



Prolonged and night-time bottle-feeding in relation to early childhood caries: a systematic review

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Abstract

Purpose Early childhood caries (ECC) remains a major public health problem worldwide. Infant feeding practices, particularly bottle-feeding duration and nocturnal bottle use, have been implicated as potential risk factors; however, evidence regarding duration-specific effects remains inconsistent. The aim was to systematically evaluate whether prolonged bottle-feeding and nocturnal bottle use are associated with increased prevalence of ECC.

Methods This systematic review followed PRISMA guidelines and was registered in PROSPERO (CRD420251186608). MEDLINE, Cochrane Central, ScienceDirect and Scopus were searched up to May 2026. Observational studies involving children ≤ 71 months that reported ECC outcomes (dmft/dmfs/dft/deft) in relation to bottle-feeding duration and/or night-time bottle use were included. Risk of bias was assessed using ROBINS-E, and certainty of evidence was evaluated using GRADE.

Results Twelve studies (two prospective cohorts and ten cross-sectional; 6,955 children) were included. Bottle-feeding limited to the first year of life was not associated with increased caries severity. Continuation beyond 12 months was associated with a gradual increase in ECC, whilst bottle-feeding beyond 24 months showed a consistent and clinically relevant increase in caries severity. Nocturnal bottle-feeding further amplified risk, particularly beyond 24 months, with evidence of dose–response relationships. Overall certainty of evidence was low to very low, limited primarily by observational study design, heterogeneity in exposure definitions and residual confounding.

Conclusions Evidence suggests a duration-dependent association between prolonged bottle-feeding and ECC severity, particularly beyond 24 months and during night-time. These findings support current recommendations for timely cessation of bottle use and avoidance of night-time bottle-feeding to reduce ECC burden.

Keywords Early childhood caries · Bottle-feeding · Prolonged bottle use · Night-time feeding · Infant feeding practices · Dental caries severity

Introduction

Early childhood caries (ECC) is defined as the presence of one or more cavitated or noncavitated lesions, or a missing or filled primary tooth due to caries in a child 71 months of age or younger (AAPD 2023; WHO 2018). It is the most prevalent chronic infectious disease of childhood and remains a major

public health concern worldwide. According to the Global Burden of Disease Study in 2017, more than 530 million children are affected by dental caries in the primary dentition, highlighting the substantial burden of this disease. Although ECC is not life-threatening, it has profound negative effects on children's quality of life, particularly when associated with pain. ECC can impair mastication, sleep, growth and nutrition and has been linked to adverse social, cognitive and neurodevelopmental outcomes. In addition, the condition places considerable emotional and financial strain on affected families (Folayan & Olatubosun 2018; WHO 2020).

Despite the temporary nature of primary teeth, the effects of ECC should not be underestimated, as it has been shown to influence both primary and permanent dentitions and to affect general health across the life course. Moreover, ECC shares common risk factors with other noncommunicable

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childhood diseases, particularly high free-sugar intake, and has been associated with childhood obesity and impaired growth. Severe dental caries may also lead to pain, abscess formation, difficulties in eating and sleeping, and reduced quality of life (WHO 2020).

Infant feeding practices play a critical role in the development of ECC. The World Health Organization recommends exclusive breastfeeding for the first six months of life, followed by the introduction of nutritionally adequate and safe complementary foods, whilst breastfeeding continues up to two years of age or beyond (WHO 2020, 2023). Breastfeeding is widely recognised as the optimal source of infant nutrition, providing essential nutrients and immunological protection, and providing physical, hormonal, and psychological dynamic sharing between mother and baby (CDC 2021).

In contrast, bottle-feeding practices, which commonly involve infant formula or cow's milk and may include added sugars, have been associated with an increased risk of ECC (Moynihan et al. 2019; Cheng et al. 2025). Nocturnal bottle-feeding, in particular, exposes the dentition to fermentable carbohydrates under conditions of reduced salivary flow, thereby promoting enamel demineralization (Cheng et al. 2025). However, although the confounding factors have been explored in different countries, the results may still be contradictory (Devenish et al. 2020).

Current guidelines recommend cessation of bottle-feeding and transition to cup drinking between 12 and 18 months of age; however, bottle-feeding often persists beyond the recommended age in many populations (AAPD 2023; WHO 2023). Prolonged bottle-feeding has been linked not only to ECC but also to other adverse health outcomes, including childhood overweight and obesity. Furthermore, inadequate oral hygiene practices and frequent consumption of free sugars may act synergistically with bottle-feeding habits, further increasing caries risk (Cheng et al. 2025).

Despite the extensive body of literature examining infant feeding practices and ECC, findings regarding the association between prolonged bottle-feeding and caries prevalence remain inconsistent. Variations in study design, definitions of prolonged bottle-feeding and confounding factors such as sugar exposure and oral hygiene practices contribute to these discrepancies. Therefore, the aim of the present systematic review was to evaluate the association between prolonged bottle-feeding duration and ECC prevalence/severity in children ≤ 71 months, and secondarily to assess the association between nocturnal bottle-feeding and ECC outcomes.

Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis tool (PRISMA STATEMENT) was used as a guideline in the present systematic review. The review was

registered in PROSPERO (CRD420251186608) before starting the data collection.

Review questions

Amongst children ≤ 71 months, is prolonged bottle-feeding associated with ECC prevalence and severity (dmft/dmfs/deft/dft)?

Amongst children ≤ 71 months, is nocturnal bottle-feeding associated with ECC prevalence and severity (dmft/dmfs/deft/dft)?

Eligibility criteria

PICO:

- **P (Population):** Primary-teeth children (< 71 months). The cut-off age of 71 months was used according to the definition of AAPD for ECC (AAPD 2023).
- **I (Exposure/Intervention):** bottle-feeding beyond age 12 or 24 months/nocturnal bottle-feeding)
- **C (Comparator):** No bottle-feeding/earlier bottle-feeding (before 12 months)/exclusive breastfeeding
- **O (Outcome):** Incidence or prevalence of ECC (dmft/dmfs), caries experience
- **Timing:** Review before the age of 6 years

Search strategy

A systematic search was conducted using four databases: MEDLINE via PubMed, Cochrane Central, Science Direct, SCOPUS. The search was performed in October 2025. An updated literature search was performed in May 2026 prior to manuscript revision to identify any newly published eligible studies. No additional eligible studies were found. Bibliographies of published articles were also searched to identify studies not identified previously.

A Boolean search was made in all databases for the following keywords:

Bottle Feeding OR bottle feed OR bedtime bottle OR nocturnal bottle OR night feed OR prolonged bottle OR late wean OR formula feed OR nursing bottle AND Dental Caries OR tooth decay OR early childhood caries OR ECC OR dmft OR dmfs OR severe early childhood caries AND infant OR newborn OR baby OR babies OR toddler OR preschool OR children.

Search strategy can be found in Online Appendix 1.

Inclusion criteria

Population: Human studies involving children from birth up to 71 months of age (≤ 5 years and 11 months) with primary dentition. Studies conducted in any geographic location or socio-economic context.

Exposure: Bottle-feeding practices are clearly defined and measured,

- o Prolonged bottle use (≥ 12 , ≥ 18 , or ≥ 24 months) and
- o nocturnal bottle use/bottle-to-sleep
- o Clearly defined duration of bottle-feeding

Comparator: Children not exposed to the specified bottle-feeding practice (e.g. no nocturnal feeding, earlier cessation, unsweetened contents, cup feeding, or exclusive breastfeeding).

Outcomes: ECC or severe ECC (S-ECC), measured by standard indices (dmft, dmfs, ECC prevalence).

Study Design: Observational studies: prospective and retrospective cohort studies, cross-sectional studies, and case–control studies.

Publication Type: Peer-reviewed journal articles and grey literature with sufficient methodological detail.

Language and Date: English language and publication after 2000.

Exclusion criteria

Population: Studies not involving human participants. Studies including only children over 6 years or mixed populations where data for < 6 years cannot be separated.

Exposure: Studies that do not specify bottle-feeding practices (e.g. general feeding methods without bottle-specific data). Studies where exposure cannot be distinguished from breastfeeding or other feeding modes. Studies lacking a clearly defined duration of bottle-feeding.

Outcomes: Studies not reporting ECC or related caries outcomes (e.g. plaque index only, enamel hypoplasia without caries data).

Study Design: Case reports, case series with < 10 participants, reviews, editorials, opinion pieces, commentaries, letters, master's/PhD theses or conference abstracts without full data.

Data Availability: Studies lacking extractable or calculable data for the bottle-feeding–caries association (e.g. no effect estimates or raw data, and authors were unreachable).

Duplicates: Duplicate publications; only the most comprehensive or the most recent dataset will be retained.

Data management: All records were imported into a reference manager, de-duplicated, then screened.

Study selection

Titles and/or abstracts of the initial search were reviewed independently by two authors (MA,>NNL). Included studies were assessed independently by both authors. Any discrepancies were resolved by discussion and if that was not possible, by a third author (NAL). A PRISMA 2020 flow diagram shows the results (Fig. 1).

Data extraction

Data were extracted by the two authors mentioned above in forms designed for this research. Each study had the following information extracted: publication details (authors, year of publication, design, location of study) sample characteristics (sample size, age of children at examination, breastfeeding duration) and outcome.

Data synthesis

Meta-analysis was not considered appropriate because of substantial methodological and clinical heterogeneity across studies, including variability in bottle-feeding exposure definitions, duration thresholds, assessment of nocturnal feeding, outcome indices and adjustment for confounding variables. Therefore, findings were synthesised narratively in accordance with the Synthesis Without Meta-analysis (SWiM) guidance (Campbell et al. 2020).

Risk of bias assessment & certainty of evidence

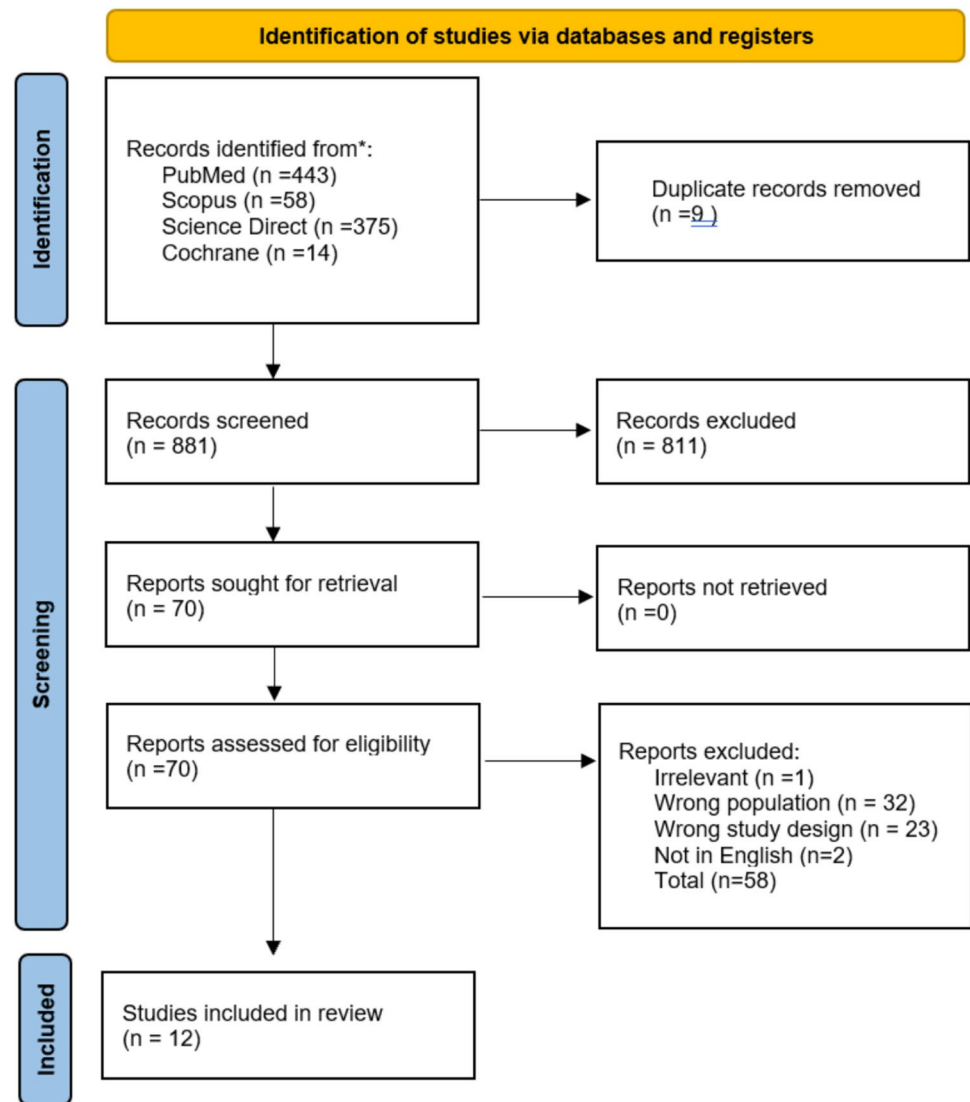
The risk of bias of the included articles was evaluated by two independent authors (MA,>NNL) using the Risk of Bias in Non-randomised Studies—of Exposure (ROBINS-E) tool (Higgins et al. 2024) according to specific guidelines for observational studies. Differences occurring during evaluation were discussed and resolved in consultation with a third author (NAL). Moreover, the certainty of current evidence was rated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria (Guyatt et al. 2008): risk of bias, indirectness, imprecision, inconsistency and publication bias. Two review authors (MA,>NNL) independently judged the evidence certainty (high, moderate, low, or very low) and resolved disagreements by discussion with a third author (NAL).

RESULTS

Search results (Fig. 1).

In the search for bottle-feeding articles, a total of 881 articles were found, having excluded 9 duplicates. After careful

Fig. 1 PRISMA flow diagram



Title-Abstract screening 811 articles were excluded and 70 remained. Following reading and evaluation of those 70 articles according to the eligibility criteria, 58 articles were excluded for specific reasons (Online appendix 1) and 12 articles were finally included in the review (Table 1).

Study characteristics

Table 1 summarises the characteristics of the 12 studies included in the review. Two studies included in the review were prospective cohort studies and ten studies were cross-sectional studies published between 2001 and 2025 (Table 1). All studies reported the age of the children (0–71 months), sample size (ranging from 95 to 2000), bottle-feeding duration categorised in various ways (e.g. ≤ 12 vs > 12 months, ≤ 24 vs > 24 months, 0–6, 7–12, 13–18, > 18 months, or specific ranges in months/years). An oral examination evaluating the prevalence of dental caries

was performed in all studies. Overall, 6955 children were included in those 12 studies.

Across the 12 included studies, all studies reported caries severity outcomes (dmft, dmfs, deft or dft) stratified by bottle-feeding duration and were included in the duration-severity synthesis (Table 2). Only four studies explicitly examined night-time bottle-feeding in relation to the duration of bottle-feeding and were therefore included in the duration-specific night-feeding synthesis (Table 3).

Bottle-feeding limited to the first year of life was not associated with increased caries severity. In two cross-sectional studies, children bottle-fed for ≤ 12 months had the lowest mean dmft values, comparable to children who were not bottle-fed (Sankeshwaria et al. 2012; Prakasha Shrutha et al. 2013). In a multivariable analysis, Al-Haj Ali et al. (2021) reported that bottle-feeding at 7–12 months was independently associated with substantially lower odds of ECC compared with bottle-feeding beyond 18 months (adjusted

Table 1 Study-level characteristics and bottle-feeding exposure of the included studies

Study (Year)	Country	Design	No	Age ($\leq 6y$)	Bottle-feeding duration categories	Night bottle feeding assessed	ECC outcome reported
Lulić-Dukić et al. 2001	Croatia	Case-control	145	24–60 m	≤ 24 vs > 24 months	Yes (sweet drinks at night)	dmfs, ECC
Ölmez et al. 2003	Turkey	Cross-sectional	95	9–57 m	≤ 37 vs > 37 months	No	dft, ECC
Hallett & O'Rourke 2006	Australia	Cross-sectional (hospital-based)	125	36–71 m	≤ 18 vs > 18 months	Yes (sleeping with bottle)	dmft, dmfs (S-ECC)
Sankeshwaria et al. 2012	India	Cross-sectional	1116	24–60 m	0–3, 4–6, 7–12, 13–24, 25–36 months	Yes	dmft, ECC
Prakasha Shrutha et al. 2013	India	Cross-sectional	2000	24–60 m	≤ 24 m vs > 24 m	Yes	dmft, ECC
Barjatya et al. 2020	India	Cross-sectional	640	24–60 m	12 m, 18 m, 24 m, > 24 m	Yes	deft/defs, ECC
Al-Haj Ali et al. 2021	Saudi Arabia	Cross-sectional	241	≤ 71 m	0–6, 7–12, 13–18, > 18 months	Yes	dmft, ECC
Olczak-Kowalczyk et al. 2020	Poland	Cross-sectional	656	36 m	≤ 12 vs > 12 months	Yes	dmft, ECC
Nishide et al. 2018	Japan	Longitudinal cohort	566	18 m $\rightarrow$ 36 m	Bottle-feeding at 18 months	Yes (overnight)	ECC
Chhabra et al. 2022	India	Cross-sectional	398	48–60 m	12, 13–18, 19–24, > 24 months	Yes	deft, ECC
Bulut & Kiliç 2023	Turkey	Cross-sectional	255	≤ 60 m	≤ 18 vs > 18 –24 months	Yes	dmft, ECC
Cheng et al. 2025	Australia	Longitudinal cohort	718	36–48 m	24 months; 36 months	Yes (to sleep)	dmfs, ECC

m months

odds ratio [AOR] 0.11, 95% CI 0.02–0.59). Overall, evidence consistently indicated no increase in caries burden when bottle-feeding ceased by 12 months.

Between 12 and 24 months of bottle-feeding, caries experience increased relative to ≤ 12 months although the magnitude of association varied across studies. Several cross-sectional studies reported higher dmft or deft values amongst children bottle-fed beyond 12 months (Sankeshwaria et al. [2012](#); Prakasha Shrutha et al. [2013](#); Chhabra et al. [2022](#)). In a Polish population, Olczak-Kowalczyk et al. ([2020](#)) demonstrated that bottle-feeding beyond 12 months was independently associated with higher dmft (AOR 1.44). Longitudinal evidence supported this association further; Cheng et al. ([2025](#)) found that bottle-feeding to sleep at 24 months was associated with a 48% increase in caries-affected tooth surfaces (dmfs ratio 1.48, 95% CI 1.00–2.20). Additionally, Nishide et al. ([2018](#)) reported higher dmft at 3 years amongst children bottle-fed at 18 months, particularly when combined with inadequate oral hygiene. Collectively, findings indicate an emerging and clinically relevant increase in caries experience when bottle-feeding continues into the second year of life.

Bottle-feeding beyond 24 months generally demonstrated the strongest and most consistent association with increased caries experience. Multiple studies demonstrated

a clear duration-response relationship, with the highest dmft, dmfs, deft or dft values observed amongst children bottle-fed for more than two years (Sankeshwaria et al. [2012](#); Barjatya et al. [2020](#); Ölmez et al. [2003](#); Bulut et al. [2023](#)). In a case-control study, Lulić-Dukić et al. ([2001](#)) reported significantly higher dmfs values amongst children bottle-fed beyond 24 months, particularly in the context of night-time consumption of sweetened liquids, indicating a marked increase in surface-level caries involvement. Dose-dependent effects were reported, with adjusted odds ratios approaching three-fold increases in caries experience for prolonged bottle-feeding (Barjatya et al. [2020](#)). Hospital-based samples reported very high dmft and dmfs values consistent with severe ECC (Hallett et al. [2006](#)). Persistence of bottle-feeding to sleep at 36 months was associated with an almost two-fold increase in dmfs (ratio 1.88, 95% CI 1.22–2.91) in a longitudinal cohort (Cheng et al. [2025](#)). Overall, prolonged bottle-feeding beyond 24 months was generally consistent with an association with greater caries burden.

Four studies examined explicitly nocturnal bottle-feeding in relation to the duration of bottle-feeding and were therefore included in the duration-specific nocturnal bottle-feeding synthesis (Table [3](#)). These studies demonstrated consistently that nocturnal bottle-feeding becomes

Table 2 Association between bottle-feeding duration and caries severity

Study	Bottle-feeding duration	Numerical values reported	Finding	Interpretation
Sankeshwaria et al. 2012	0–36 months	0–3 m: 72.09%, 4–6 m: 67.5%, 7–12 m: 64.36%, 13–24 m: 60.99% 25–36 m: 58.33% ECC prevalence	No statistically significant association with ECC ($P=0.624$)	Duration of bottle-feeding alone did not significantly affect ECC prevalence in this population.
Prakash Shruutha et al. 2013	6 months–> 2 years	6 m–1 yr: 30.8% 1–1.5 yr: 51.2% 1.5–2 yr: 61.8% > 2 yr: 75.9% ECC Caries prevalence increased 30.8% → 75.9%, $P<0.001$	Bottle-feeding restricted to first year associated with lower caries severity $P<0.001$	Longer duration of bottle-feeding, especially beyond 2 years, is strongly associated with higher ECC prevalence
Al-Haj Ali et al. 2021	≤ 12 months vs > 18 months 13–17 vs > 18 months	AOR 0.11 (95% CI 0.021–0.585) for 7–12 m vs > 18 m AOR 0.313 (95% CI 0.067–1.465) vs > 18 m	Children bottle-fed for 7–18 months had significantly lower odds of ECC compared with those bottle-fed for more than 18 months. $P<0.0001$	Bottle-feeding over 18 months is associated with increased ECC prevalence
Chhabra et al. 2022	12 to ≥ 24 months ECC prevalence	< 13m: 31.4% 13–18m: 35.6% 19–24 m: 37.2% > 24 m: 37.4%	Longer bottle-feeding duration associated with greater caries severity $P=0.04$	Increased caries burden with increased age
Oleczak-Kowalczyk et al. 2020	> 12 months	OR 1.44 for nocturnal bottle-feeding > 12 m	Bottle-feeding beyond 12 months independently increased dmft $p=0.043$	Increased caries burden over 12 months
Cheng et al. 2025	24 months	dmfs ratio 1.48 (95% CI 1.00–2.20) at 24 m	Bottle-feeding to sleep at 24 months increased caries-affected surfaces	Moderate severity increase
	36 months	dmfs ratio 1.88 (95% CI 1.22–2.91) at 36 m	Persistence of bottle-feeding to sleep was associated with higher caries	Strong severity effect
Nishide et al. 2018	18 months	AOR 14.27 (interaction with poor brushing)	Bottle-feeding at 18 months markedly increased dmft when oral hygiene was inadequate	Strong conditional risk
Lulić-Dukić et al. 2001	≤ 24 vs > 24 months	No significant difference ($p=0.994$)	Bottle-feeding does not represent a risk factor for ECC.	Bottle-feeding duration was not associated with ECC risk in this population.
Barjatya et al. 2020	≥ 24 months	AOR 2.90–2.95 for ≥ 2 y vs < 2 y in 1–1.5 yr group	Dose-dependent increase in caries severity with longer duration	ECC was found to be significantly associated with age and bottle-feeding
Ölmez et al. 2003	> 37 months	Significantly higher mean dmft in > 37 m group ($p<0.05$)	Very late bottle cessation strongly associated with caries	Highly cariogenic practice
Hallett & O'Rourke 2006	≤ 18 vs ≥ 19 months	≥ 19 months: 94% S-ECC, mean dmfs 28.5 ≤ 18 months: 97% S-ECC, mean dmfs 24.5	Prolonged bottle use associated with severe ECC	Severe disease
Bulut & Kiliç 2023	Months < 12 12–17 17–23 > 24	Mean dmft 7.18 ± 5.21 6.47 ± 5.27 10.29 ± 5.45 8.59 ± 3.72	There was no association between bottle-feeding and ECC/S-ECC. $P=0.106$	Prolonged bottle-feeding is not associated with ECC

Table 3 Association between nocturnal bottle-feeding and caries severity

Study	Night-time feeding	Outcome index	Numerical values	Key finding	Interpretation
Nishide et al. 2018	Overnight bottle-feeding at 18 months	ECC	AOR 14.27 (with poor brushing)	Night-time bottle-feeding at 18 months was associated with markedly more cavities at 2 years, particularly when oral hygiene was inadequate	Strong duration-anchored effect
Olczak-Kowalczyk et al. 2020	Night bottle-feeding > 12 months	dmft	OR 1.44	Bottle-feeding beyond 12 months, including night use increased dmft	Significant duration threshold effect
Lulić-Dukić et al. 2001	Sweetened drinks at night after 24 months	dmfs	Significantly higher dmfs (8.6) ($p < 0.001$)	Night-time intake of sweetened liquids and poor brushing beyond 2 years strongly associated with caries severity	Highly cariogenic practice
Cheng et al. 2025	Bottle-feeding to sleep at 24 months	dmfs	dmfs ratio 1.48 (95% CI 1.00–2.20)	Bottle-feeding to sleep at 24 months was associated with greater caries experience	Moderate severity increase
	Bottle-feeding to sleep at 36 months	dmfs	dmfs ratio 1.88 (95% CI 1.22–2.91)	Bottle-feeding to sleep at 36 months was associated with greater caries experience	Strong dose–response effect

increasingly cariogenic when it persists beyond two years of age.

Night-time bottle-feeding at 18 months was associated with a marked increase in dmft at 2 years of age, particularly when combined with poor oral hygiene practices (AOR 14.27) (Nishide et al. 2018). In cross-sectional analyses, bottle-feeding beyond 12 months, including night-time use, was associated with higher dmft (AOR 1.44) (Olczak-Kowalczyk et al. 2020). Stronger effects were observed with increasing duration: bottle-feeding to sleep at 24 months was moderately associated with higher caries experiences (dmfs 1.48, 95%CI: 1.00–2.20, $p = 0.051$), whilst persistence of bottle-feeding to sleep at 36 months was strongly associated with higher caries experience (dmfs 1.88, 95%CI: 1.22–2.91) (Cheng). In a case-control study, night-time consumption of sweetened liquids after 24 months was strongly associated with increased caries severity (Lulić-Dukić et al. 2001).

Risk of bias assessment

In total, eight studies were assessed to be of overall high risk of bias and four were assessed to be of moderate risk of bias. Figure 2 shows the ROBINS-E risk of bias assessment for each domain separately.

Certainty of evidence

The Summary of GRADE evidence table (Table 4) synthesises the certainty and magnitude of evidence relating bottle-feeding practices to caries severity in early childhood. Overall certainty of evidence was low to very low, because the available literature consisted predominantly of observational studies with substantial risk of bias, heterogeneity in exposure definitions, and variable control of confounding factors. Although several studies demonstrated consistent trends towards greater caries severity with prolonged and night-time bottle-feeding, interpretation should remain cautious given limitations related to study design, exposure assessment, and residual confounding.

Discussion

Taken together, the available observational evidence suggests a duration-related association: bottle-feeding limited to the first year of life is not associated with increased caries experience, whereas continuation beyond 12 months is associated with progressively higher caries burden, with the greatest severity observed when bottle-feeding persists beyond 24 months (Sankeshwaria et al. 2012; Barjatya et al. 2020; Cheng et al. 2025). The four studies that examined nocturnal bottle-feeding consistently demonstrated that

caries experience is greater when it persists beyond two years of age.

The present findings can be interpreted in the context of the WHO-commissioned systematic review by Moynihan et al. (2019), which evaluated a broad range of *modifiable risk factors* for ECC, including infant feeding practices. With respect to bottle-feeding, Moynihan et al. reported low-quality evidence indicating increased ECC risk associated with consumption of sugars from feeding bottles, but did not stratify bottle-feeding by duration, nor examine duration-specific night-time bottle-feeding as a distinct exposure.

Similarly, the systematic review and meta-analysis by Avila et al. (2015) compared breastfeeding and bottle feeding as categorical exposures and demonstrated higher odds of caries experience amongst bottle-fed children, but did not evaluate exposure gradients by age or feeding duration, and focussed primarily on caries prevalence rather than severity outcomes. More recently, Khan et al. (2023) synthesised evidence on multiple caries risk factors in children under six years of age to inform risk assessment tools. Feeding practices were included as part of a multifactorial framework. Two studies linked bottle-feeding after one year to increased caries risk and four studies revealed that nocturnal breastfeeding or bottle-feeding was related to a significantly increased risk of ECC; however, duration-specific bottle-feeding thresholds and severity-based outcomes were not the primary focus.

The observed duration-related associations are biologically plausible. Prolonged bottle-feeding may increase the

frequency and duration of exposure of primary teeth to fermentable carbohydrates, particularly when feeding occurs during sleep, when salivary flow and oral clearance are reduced (Moynihan et al. 2019; AAPD 2023). In addition, prolonged bottle-feeding may coexist with other cariogenic behaviours, including frequent free-sugar consumption, delayed transition to cup drinking, and suboptimal oral hygiene practices (WHO 2020; Cheng et al. 2025). Consequently, prolonged bottle-feeding may function both as a direct source of cariogenic exposure and as a behavioural marker of broader dietary and oral health patterns associated with ECC.

Strengths

The strength of the present review is that it provides a targeted, duration-based synthesis of bottle-feeding in a large number of children, separating exposures into clinically relevant age categories (≤ 12 months, 12–24 months, and > 24 months) and prioritising caries experience indices (dmft/dmfs/deft/dft). Importantly, the present review uniquely isolates evidence on night-time bottle feeding at defined ages, allowing assessment of duration-anchored nocturnal exposure, which was not examined explicitly in previous reviews. Methodological rigour was enhanced through application of ROBINS-E for exposure-specific risk-of-bias assessment and GRADE to evaluate certainty of evidence.

Overall, whilst previous systematic reviews—including the WHO-commissioned review (Moynihan et al.

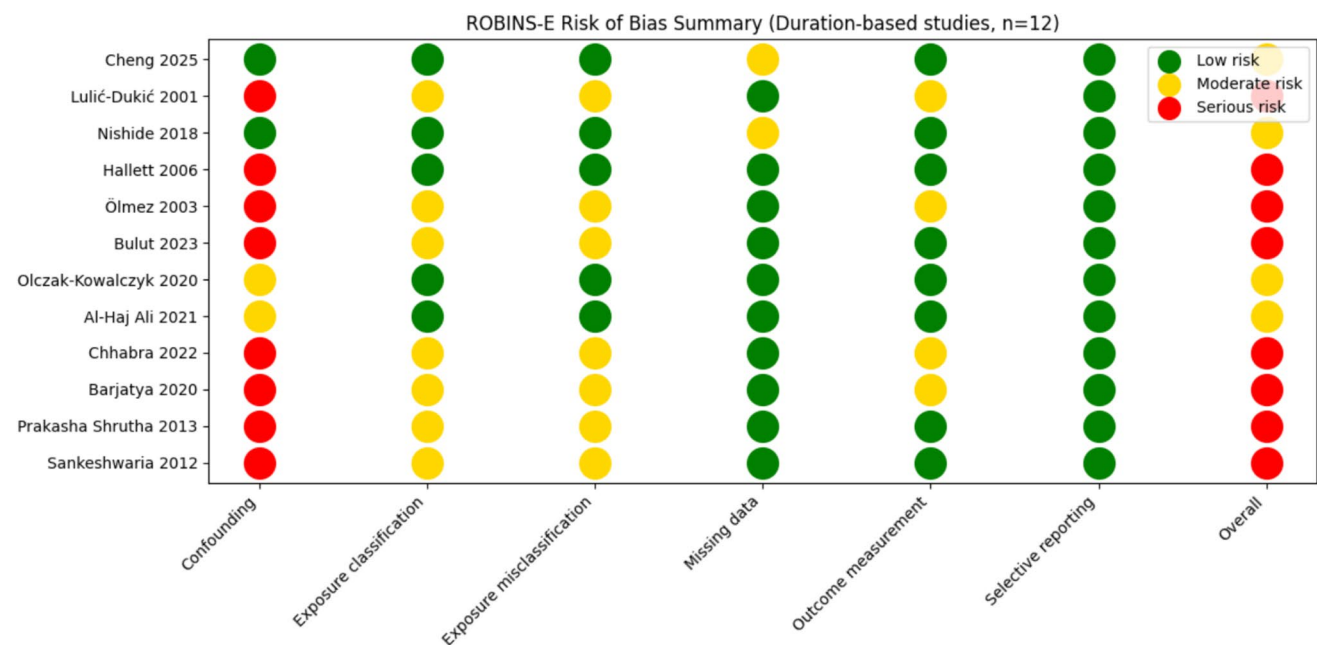


Fig. 2 ROBINS-E risk-of-bias summary for included studies. Each domain is rated as low (green), moderate (yellow), or serious (red) risk of bias

Table 4 Summary of grade quality of evidence certainty

Outcome (Increase in ECC prevalence)	No. of studies (participants) Studies	Study design	Main Limitations	Final certainty
Bottle-feeding ≤ 12 months vs no/prolonged feeding	3 (~ 3200) Sankeshwaria et al. 2012; Prakasha Shrutha et al. 2013; Al-Haj Ali et al. 2021	Cross-sectional	Serious risk of bias, cross-sectional design, residual confounding, heterogeneous exposure definitions	$\oplus\oplus\bigcirc\bigcirc$ Low
Bottle-feeding 12–24 months vs ≤ 12 months	6 (~ 5600) Sankeshwaria et al. 2012; Prakasha Shrutha et al. 2013; Chhabra et al. 2022; Oleczak-Kowalczyk et al. 2020; Nishide et al. 2018; Cheng et al. 2025	Cross-sectional + cohort	Serious risk of bias, inconsistent confounder adjustment, heterogeneous duration thresholds and outcome measures	$\oplus\oplus\bigcirc\bigcirc$ Low
Bottle-feeding > 24 months vs ≤ 24 months	7 (~ 6300) Barjatiya et al. 2020; Ölmez et al. 2003; Hallett & O'Rourke 2006; Cheng et al. 2025; Lulić-Dukić et al. 2001; Bulut & Kiliç 2023; Prakasha Shrutha et al. 2013	Cross-sectional + cohort	Serious risk of bias, substantial heterogeneity, residual confounding, limited longitudinal evidence	$\oplus\oplus\bigcirc\bigcirc$ Low
Night-time bottle-feeding ≥ 12 months	2 (~ 1700) Oleczak-Kowalczyk et al. 2020; Nishide et al. 2018	Cross-sectional + cohort	Small evidence base, heterogeneous exposure definitions, risk of confounding, limited precision	$\oplus\bigcirc\bigcirc\bigcirc$ Very low
Night-time bottle-feeding ≥ 24 months	2 (~ 1100) Cheng et al. 2025; Lulić-Dukić et al. 2001	Case-control + cohort	Very small evidence base, serious risk of bias, heterogeneous study designs, poorly defined bottle contents, residual confounding	$\oplus\bigcirc\bigcirc\bigcirc$ Very low

2019)—establish that feeding practices involving bottle use are relevant to ECC risk, the present systematic review advances the evidence by demonstrating a duration-dependent gradient, with the strongest and most consistent associations observed for bottle-feeding beyond 24 months and for prolonged nocturnal bottle-feeding. This distinction supports age-specific clinical guidance and public health messaging rather than treating bottle-feeding as a uniform exposure across early childhood.

Limitations

Several limitations warrant consideration. The evidence base was dominated by observational studies, many of which were cross-sectional and therefore susceptible to residual confounding and recall bias. Definitions of bottle-feeding duration and nocturnal feeding varied across studies, and caries experience outcomes were reported using different indices, limiting comparability and precluding meta-analysis. Only a small number of studies examined nocturnal feeding explicitly in relation to specific durations, restricting precision for this exposure. Finally, of the 12 studies, only one (Cheng et al. 2025) differentiated between expressed milk, cow's milk or formula in the bottle, whereas the remaining did not state the contents of the bottle.

Bottle-feeding-related caries should be interpreted as multifactorial. Duration of bottle use, nocturnal feeding practices, feeding frequency, and bottle contents may each contribute differently to cariogenic risk (Moynihan et al. 2019; WHO 2020). In particular, nocturnal feeding may increase cariogenic potential because reduced salivary flow during sleep prolongs exposure of the dentition to fermentable carbohydrates (AAPD 2023; Cheng et al. 2025). However, most included studies did not consistently distinguish between these exposure domains or adequately adjust for related confounding variables such as dietary free-sugar intake, oral hygiene practices, fluoride exposure, and socioeconomic status. Additionally, since many included studies were cross-sectional, temporality between prolonged bottle use and ECC development could not be firmly established. Consequently, the observed associations should be interpreted cautiously as reflecting complex feeding behaviours and broader behavioural or socioeconomic patterns rather than isolated effects of bottle-feeding duration alone.

Despite these limitations, the consistency of findings across settings, the presence of biologically plausible dose-response patterns, and supportive longitudinal evidence strengthen confidence in the conclusions. Future research should prioritise prospective cohorts with standardised definitions of feeding duration and nocturnal practices,

improved control of confounding, and harmonised reporting of caries outcomes.

Clinical and policy implications

The findings of the present review are consistent with existing recommendations from the American Academy of Paediatric Dentistry and the World Health Organization, which emphasise early transition from bottle-feeding and avoidance of feeding practices that promote prolonged sugar exposure (WHO 2015, 2023; AAPD 2023). In line with AAPD guidance advocating discontinuation of bottle use by approximately 12 months of age and avoidance of nocturnal bottle-feeding, the present findings provide support that continued bottle-feeding beyond infancy, particularly beyond 24 months and nocturnally, contributes to increased caries experience. Similarly, WHO recommendations promoting appropriate complementary feeding practices and limiting free-sugar exposure are reinforced by the observed duration-dependent gradient in caries risk.

Conclusions

- According to the findings of the present systematic review and within its limitations, bottle-feeding practices are associated with ECC in a duration-dependent manner. Bottle-feeding limited to the first year of life was not consistently associated with increased caries severity in the included studies, whereas continuation beyond 12 months—particularly beyond 24 months—was generally associated with greater caries experience. Nocturnal bottle-feeding at defined ages further amplified caries risk, with the strongest effects observed when feeding persists beyond 24 months.
- Although much of the evidence is observational, consistent dose-response relationships and supportive longitudinal data strengthen confidence in the present findings.
- The results reinforce current recommendations for timely cessation of bottle-feeding and avoidance of nocturnal feeding, and highlight the importance of early, age-specific preventive guidance to reduce the burden of ECC.
- The role of the paediatric dentist/dentist is crucial and early dental appointments (within the first year of life of the child) should be scheduled in order to inform parents and reinforce their knowledge regarding healthy dietary habits and feeding practices.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s40368-026-01230-x>.

Author contributions N.N.L. conceived the idea. M.A. and N.N.L. did the study selection, data extraction, screening of the papers, data synthesis and the RoB and GRADE assesment. M.A. drafted the paper. N.N.L. and N.A.L. reviewed and revised the paper. All authors approved the final version.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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