyzed in the present study due to lack of sufficient information. Besides, it has been suggested that in extreme economic conditions of the household, there are other factors beyond cariogenic diets or suboptimal dental care contributing to dental problems, e.g., childhood toxic stress. Facing strong, frequent or prolonged adversity, including the accumulated burdens of household financial hardship accompanying such deprivation, is viewed as a stressor for children.[15, 39]

Among other things, FI is related with low maternal educational level, which can, in turn, contribute to lower oral health literacy.[46] Low-income neighbourhoods may also limit dietary choices of their food insecure residents.[36, 47] Higher dental caries in children belonging to the black American and Mexican American ethnic groups has also been reported.[35, 48] Household socioeconomic status, income/wealth, and dietary intake were, in descending order, the most significant predictors of dental caries in both children and adolescents.[40, 49]

A variety of approaches was adopted in the reviewed studies for the purpose of caries assessment. Recent studies were more inclined to report non-cavitated lesions, with higher sensitivity. [50] Given the growing interest in minimally invasive dentistry, detecting pre-cavitated lesions seems to be considered. Nonetheless, adopting such an approach might not be viable for epidemiological surveys, especially in low-income settings where resources are scarce. [51] Besides, most studies included in this meta-analysis reported data from children aged five years and older; of those, all but one reported data on both primary and permanent tooth caries. This allowed us consider the non-age-dependent approach, and further avoided the common caries-free pattern seen in permanent teeth of individuals in their early mixed dentition.[37]

Almost all cross-sectional studies included in the present systematic review were of low risk of bias; however, four studies were not included in the meta-analysis due to either insufficient/overlap data, or being the duplicate report of the same study.[36, 38-40] Using the USDA Household Food Security Scale Measure or its local versions for determining household and child FI as a valid measure, large sample size, and controlling the confounders by advanced statistical models ensured the low risk of bias of most of the reviewed studies.

The main limitation of the present study was the small number of included studies. Adopting different approaches for caries assessment and FI were among other limitations encountered. In addition, there was overlap in the data sources analyzed in two studies. To avoid duplication, the study by Bahanan et al. with larger sample size, shorter age span, and more accurate definition of dental caries was selected for the meta-analysis.[35] Moreover, two dependent outcomes were reported from one sub-group (6-to-11-year-old children) of the study by Braunstein et al., i.e., the prevalence of dental caries was separately reported for primary (dft) and permanent (DMFT) teeth.[13] Including both datasets in the meta-analysis can also be accounted as a limitation. Although most of the included studies used national data to examine the association between FI and dental caries, some reported from a small sample of dental clinics which may not be regarded as representative of the target population. Another limitation was that the data came from four countries, of which one failed to be included in the meta-analysis, however, publication bias of the included studies was not significant.

Nevertheless, it appears that FI is an independent predictor of dental caries in both children and adolescents after adjusting for socioeconomic status. Therefore, public health efforts and policies should be targeted to reduce FI, especially in low-income households. For example, targeted cash and food transfers toward increasing nutritious food access and decreasing empty calorie food consumption may be considered. These measures may also affect both obesity and dental caries, two non-communicable diseases, which is in line with the Common Risk Factor Approach. [52] It is suggested that future longitudinal studies may focus on behaviors that link FI to pediatric tooth decay for better understanding of such a relationship. Furthermore, researchers are encouraged to investigate the time point and duration of being food insecure that may affect the prevalence/rate of dental caries as well as any interventions that may mitigate the adverse effects of FI on early childhood.

**Why this paper is important to paediatric dentists?**

- For pediatric dentists working in low-income settings, the awareness of relationship between dental caries and FI can help them adopt additional/appropriate measures for dental caries prevention.
- The presented results highlight key areas for future studies and policymaking.

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Table 1. Characteristics of included studies in the systematic review of food insecurity and dental caries in children and adolescents.

| NO. | First author, Publication (Study) year | Country/ Setting | Study design | Sample size/ Sampling method | FI assessment tool | FI categories/ status | Definition and scoring system of dental caries | Relationship between food (in)security and dental caries† | Risk of bias assessment‡ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Bahanan et al.,[35] 2021 (2011-2014) | US/NHANES 2011-2012 and 2013-2014 | A cross-sectional study using NHANES data | 4822 children aged 5-17 years/ Nationally representative population-based sample | USDA 18-item scale Household Food Security Survey Measure | Overall (marginal, low, very low) FI: 41.9% Household full FS (score 0): 66.23%, marginal FS (1-2): 12.31%, low FS (3-7): 14.39%, very low FS (≥8): 7.07% | Untreated dental caries, including white spots on smooth surfaces (no carious teeth (83.73%) vs. ≥1 carious teeth) using the carious teeth index | Untreated dental caries in FI children was 1.38 times more than in fully FS ones (95%CI: 1.11-1.72, *P* = .006) after controlling for cofounders. Untreated caries was 1.48 and 1.59 times greater in children living in marginal (95%CI: 1.10-2.01, *P* = .01) and very low (95%CI: 1.12-2.26, *P* = .01) FS households, respectively, compared with those from fully FS households. | Low |
| 2 | Tsai & Lawrence,[15] 2021 (2014-2015) | Canada (Ontario and Manitoba)/ First Nations communities (on-/off-reserve population) | 2nd-year post-parturition data nested in the Baby Teeth Talk Study (a community-based ECC | 344 First Nations children aged 2 years/The participants were recruited through referrals and media. On-reserve population (n= 229) | Modification of the WHO's one-item ACE International Questionnaire (undergoing validation) | Four-point scale: Sometimes/Most of the time (67.4%), Rarely/Never (32.6%) | S-ECC: having a dmft score >9 (including non-cavitated lesions) S-ECC: 47.6%, non-S-ECC: 52.4% | FI was associated with S-ECC for on-reserve children after adjusting for maternal age, source of income and other variables (OR: 2.86, 95% CI: 1.53–5.34, *P* = .001) | Low |

| NO. | First author, Publication (Study) year | Country/ Setting | Study design | Sample size/ Sampling method | FI assessment tool | FI categories/ status | Definition and scoring system of dental caries | Relationship between food (in)security and dental caries† | Risk of bias assessment‡ |
|---|---|---|---|---|---|---|---|---|---|
| | | | randomized controlled trial) | Off-reserve population (n=115) | | Sometimes/Most of the time (58.4%), Rarely/Never (41.6%) | S-ECC: 7.0%, non-S-ECC: 93.0% | Not significant (OR: 2.25, 95%CI: 0.43–11.67, $P = .47$) § | |
| **3** | Hill,[38] 2020 (2013-2014) | US/NHANES 2013-2014 | Analysis of a piece of data from the cross-sectional survey (NHANES) | 4406 children aged 1-19 years/ Nationally representative sample | NHANES interview questionnaire (including child and family FS status) | Child full FS: 86.1%, marginal FS: 5.6%, low FS: 7.0%, very low FS: 1.3% | Presence or absence of active carious lesions on a primary or permanent tooth (the prevalence of dental caries: ~15%) | Children categorized as having very low FS experienced 2.84 (95% CI: 1.13-7.12) times more dental caries than food secure children after adjusting for age, household FIP ratio and family SNAP category | Low |
| **4** | Kim et al.,[40] 2020 (2013-2015)⁋ | South Korea/ KNAHNES VI | The study used the data from KNHANES | 610 preschool children aged 3-5 years/ Multistage, stratified, and clustered samples | 18-item FS survey | FS (0-2): 91.3%, FI (≥3): 8.7% | dft and dt (untreated decayed teeth) following the WHO protocol-1997 (The threshold was D3 caries into the dentine), experience rate of dft/dt: yes (dft/dt ≥ 1), no (dft/dt = 0) | FI was significantly associated with dft (B = 0.809, $P = .030$) and dt (B = 1.018, $P < .001$) after adjusting for age and sex | Low |

| NO. | First author, Publication (Study) year | Country/ Setting | Study design | Sample size/ Sampling method | FI assessment tool | FI categories/ status | Definition and scoring system of dental caries | Relationship between food (in)security and dental caries† | Risk of bias assessment‡ |
|---|---|---|---|---|---|---|---|---|---|
| **5** | Angelopoulou et al.,[12] 2019 (2016) | US/A university-based community clinic | A cross-sectional study | 82 preschool children aged 12-71 months (median: 48 months)/Invitation to participate | Six-item validated USDA FI questionnaire (English and Spanish versions) assessing family FI | High FS (Score 0): 58.5%, marginal FS (1): 11.0%, low FS (2-4): 24.4%, very low FS (5,6): 6.1% | dmft index (ECC) based on the ICDAS criteria (including early stage lesions at the pre-cavitation stage)/Prevalence of untreated dental caries was 56%. | A positive correlation existed between dental caries (dmft) and FI ($P$ = .002, $R^2$= 0.115), especially concerning the number of decayed teeth (dt, d1t) after adjusting for confounders. | Moderate |
| **6** | Ferreira et al.,[14] 2019 (2010)<br>Santin et al.,[39] 2016 (2010) | Brazil (Araucária in the state of Paraná)/ Urban public and private schools | A cross-sectional/ population-based study | 538 schoolchildren aged 12 years (318 girls and 220 boys)/ Two-stage randomized cluster sampling (schools and children) using a simple lottery system, with additional stratification by regional administration district and type of school | 15-item validated FIS-B (using a specific version for households with children and/or adolescents) | Household FS (score: 0): 61%, mild FI (1-5): 28%, moderate FI (6-10): 6%, severe FI (11-15): 5% | Untreated dental caries based on DMFT index: present (D component ≥ 1): 45% (95% CI: 41-50), absent (D component = 0) | FI was not associated with untreated dental caries after adjusting for per capita household income (PR: 1.14, 95% CI: 0.92-1.41). | Low |

| NO. | First author, Publication (Study) year | Country/ Setting | Study design | Sample size/ Sampling method | FI assessment tool | FI categories/ status | Definition and scoring system of dental caries | Relationship between food (in)security and dental caries† | Risk of bias assessment‡ |
|---|---|---|---|---|---|---|---|---|---|
| **7** | Chi et al.,[36] 2014 (2007-2008)⁋ | US/NHANES 2007-2008 | A cross-sectional analysis of US NHANES data | 2206 children aged 5-17 years/ Nationally representative data | 18-item USDA validated Household Food Security Survey | Full FS (0): 62%, marginal FS (1-2): 13%, low FS (3-7): 17%, very low FS (≥8): 8% | Untreated dental caries (stains, white spots, pitted enamel, and erosion were not included): yes (~20.1%)/no | Food secure children had similar prevalence of dental caries compared to those with marginal (PR: 1.07, 95% CI: 0.66-1.75, *P* = .77), low (PR: 1.42, 95% CI: 0.85-2.38, *P* = .17) or very low (PR: 1.12, 95% CI: 0.60-1.12, *P* = .77) FS after adjusting for SES. | Low |
| **8** | Frazao et al.,[37] 2014 (2009-2010) | Brazil (The western Brazilian Amazon)/ Urban schools | A cross-sectional survey nested in a population-based cohort study | 203 schoolchildren aged 7-9 years (108 girls and 95 boys)/ Census | 15-item validated scale of USDA (Brazilian–Portuguese language version) for households with children and adolescents | Score 0 (food-secure household): 45.9%, Score 1-4: 32.4%, Score ≥5: 21.6% | Untreated decayed deciduous and permanent teeth (dt+DT): 3.63±3.26 (mean±SD)/ dmft/DMFT index based on the WHO criteria (1997) for oral health surveys: 20.7% of children were caries-free. | High scores of FI (>4) were associated with dental caries after adjusting for sex and SES (wealth index) (RR= 1.48 (95% CI: 1.05-2.08, *P* = .024) | Low |

| NO. | First author, Publication (Study) year | Country/ Setting | Study design | Sample size/ Sampling method | FI assessment tool | FI categories/ status | Definition and scoring system of dental caries | Relationship between food (in)security and dental caries† | Risk of bias assessment‡ |
|---|---|---|---|---|---|---|---|---|---|
| **9** | Braunstein et al.,[13] 2008 (2001-2002) | US/NHANES 2001-2002 | Cross-sectional data from NHANES | 801 children aged 2-5 years/ A complex sampling design: over-sampling of low-income households, children, elderly, African Americans, and Mexican Americans | 18-item U.S. Food Security Scale (including Child Food Security) | High FS (76.6%), marginal FS (7.4%), low FS (14.4%), and very low FS (1.6%) | ECC: one or more primary teeth with decayed cavitated lesions, missing due to caries, or filled tooth surfaces (yes: 25.6%, no: 74.4%) | ECC in food insecure children (38.2%) was 1.8 (95% CI: 1.09 - 2.97) times more than in food secure children (23.0%), (*P* = .022) after adjusting for confounders. | Low |
| | | | | 1097 children aged 6-11 years | Household and child FS | High FS (75.8%), marginal FS (8.6%), low FS (13.6%), and very low FS (2.0%) | Caries experience was measured by dft (yes: 51.0%, no: 49.0%) | Child FS was not associated with dft after adjusting for confounders (*P* = .174). | Low |
| | | | | | | | DMFT: (yes: 79.4%, no: 20.6%) | Child FS was not associated with DMFT after adjusting for confounders (*P* = .603). | |

ACE: adverse childhood experiences; CI: confidence interval; d(m)(f)t: number of decayed (missing) (filled) primary teeth due to caries; D(M)(F)T: number of decayed (missing) (filled) permanent teeth due to caries; (S-)ECC: (severe) early childhood caries; FI: food insecurity/insecure; FIP: federal income to poverty; FIS-B: Brazilian Food Insecurity Scale; FS: food security/secure; ICDAS: International Caries Detection and Assessment System; (K)NHANES: (Korea) National Health and Nutrition Examination Survey; NM: not mentioned; OR: odds ratio; PR: prevalence ratio; RR: relative risk; SES: socioeconomic status; SNAP: Supplemental

Nutrition Assistance Program; USDA: US Department of Agriculture; WHO: World Health Organization; WIC: Women, Infants, and Children.

† Adjusted values are presented unless identified.

‡ Risk of bias of papers was assessed using adapted Newcastle - Ottawa Quality Assessment Scale for cross-sectional studies: 7-10: low risk of bias, 5-6: moderate risk of bias, 0-4: high risk of bias.[19]

§ Unadjusted values

‖ These two studies were not included in the meta-analysis due to insufficient required data reported.

Table 2. Relationship between dental caries and other socioeconomic and dietary factors in the studies included in the systematic review.

| #NO. | First author, Year of publication | Country | Sample size | Dental caries definition | Other SES and dietary factors affecting dental caries | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Household SES/income/wealth | Race/Ethnicity | Age | Gender | Maternal education | Dietary factors/ sugar intake |
| **1** | Bahanan et al.,[35] 2021 | US | 4822 children aged 5-17 years | Untreated caries, including white spots on smooth surfaces | OR for children with annual family income <$20,000 compared with those with ≥ $20,000 = 1.48 (95% CI: 1.08-2.03, *P* = .02) | OR for black children compared to their white counterparts = 2.39 (95% CI: 2.09-1.77, *P* = .01) | OR for 8-11-year-old children compared with 5-7-year-olds= 1.33 (95% CI = 1.06-1.69, *P* = .02) | NS | - | NS[†] diet quality measured by the Healthy Eating Index-2015 was not significantly associated with untreated caries (*P* = .07). |
| **2** | Tsai & Lawrence,[15] 2021 | Canada | 344 First Nations children aged 2 years | S-ECC: having a dmft score >9 (including non-cavitated lesions) | Primary source of income:<br>On-reserve population: NS<br>Off-reserve population: NS | - | Age of mother:<br>On-reserve population: NS<br>Off-reserve population: NS | - | - | - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **3** | Hill,[38] 2020 | US | 4406 children aged 1-19 years | Presence or absence of active carious lesions on a primary or permanent tooth | OR† for family income to poverty ratio >1.3 compared with ≤1.3 = 1.50 (95% CI = 1.16, 1.95) | NS | OR= 2.60 (95% CI: 1.67-4.05) for children aged 6-11, 2.9 (95% CI: 1.85-4.67) for children aged 12-15, 4.2 (95% CI: 2.42-7.22) for children aged 16-19 compared to children aged 1-5 | NS† | - | - |
| **4** | Kim et al.,[40] 2020 | South Korea | 610 preschool children aged 3-5 years | dft and dt (untreated decayed teeth) following the WHO protocol-1997 (The threshold was D3 caries into the dentine) | Household income<br>dt: NS<br>dft: NS | - | dt: NS<br>dft: B= 0.567, *P* < .001 | dt: NS<br>dft: NS | dt: NS<br>dft: NS | Children's NINQ and MAR<br>dt: NS<br>dft: NS |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **5** | Ferreira et al.,[14] 2019 Santin et al.,[39] 2016 | Brazil | 538 school children aged 12 years | Untreated dental caries: D component of DMFT index ≥ 1 | PR for per capita household income (BMMW divided by the number of residents in the home) ≤ US$ 71 compared with > US$ 284 = 1.59 (95% CI: 1.06-2.37) | - | - | NS[†] | PR[†] for children whose mothers had up to 8 years of schooling compared with those with >8 years = 1.26 (*P* = .021, 95% CI 1.04-1.52) | PR[†] for 4-6 and >7 daily sugary food intake compared with 0-3 daily sugary food consumption was 1.36 (*P* = .025, 95% CI 1.04-1.79) and 1.60 (*P* < .001, 95% CI 1.24-2.05), respectively. |
| **6** | Chi et al.,[36] 2014 | US | 2206 children aged 5 to 17 years | Untreated dental caries (stains, white spots, pitted enamel, and erosion were not included) | PR for household SES (household income to poverty ratio) = 0.79 (95% CI: 0.64- 0.97, *P* = .03) | - | - | - | - | - |
| **7** | Frazao et al.,[37] 2014 | Brazil | 203 school children aged 7-9 years | Untreated decayed deciduous and permanent teeth (dt+DT) | RR for upper tercile of household wealth index compared with lower tercile= 0.66 (95% CI: 0.46-0.95, *P* = .024) (*P* for trend = 0.037) | - | NS[†] | RR for boys compared with girls= 1.31 (95% CI: 1.02–1.67, *P* = .032) | RR for mother schooling >7 years compared with <4 years= 0.74 (95% CI: 0.56-0.99, *P* = .045) | - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **8** | Braunstein et al.,[13] 2008 (2001-2002) | US | 801 children aged 2-5 years | ECC: one or more primary teeth with decayed cavitated lesions, missing due to caries, or filled tooth surfaces | OR for Poverty Income Ratio <1.30 compared to ≥ 1.85 = 2.61 (95% CI: 1.36-5.02), *P* = .007 | OR for Mexican Americans compared to non-Hispanic whites = 2.12 (95% CI: 1.23-3.66), *P* = .033 | *P* < .001 | NS† | - | OR for the highest quartile of the Revised Child Diet Quality using a single 24-hour recall compared to the lowest and second lowest = 0.31 (95% CI: 0.18-0.56) and 0.43 (0.29-0.64), respectively, *P* < .001 |
| | | | 1097 children aged 6-11 years | dft | dft: NS | dft: NS | dft: *P* = .027 | dft: *P* = .002 | - | Soda consumption (*P* = .002) and total number of meals and snacks per day (*P* < .001) were associated with dft. |
| | | | | DMFT | DMFT: *P* = .036 | DMFT: NS | DMFT: *P* < .001 | DMFT: NS | - | Quartiles of the Revised Child Diet Quality Index were associated with DMFT (*P* = .045). |

B(M)MW: Brazilian (monthly) minimum wage; CI: confidence interval; d(m)(f)t: number of decayed (missing) (filled) primary teeth due to caries; D(M)(F)T: number of decayed (missing) (filled) permanent teeth due to caries; (S-)ECC: (severe) early childhood caries; MAR: mean nutritional adequacy ratio; NINQ: number of nutrients with an index of nutritional quality less than 1; NS: not significant; OR: odds ratio; PR: prevalence ratio; RC-DQI: Revised Child Diet Quality Index; RR: relative risk; SES: socioeconomic status; WHO: World Health Organization.

†: Unadjusted (based on crude analysis)

**Figure Legends**

Figure 1. PRISMA 2020 flow diagram of the study selection.

Figure 2. Pooled odds ratio of caries experience in food-secure and food-insecure children and adolescents based on (A) country, (B) age of participants, (C) caries assessment criteria, and (D) tooth type. Both: primary and permanent teeth; CI: confidence interval; d(m)(f)t/s: number of decayed, (missing), and (filled) primary teeth/tooth surfaces due to caries; D(MF)T: number of decayed (missing and filled) permanent teeth due to caries; FI: food insecurity; FS: food security; N: no; NM: not mentioned; OR: odds ratio, WSLs: white spot lesions; Y: yes.

Figure 3. Pooled odds ratio of caries experience in food-secure children and adolescents compared to those with (A) marginal, (B) low, and (C) very low food insecurity. Both: primary and permanent teeth; CI: confidence interval; d(mf)t/s: number of decayed (missing and filled) primary teeth/tooth surfaces due to caries; DT: number of decayed permanent teeth; FI: food insecurity; FS: food security; N: no; OR: odds ratio, WSLs: white spot lesions; Y: yes.

Figure 4. Meta-regression of the association between dental caries and food insecurity in children and adolescents based on (A) year of study, (B) sample size, (C) country under study, and (D) age of participants.

Figure 5. Egger's test results on publication bias.

**Appendices**

Appendix 1

Details of search strategy for electronic databases.

<table>
<tr><th>#</th><th>Database</th><th>Search strategy</th></tr>
<tr><td>1</td><td>MEDLINE (via PubMed)</td><td>("Dental Caries"[Mesh] OR (Dental Decay) OR (Carious Dentin*) OR (Dental White Spot*) OR (White Spot*)) AND ("Food Supply"[Mesh] OR (Food Supplies) OR (Food Insecurity) OR (Food Insecurities) OR (Food Security))</td></tr>
<tr><td>2</td><td>EMBASE</td><td>((Dental Caries) OR (Dental Decay) OR (Carious Dentin*) OR (Dental White Spot*) OR (White Spot*)) AND ((Food Supply) OR (Food Supplies) OR (Food Insecurity) OR (Food Insecurities) OR (Food Security))</td></tr>
<tr><td>3</td><td>Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews</td><td rowspan="4">("Dental Caries" OR (Dental Decay) OR (Carious Dentin*) OR (Dental White Spot*) OR (White Spot*)) AND ("Food Supply" OR (Food Supplies) OR (Food Insecurity) OR (Food Insecurities) OR (Food Security))</td></tr>
<tr><td>4</td><td>Web of Science (all databases)</td></tr>
<tr><td>5</td><td>SCOPUS</td></tr>
<tr><td>6</td><td>ProQuest Dissertations & Theses Database Global</td></tr>
</table>

Appendix 2

Excluded records identified from electronic search and reasons for exclusion from the systematic review.

| No. | Author, Publication year | Main reason for exclusion |
|---|---|---|
| 1 | Miller and Morrissey,[33] 2021 | Dental caries was not assessed among health outcomes |
| 2 | Patel,[34] 2021 | Food insecurity was not assessed by a specific questionnaire (Food desert was identified by patients' ZIP code of residence) |
| 3 | Bencze et al.,[23] 2021 | Food insecurity was not assessed as a risk factor of early childhood caries |
| 4 | Jackson and Testa,[26] 2021 | Child teeth condition was evaluated through a question asking from caregivers |
| 5 | Sachdev et al.,[29] 2021 | Participants were adult women aged 18-50 years |
| 6 | Bahanan,[22] 2019 | The full text of this thesis document could not be retrieved. However, its published report was available.[35] |
| 7 | Calache et al.,[24] 2019 | Food insecurity was not assessed among the potential risk factors for dental caries |
| 8 | Ziegler et al.,[31] 2019 | The full text could not be retrieved |
| 9 | Bae and Obounou,[21] 2018 | Presence of dental caries was identified through asking a question in the health interview |
| 10 | Weigel et al.,[30] 2016 | Dental disease was assessed by a structured questionnaire |
| 11 | Ismail et al.,[25] 2008 | Food insecurity was not assessed among the caries risk indicators |

| | | |
|---|---|---|
| 12 | Jamieson and Koopu,[32] 2008 | A computer-based home interview was used to collect data on dental health |
| 13 | Jamieson and Koopu,[28] 2007 | A computer-based home interview was used to collect data on dental health |
| 14 | Jamieson and Koopu,[27] 2006 | A computer-based home interview was used to collect data on dental health |

Appendix 3

Risk of bias of included studies in the systematic review, assessed by Newcastle-Ottawa quality assessment scale adapted for cross-sectional studies.

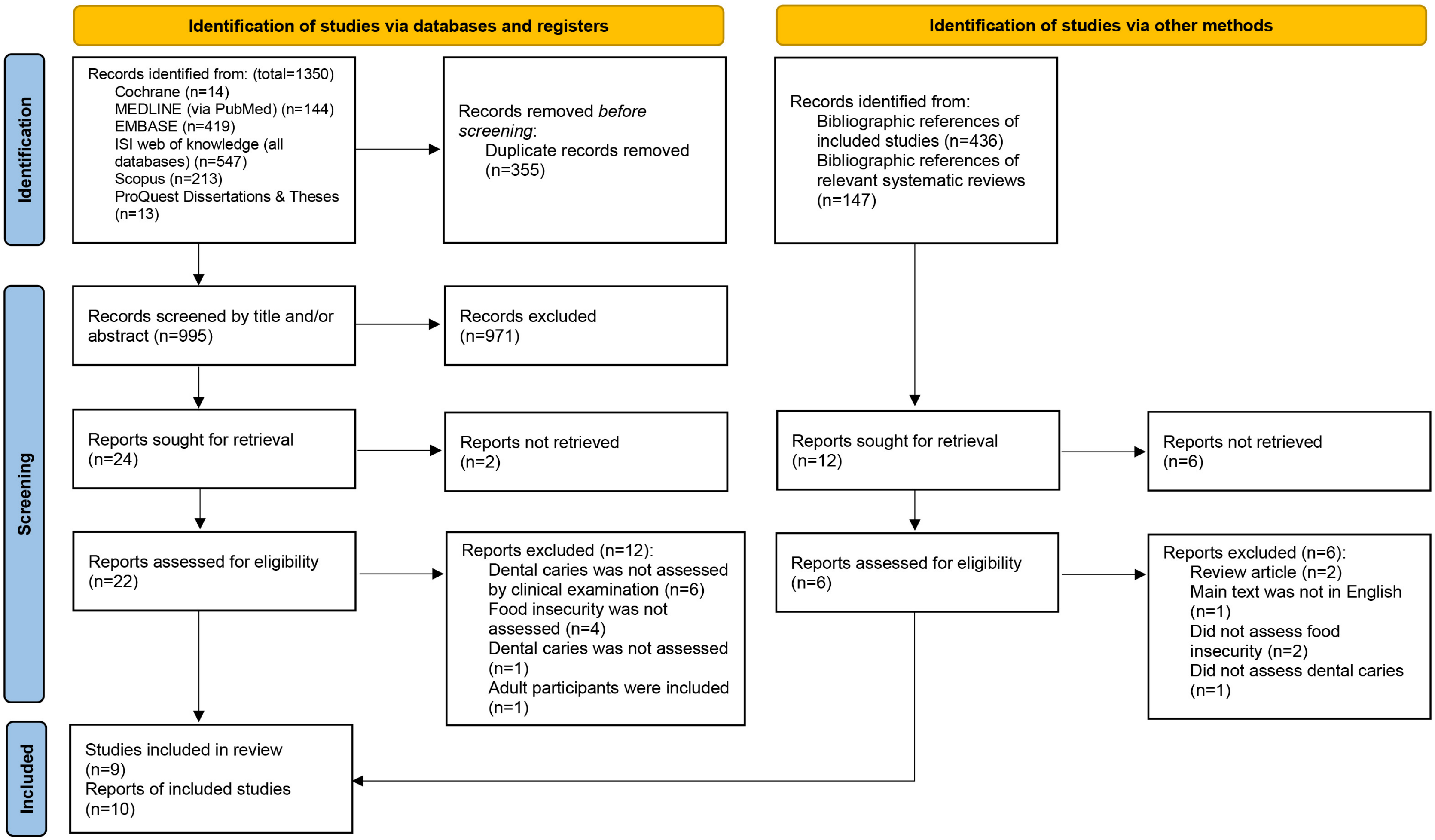
| # | Author, Year of publication | Selection | | | | Comparability | Outcome | | Total score* |
|---|---|---|---|---|---|---|---|---|---|
| | | Representativeness of the sample | Sample size | Non-respondents | Ascertainment of exposure | Controlling confounding factors/ Comparability of subjects | Assessment of outcome | Statistical test | |
| 1 | Bahanan et al.,[35] 2021 | * | * | | ** | ** | ** | * | 9 |
| 2 | Tsai & Lawrence,[15] 2021 | * | * | * | * | ** | ** | * | 9 |
| 3 | Hill,[38] 2020 | * | * | | ** | ** | ** | * | 9 |

| # | Author, Year of publication | Selection | | | | Comparability | Outcome | | Total score* |
|---|---|---|---|---|---|---|---|---|---|
| | | Representativeness of the sample | Sample size | Non-respondents | Ascertainment of exposure | Controlling confounding factors/ Comparability of subjects | Assessment of outcome | Statistical test | |
| 4 | Kim et al.,[40] 2020 | * | | | ** | ** | ** | | 7 |
| 5 | Angelopoulou et al.,[12] 2019 | | * | | ** | * | ** | | 6 |
| 6 | Ferreira et al.,[14] 2019<br>Santin et al.,[39] 2016 | * | * | | ** | ** | ** | * | 9 |
| 7 | Chi et al.,[36] 2014 | * | * | | ** | ** | ** | * | 9 |

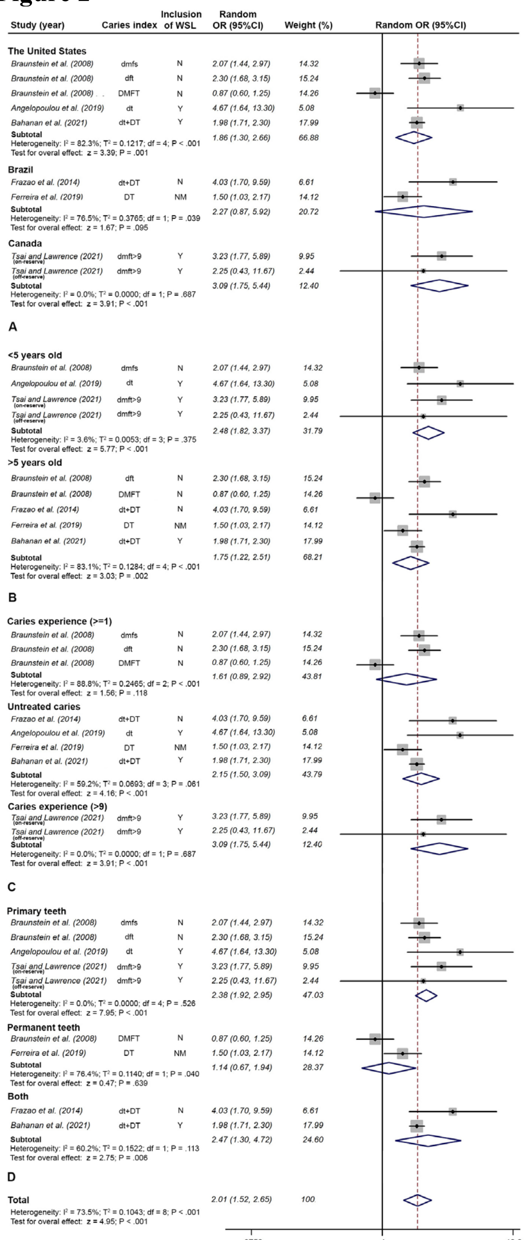
| # | Author, Year of publication | Selection | | | | Comparability | Outcome | | Total score* |
|---|---|---|---|---|---|---|---|---|---|
| | | Representativeness of the sample | Sample size | Non-respondents | Ascertainment of exposure | Controlling confounding factors/ Comparability of subjects | Assessment of outcome | Statistical test | |
| 8 | Frazao et al.,[37] 2014 | * | | | ** | ** | ** | * | 8 |
| 9 | Braunstein et al.,[13] 2008-Chapter 2 | * | * | | ** | ** | ** | * | 9 |
| 10 | Braunstein et al.,[13] 2008-Chapter 3 | * | * | | ** | ** | ** | | 8 |

* 7-10: low risk of bias, 5-6: moderate risk of bias, 0-4: high risk of bias

**Figure 1**


Identification of studies via databases and registers
Identification of studies via other methods
Identification
Screening
Included
Records identified from: (total=1350)
Cochrane (n=14)
MEDLINE (via PubMed) (n=144)
EMBASE (n=419)
ISI web of knowledge (all databases) (n=547)
Scopus (n=213)
ProQuest Dissertations & Theses (n=13)
Records removed *before screening*:
Duplicate records removed (n=355)
Records identified from:
Bibliographic references of included studies (n=436)
Bibliographic references of relevant systematic reviews (n=147)
Records screened by title and/or abstract (n=995)
Records excluded (n=971)
Reports sought for retrieval (n=24)
Reports not retrieved (n=2)
Reports sought for retrieval (n=12)
Reports not retrieved (n=6)
Reports assessed for eligibility (n=22)
Reports excluded (n=12):
Dental caries was not assessed by clinical examination (n=6)
Food insecurity was not assessed (n=4)
Dental caries was not assessed (n=1)
Adult participants were included (n=1)
Reports assessed for eligibility (n=6)
Reports excluded (n=6):
Review article (n=2)
Main text was not in English (n=1)
Did not assess food insecurity (n=2)
Did not assess dental caries (n=1)
Studies included in review (n=9)
Reports of included studies (n=10)

# Figure 2



Study (year)
Caries index
Inclusion of WSL
Random OR (95%CI)
Weight (%)
Random OR (95%CI)
The United States
Braunstein et al. (2008) dmfs N 2.07 (1.44, 2.97) 14.32
Braunstein et al. (2008) dft N 2.30 (1.68, 3.15) 15.24
Braunstein et al. (2008) DMFT N 0.87 (0.60, 1.25) 14.26
Angelopoulou et al. (2019) dt Y 4.67 (1.64, 13.30) 5.08
Bahanan et al. (2021) dt+DT Y 1.98 (1.71, 2.30) 17.99
Subtotal 1.86 (1.30, 2.66) 66.88
Heterogeneity: I² = 82.3%; T² = 0.1217; df = 4; P < .001
Test for overal effect: z = 3.39; P = .001
Brazil
Frazao et al. (2014) dt+DT N 4.03 (1.70, 9.59) 6.61
Ferreira et al. (2019) DT NM 1.50 (1.03, 2.17) 14.12
Subtotal 2.27 (0.87, 5.92) 20.72
Heterogeneity: I² = 76.5%; T² = 0.3765; df = 1; P = .039
Test for overal effect: z = 1.67; P = .095
Canada
Tsai and Lawrence (2021) (on-reserve) dmft>9 Y 3.23 (1.77, 5.89) 9.95
Tsai and Lawrence (2021) (off-reserve) dmft>9 Y 2.25 (0.43, 11.67) 2.44
Subtotal 3.09 (1.75, 5.44) 12.40
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 1; P = .687
Test for overal effect: z = 3.91; P < .001
A
<5 years old
Braunstein et al. (2008) dmfs N 2.07 (1.44, 2.97) 14.32
Angelopoulou et al. (2019) dt Y 4.67 (1.64, 13.30) 5.08
Tsai and Lawrence (2021) (on-reserve) dmft>9 Y 3.23 (1.77, 5.89) 9.95
Tsai and Lawrence (2021) (off-reserve) dmft>9 Y 2.25 (0.43, 11.67) 2.44
Subtotal 2.48 (1.82, 3.37) 31.79
Heterogeneity: I² = 3.6%; T² = 0.0053; df = 3; P = .375
Test for overal effect: z = 5.77; P < .001
>5 years old
Braunstein et al. (2008) dft N 2.30 (1.68, 3.15) 15.24
Braunstein et al. (2008) DMFT N 0.87 (0.60, 1.25) 14.26
Frazao et al. (2014) dt+DT N 4.03 (1.70, 9.59) 6.61
Ferreira et al. (2019) DT NM 1.50 (1.03, 2.17) 14.12
Bahanan et al. (2021) dt+DT Y 1.98 (1.71, 2.30) 17.99
Subtotal 1.75 (1.22, 2.51) 68.21
Heterogeneity: I² = 83.1%; T² = 0.1284; df = 4; P < .001
Test for overal effect: z = 3.03; P = .002
B
Caries experience (>=1)
Braunstein et al. (2008) dmfs N 2.07 (1.44, 2.97) 14.32
Braunstein et al. (2008) dft N 2.30 (1.68, 3.15) 15.24
Braunstein et al. (2008) DMFT N 0.87 (0.60, 1.25) 14.26
Subtotal 1.61 (0.89, 2.92) 43.81
Heterogeneity: I² = 88.8%; T² = 0.2465; df = 2; P < .001
Test for overal effect: z = 1.56; P = .118
Untreated caries
Frazao et al. (2014) dt+DT N 4.03 (1.70, 9.59) 6.61
Angelopoulou et al. (2019) dt Y 4.67 (1.64, 13.30) 5.08
Ferreira et al. (2019) DT NM 1.50 (1.03, 2.17) 14.12
Bahanan et al. (2021) dt+DT Y 1.98 (1.71, 2.30) 17.99
Subtotal 2.15 (1.50, 3.09) 43.79
Heterogeneity: I² = 59.2%; T² = 0.0693; df = 3; P = .061
Test for overal effect: z = 4.16; P < .001
Caries experience (>9)
Tsai and Lawrence (2021) (on-reserve) dmft>9 Y 3.23 (1.77, 5.89) 9.95
Tsai and Lawrence (2021) (off-reserve) dmft>9 Y 2.25 (0.43, 11.67) 2.44
Subtotal 3.09 (1.75, 5.44) 12.40
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 1; P = .687
Test for overal effect: z = 3.91; P < .001
C
Primary teeth
Braunstein et al. (2008) dmfs N 2.07 (1.44, 2.97) 14.32
Braunstein et al. (2008) dft N 2.30 (1.68, 3.15) 15.24
Angelopoulou et al. (2019) dt Y 4.67 (1.64, 13.30) 5.08
Tsai and Lawrence (2021) (on-reserve) dmft>9 Y 3.23 (1.77, 5.89) 9.95
Tsai and Lawrence (2021) (off-reserve) dmft>9 Y 2.25 (0.43, 11.67) 2.44
Subtotal 2.38 (1.92, 2.95) 47.03
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 4; P = .526
Test for overal effect: z = 7.95; P < .001
Permanent teeth
Braunstein et al. (2008) DMFT N 0.87 (0.60, 1.25) 14.26
Ferreira et al. (2019) DT NM 1.50 (1.03, 2.17) 14.12
Subtotal 1.14 (0.67, 1.94) 28.37
Heterogeneity: I² = 76.4%; T² = 0.1140; df = 1; P = .040
Test for overal effect: z = 0.47; P = .639
Both
Frazao et al. (2014) dt+DT N 4.03 (1.70, 9.59) 6.61
Bahanan et al. (2021) dt+DT Y 1.98 (1.71, 2.30) 17.99
Subtotal 2.47 (1.30, 4.72) 24.60
Heterogeneity: I² = 60.2%; T² = 0.1522; df = 1; P = .113
Test for overal effect: z = 2.75; P = .006
D
Total 2.01 (1.52, 2.65) 100
Heterogeneity: I² = 73.5%; T² = 0.1043; df = 8; P < .001
Test for overal effect: z = 4.95; P < .001
.0752
Favors FS
1
Favors FI
13.3

## Figure 3

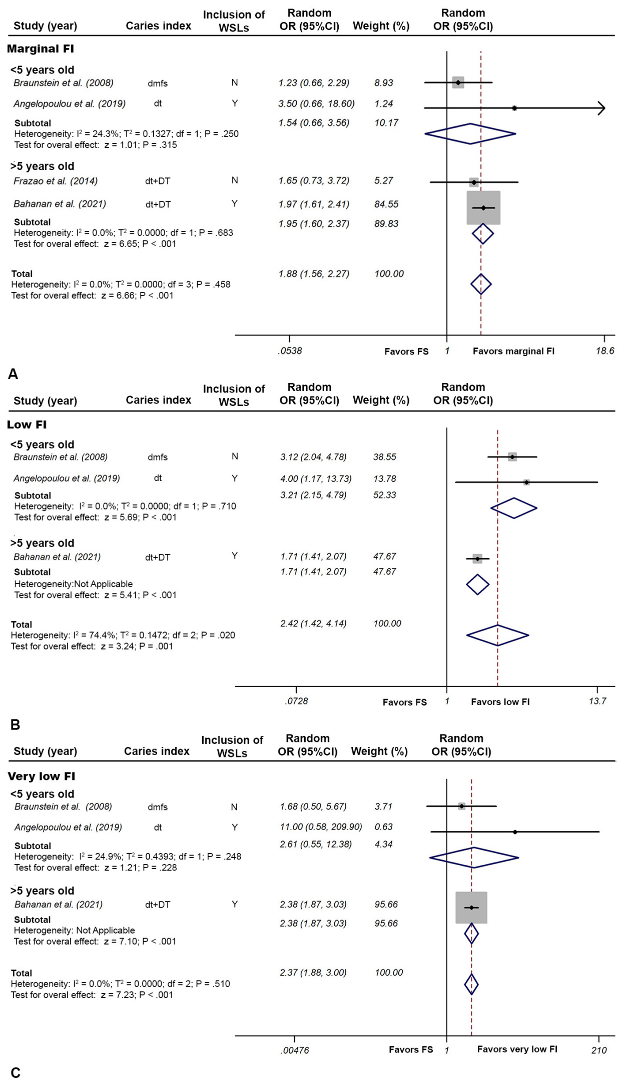

Study (year)
Caries index
Inclusion of WSLs
Random OR (95%CI)
Weight (%)
Random OR (95%CI)
Marginal FI
<5 years old
Braunstein et al. (2008) dmfs N 1.23 (0.66, 2.29) 8.93
Angelopoulou et al. (2019) dt Y 3.50 (0.66, 18.60) 1.24
Subtotal 1.54 (0.66, 3.56) 10.17
Heterogeneity: I² = 24.3%; T² = 0.1327; df = 1; P = .250
Test for overal effect: z = 1.01; P = .315
>5 years old
Frazao et al. (2014) dt+DT N 1.65 (0.73, 3.72) 5.27
Bahanan et al. (2021) dt+DT Y 1.97 (1.61, 2.41) 84.55
Subtotal 1.95 (1.60, 2.37) 89.83
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 1; P = .683
Test for overal effect: z = 6.65; P < .001
Total 1.88 (1.56, 2.27) 100.00
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 3; P = .458
Test for overal effect: z = 6.66; P < .001
.0538
Favors FS
1
Favors marginal FI
18.6
A
Study (year)
Caries index
Inclusion of WSLs
Random OR (95%CI)
Weight (%)
Random OR (95%CI)
Low FI
<5 years old
Braunstein et al. (2008) dmfs N 3.12 (2.04, 4.78) 38.55
Angelopoulou et al. (2019) dt Y 4.00 (1.17, 13.73) 13.78
Subtotal 3.21 (2.15, 4.79) 52.33
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 1; P = .710
Test for overal effect: z = 5.69; P < .001
>5 years old
Bahanan et al. (2021) dt+DT Y 1.71 (1.41, 2.07) 47.67
Subtotal 1.71 (1.41, 2.07) 47.67
Heterogeneity:Not Applicable
Test for overal effect: z = 5.41; P < .001
Total 2.42 (1.42, 4.14) 100.00
Heterogeneity: I² = 74.4%; T² = 0.1472; df = 2; P = .020
Test for overal effect: z = 3.24; P = .001
.0728
Favors FS
1
Favors low FI
13.7
B
Study (year)
Caries index
Inclusion of WSLs
Random OR (95%CI)
Weight (%)
Random OR (95%CI)
Very low FI
<5 years old
Braunstein et al. (2008) dmfs N 1.68 (0.50, 5.67) 3.71
Angelopoulou et al. (2019) dt Y 11.00 (0.58, 209.90) 0.63
Subtotal 2.61 (0.55, 12.38) 4.34
Heterogeneity: I² = 24.9%; T² = 0.4393; df = 1; P = .248
Test for overal effect: z = 1.21; P = .228
>5 years old
Bahanan et al. (2021) dt+DT Y 2.38 (1.87, 3.03) 95.66
Subtotal 2.38 (1.87, 3.03) 95.66
Heterogeneity: Not Applicable
Test for overal effect: z = 7.10; P < .001
Total 2.37 (1.88, 3.00) 100.00
Heterogeneity: I² = 0.0%; T² = 0.0000; df = 2; P = .510
Test for overal effect: z = 7.23; P < .001
.00476
Favors FS
1
Favors very low FI
210
C

**Figure 4**

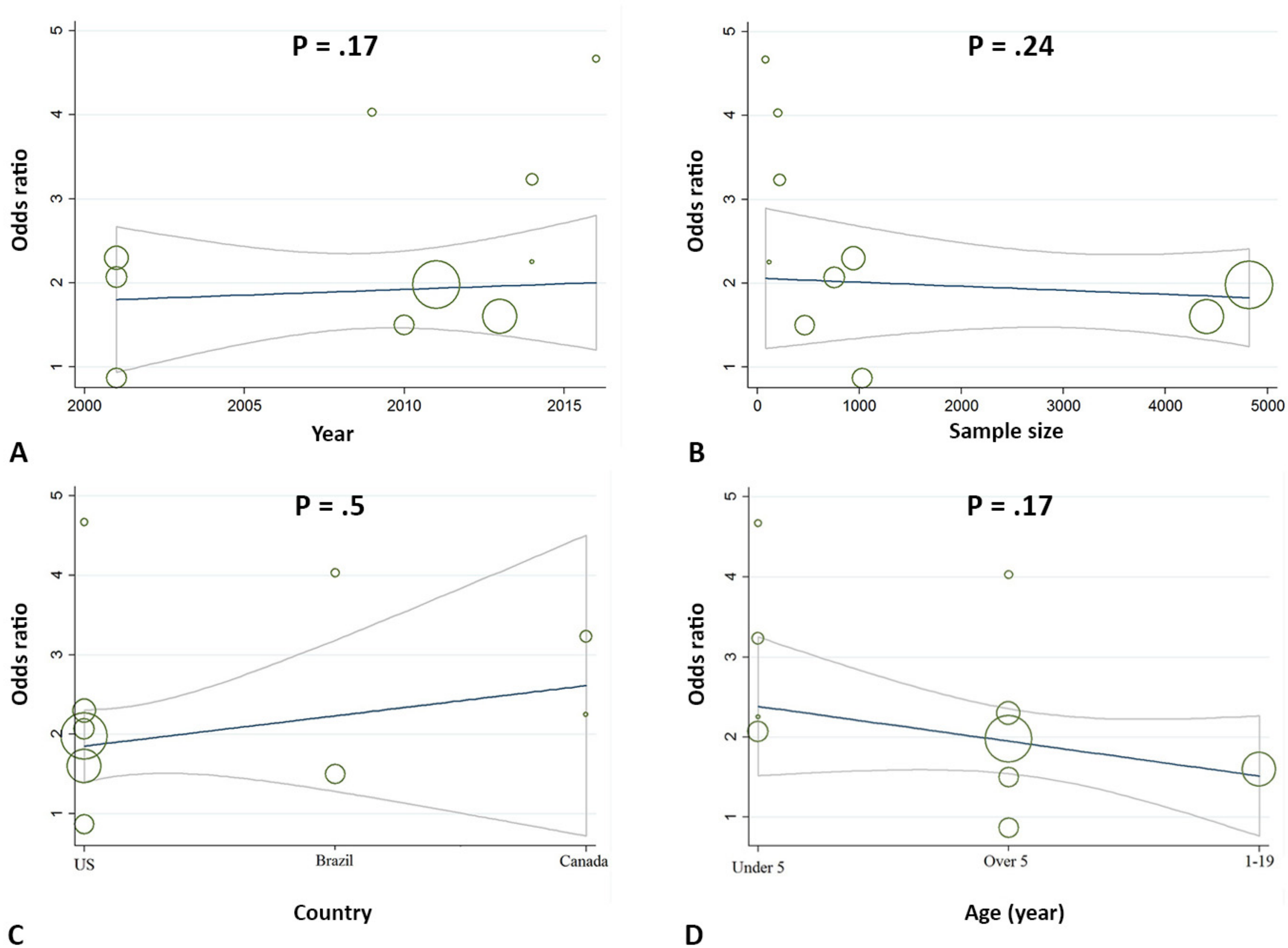

P = .17
Odds ratio
1
2
3
4
5
2000
2005
2010
2015
Year
A
P = .24
Odds ratio
1
2
3
4
5
0
1000
2000
3000
4000
5000
Sample size
B
P = .5
Odds ratio
1
2
3
4
5
US
Brazil
Canada
Country
C
P = .17
Odds ratio
1
2
3
4
5
Under 5
Over 5
1-19
Age (year)
D

**Figure 5**