Original Article

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Dentistry Section

Adverse Effects of Paediatric Liquid Medications on Primary Teeth: A Systematic Review

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ABSTRACT

Introduction: Paediatric liquid medications are widely administered due to their ease of use and high compliance. Emerging evidence, however, suggests these formulations may have unintended oral health consequences. Specifically, the primary dentition may experience erosion, discolouration, and altered surface properties. Studying the adverse effects of different paediatric liquid medications on primary teeth reflects a growing understanding of the complex interactions between medications and dental health and ongoing efforts to mitigate potential risks to children's oral health.

Aim: The present systematic review was conducted to summarise and assess the effects of various paediatric drugs on primary teeth by reviewing the available literature.

Materials and Methods: The present systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) guidelines and was registered on PROSPERO (CRD42023413689). The PROSPERO record is available at https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023413689. An extensive search of electronic databases was conducted covering January 2000 to December 2023 to identify studies reporting adverse effects of paediatric drugs on primary teeth. Quality assessment of the included studies was performed using the Quality Assessment Tool For In Vitro Studies (QUIN) tool.

Results: After meeting the eligibility criteria 24 in-vitro studies were included. Each study analysed the effects of medications on primary teeth. Enamel erosion, increased surface roughness, and discolouration were observed with most paediatric liquid medications.

Conclusion: This systematic review, included 24 studies, demonstrated associations between paediatric liquid medications and deleterious effects on the primary dentition. These adverse effects are likely driven by the acidic components, colouring additives, and prolonged contact time of the formulations. Despite methodological variations among studies, the consistent findings across different medication classes reinforce these conclusions. By integrating this knowledge into clinical practice, healthcare professionals can contribute to the promotion of optimal oral health in paediatric patients.

Keywords: Dental caries, Dental erosion, Discolouration, Enamel loss

INTRODUCTION

Doctors recommend medications to address various health concerns [1]. The various routes of drug administration are oral, nasal, sublingual, cutaneous, parenteral, and rectal [2]. Among these, the oldest, most common, and easiest administration route is the oral route [3]. Oral drugs, such as capsules, are coated to mask unpleasant tastes and are inappropriate for use in children due to their inability to swallow them at a young age [4]. Therefore, medication in liquid form is recommended for them. Both parents and children find them easily obtainable and highly acceptable [5]. In paediatric medicine, syrups have been used for an extensive period. Their use is typically for a shorter period, but it may be a regular occurrence for some children [5]. Long-term use of sugary liquid medications increases the risk of cavities. While parents know sugar causes decay, they often overlook medications as a sugar source. Children taking medications for chronic or recurring illnesses, and even supplements, are at risk of dental caries [6,7].

Analysis of drug properties revealed that pH, viscosity, acidity, and sugar content contribute to adverse dental effects such as erosion, staining, and hypoplasia [5,8]. Studies show that children using long-term, sugar-containing medications have a higher rate of caries than those not taking such medications [8-11].

Dental erosion, defined as irreversible tooth loss from acid (not bacteria), has external and internal causes. Internal causes include stomach acid contact with the tooth, as in GERD. Extrinsic sources of dental erosion include excessive consumption of acid-containing drinks, beverages, foods, and acidic medicines [6]. A drug's erosive potential depends on its titratable acidity, pH, and pKa. Acidic formulations are often needed for effective dispersal, reactions, stability, compatibility, and taste [7,12]. Frequent ingestion (more than twice daily), night time or between-meal consumption, high viscosity, and reduced saliva flow can increase medication-induced dental erosion [1,13,14].

Certain in vitro studies have shown that drugs may disrupt the structure and hardness of enamel [12,14]. However, the literature lacks research examining how medications affect primary tooth enamel, and the results of these investigations are restricted to a limited number of drugs [15]. According to some authors [5,8], the difference in erosion between primary and permanent teeth is due to differences in their morphology. Nevertheless, there is still debate regarding the vulnerability of primary teeth to both caries and erosion compared to permanent teeth [14].

To address the lack of thorough research on paediatric medication effects on primary teeth, a systematic literature review was conducted to summarise and evaluate these effects.

MATERIALS AND METHODS

This review was conducted in compliance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) statement. An extensive search of electronic databases was conducted covering January 2000 to December 2023.

Data Items

The aim of this review was to assess the effect of various paediatric liquid medications on primary teeth. The research question in PICOS format was: "What are the adverse effects of various paediatric

liquid medications on primary teeth?" The PICOS criteria were as follows:

P (Participants/Population): Primary teeth exposed to drugs;

I (Intervention) E (Exposure): Drugs to which participants were exposed

C (Comparison): Comparators were the control groups of each study

O (Outcome): To assess and evaluate the effect and impact of various paediatric drugs on primary teeth

S (Study Design): In-vitro studies

Inclusion criteria:

- Articles in English language;
- Articles with adequate information on adverse effects of paediatric drugs on primary teeth
- Studies published from 2000 to 2023
- Study design: in vitro studies or comparative studies
- Studies involving assessment of outcomes in the primary dentition.

Exclusion criteria:

- Articles not in English
- Studies conducted before 2000
- Abstracts, reviews, and systematic reviews
- Studies assessing outcomes only in permanent dentition.

Data Extraction

Data extraction was performed independently by two reviewers. After extraction, the reviewers compared their results and resolved any discrepancies through discussion or consultation with a third reviewer when needed. The following variables were included: author(s), year of study, sample size, control group, drugs intervened, drugs' pH range, contact time with the drug, intervention assessment, and author conclusions.

Information Sources and Search Strategy

A thorough electronic search was performed for studies published in the last 23 years using PubMed, Google Scholar, EBSCOhost, and Web of Science. A manual search of specialty journals including the Journal of Indian Society of Pedodontics and Preventive Dentistry, International Journal of Paediatric Dentistry, International Journal of Clinical Paediatric Dentistry, International Journal of Contemporary Paediatrics, and the European Journal of Paediatric Dentistry was performed. Specialised gray literature databases were searched, including OpenGrey, Grey Literature Report, and GreyLit.org. Using appropriate keywords, Boolean operators, and MeSH terms, the search was performed. Following are keywords and their combinations:

((((((((((((((((((((primary teeth) OR (deciduous teeth)) OR (milk teeth)) OR (child teeth)) AND (paediatric drugs)) OR (paediatric liquid medication)) OR (paediatric syrups)) OR (paediatric medications)) OR (over the counter paediatric medicines)) OR (paediatric oral suspension)) AND (staining)) OR (discolouration)) AND (dental erosion)) OR (enamel loss)) OR (enamel microhardness)) OR (enamel roughness)) OR (enamel mineral loss)) OR (enamel defects)) AND (dental caries)) OR (tooth decay)) OR (tooth cavity)) OR (tooth deterioration), effect of paediatric drugs on primary teeth (MeSH Terms), ((effect of paediatric drugs on primary teeth (MeSH Terms)) OR (enamel loss due to paediatric drugs (MeSH Terms))) OR (tooth discolouration due to syrups (MeSH Terms)), (((enamel loss due to drugs (MeSH Terms))) OR (dental erosion due to syrups (MeSH Terms))) OR (tooth discolouration due to paediatric syrups (MeSH Terms)), (((((((paediatric liquid medication) OR (paediatric syrups)) OR (paediatric drops)) OR (paediatric medicine)) OR (paediatric drugs)) AND (tooth caries)) OR (cariogenic potential)) OR (tooth decay)) OR (teeth cavities).

Additionally, hand-searching was performed by screening reference lists of relevant articles, reviews, and systematic reviews to identify additional sources.

Selection Process

A two-phase selection of articles was performed. In the first phase, studies were evaluated for relevance to the research question or objective of the review and assessed against predefined inclusion and exclusion criteria. Studies that did not meet the criteria were excluded at this stage, while those that appeared relevant or required further assessment proceeded to the second phase. In the second phase, reviewers retrieved and reviewed the full texts of studies that passed the initial title and abstract screening. Each full text was carefully examined to determine its eligibility for inclusion in the review based on the predefined criteria. Studies meeting the criteria were included in the review, while those that did not meet the criteria were excluded.

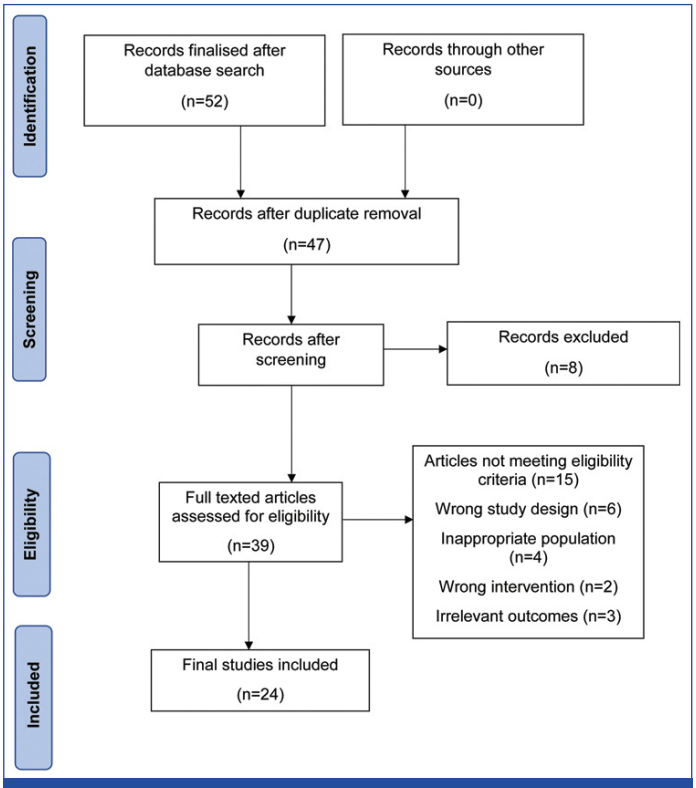
Assessment of Methodological Quality

Quality assessment of included studies was conducted using the QUIN tool [16-18]. The tool was evaluated using content validity and reliability testing methods. This tool includes 12 criteria with scoring and grading options. The QUIN tool comprises three scores, with a maximum score of two indicating adequately specified data, a score of 1 indicating inadequately specified data, and a score of 0 indicating data not specified. The formula used to estimate ROB was: ROB=Final score=(Total score×100)/(Number of applicable criteria×2). If the overall score is above 70%, the study is regarded as having a low risk of bias; scores between 50% and 70% indicate a moderate risk, and scores below 50% signify a high risk of bias [18].

RESULTS

Study Selection

A total of 47 articles were screened after duplicates were removed. Of these, eight articles were excluded due to non relevance to the topic, conference abstracts, or insufficient data. A total of 39 articles were assessed for eligibility. Articles not meeting eligibility criteria were excluded (n=15). A total of 24 studies met the eligibility criteria and were included in this review [3,19-41]. The flow chart is shown in [Table/Fig-1].



[Table/Fig-1]: PRISMA flow chart.

Characteristics of Eligible Studies

Characteristics of the included studies are shown in [Table/Fig-2] [3,19-41]. All studies were performed on human teeth and analysed the effects of paediatric drugs on human primary teeth. Assessment of the effects was measured in terms of tooth mineral loss, changes in enamel microhardness, dental erosion, and tooth discolouration.

S. No.	Author (year)	Sample size	Control	Drugs	pH	Time	Intervention assessment	Authors conclusion
1.	KL Girish Babu et al., [19] (2008)	27	Artificial saliva	8 PLM Analgesic Antibiotic Anti-asthmatic Multivitamins	6.05 to 6.77	1 min, 10 mins, and 8 hours	Primary enamel surface changes under SEM	Erosion of primary enamel occurs regardless of pH.
2.	Soares DN et al., [20] (2013)	25	Positive control=10% sucrose Negative control=area covered with nail varnish	3 PLM Antihistamine Antibiotic	2.70 to 5.04	Daily 1 min for 1 week	Cross-sectional enamel hardness using micro durometer	All medications caused high mineral loss. Lowest-pH antihistamines caused the greatest hardness loss.
3.	Scatena C et al., [22] (2014)	60	Artificial saliva	3 medications Guaifenesin; Ferrous Sulfate; Salbutamol Sulfate	3.64 to 7.0	1-minute agitation, thrice daily, for 28 days	Enamel microhardness by SEM	Primary enamel erosion depended on medication type and exposure time.
4.	Tupalli AR et al., [23] (2014)	33	Artificial saliva	10 PLMS Analgesics Antibiotic Anti-epileptic Multivitamin Antitussive	4.3 to 7.3	1 minute, 10 minutes and 8 hours	Primary enamel surface changes under the SEM	Erosive effect on the primary enamel surface.
5.	Kiran K et al., [21] (2015)	Not mentioned	Not mentioned	17 paediatric Syrups Antibiotics, Analgesics, Antihistamines, Antitussive, Anti-asthmatics, Anti-epileptics, Anti-diarrhoeals, Appetisers, Calcium supplement, Iron supplement, Multivitamin	3.53 to 8.12	10 minutes, 1 hour and 8 hours	Enamel loss (optical 3D profilometer)	Lowest-pH Api caused the most enamel loss; highest-pH Azee, the least. Inherent pH is the key erosion factor.
6.	Mali G et al., [24] (2015)	40	Artificial saliva	4 paediatric Syrup M solvin, Syrup Trustyl M, Althrocin liquid, Syrup Zukamin	5.77 to 6.4	1 min thrice daily for 14 days	Enamel surface microhardness using Vickers hardness testing machine	Sugar-free paediatric medications can reduce dental erosion.
7.	Pasdar N et al., [25] (2015)	40	Not mentioned	4 drugs Iron drop Multivitamin drop	2.1 to 3.36	5 min	Surface microhardness was measured using Vickers microhardness tester machine. The surface structure of the teeth by SEM	All drugs caused erosion-most with Kharazmi iron drops, least with Eurovit multivitamins.
8.	Kulkarni P et al., [26] (2016)	60	Artificial saliva	3 Ferium XT, Crocin Syrup, Wikoryl	Low pH, value not mentioned	1-min agitation in 5 mL, thrice daily (6-h intervals), for 7, 14, 21, and 28 days	Surface microhardness using the universal microhardness machine	Anti-tussives caused significant, gradual surface microhardness loss throughout the study.
9.	Cheun SK et al., [27] (2016)	20 (96 pieces)	Distilled water	3 kinds of Analgesics and Antipyretic drugs	4.15±0.00 to 6.89±0.02	During 8 days, 4 times a day, 20 minutes for each session	Microhardness on the surface of primary teeth's enamel 2. Quantitative analysis of Calcium (Ca) and Phosphorus (P) using Energy Dispersive X-ray Spectroscopy (EDS or EDX)	Lowest-pH medicine (Tylenol tablet) caused the roughest surface, followed by Brufen syrup and Tylenol suspension.
10.	Venkataraghavan K et al., [28] (2017)	39	Artificial saliva	Four PLMS Allopathic (Benadryl), Ayurvedic (Adusol), Unani (Saduri), and Homeopathic (Stodal)	3.73 to 4.84	1 minute, 10 minutes, and 8 hours	Primary enamel surface changes by SEM. Calcium dissolution potential by atomic absorption spectrophotometry	All PLMS eroded primary enamel, with Unani medicine Saduri causing the most erosion.
11.	Zhao D et al., [29] (2017)	20	Deionised water	Five groups Paracetamol (Jean-Marie Paracetamol syrup, Uni-Febrin syrup), Chlorpheniramine (Jean-Marie Chlorpheniramine syrup, Allerief syrup)	4.97 to 7.17	15 s, twenty cycles of immersion	Hardness measurements, SEM, and EDS evaluated tooth block surface morphology and chemistry	Paediatric Over-the-counter (OTC) oral liquids can significantly soften enamel, increasing caries susceptibility.
12.	Dhawan L et al., [30] (2017)	20	Artificial saliva	4 groups Ferium XT, Crocin syrup, Wikoryl syrup	Not mentioned	Immersed in 5 mL of each syrup for 1 min, thrice daily (6-h intervals).	Surface microhardness measured using a universal microhardness machine at 7, 14, 21, and 28 days.	Antitussive syrup (Ascoril-D) had the highest erosive potential

13.	Mahmoud E et al., [31] (2018)	50	Artificial Saliva	8 different PLMS Analgesics, Antipyretics, Antibiotics, Antitussive drugs, Nutritional supplements	3.47 to 6.92	3, 5, and 8 days, 20 min for each session	Enamel erosion by SEM; Ca/P content by EDX	Multivitamins cause more severe enamel irregularities than analgesics and antibiotics. Ca/P loss was greatest with antibiotics and multivitamins.
14.	Hekmatfar S et al., [32] (2018)	40	Not mentioned/not required	5 types of iron supplement Ferrous sulfate iron drops, Ferbolin iron drops, Feriron iron drops Irovit iron drops, FerroKids iron drops	1.882 to 2.378	1 mL iron drops: 3-min exposure, transfer to fresh drops, dilution, washing, and 24-h immersion in 2M HCl	Level of iron absorption atomic absorption	All drops have acidic content that increases their potential for erosion.
15.	Feroz S et al., [33] (2018)	60	Deionised water	3 groups Paracetamol, Chlorpheniramine	2.43 to 7.09	Twenty cycles of 15 seconds of immersion at 6 hours interval	Surface roughness evaluation by Atomic Force Microscopy	Paediatric oral liquids increase surface roughness; both sugar-free and sugar-containing types cause erosion, but sugar-free options cause less roughness.
16.	Vakil N et al., [34] (2019)	30	Artificial saliva	2 groups Ferium XT, Crocin syrup	Not mentioned	1 min in 5 mL of each medication, under agitation, three times daily with 6-h intervals	Surface microhardness at 2, 3, and 4 weeks using the universal microhardness machine	Medicinal syrups can erode primary enamel with repeated exposure.
17.	Singh RK et al., [35] (2019)	27	Artificial saliva	8 drugs Analgesics, Antibiotics, Antihistamines, Multivitamins	4.49 to 5.56	1 minute and 10 minutes of time intervals	Assessment of enamel erosion under SEM	Most medicaments etched primary teeth, creating prism patterns and craters.
18.	Thilak N et al., [36] (2020)	40	Distilled water	4 groups Mefenamic acid syrup (Meftal P), Cetirizine syrup (Alerid), Multivitamin syrup (Zincovit)	4.2 to 5.2	1 minute, In group a, the samples were dipped twice daily, in group b and c, the samples were dipped once daily for 14 days	Assessment of enamel surface microhardness using Vickers hardness tester	Microhardness loss was greatest for Meftal P, followed by Alerid, and least for Zincovit. All syrups caused microhardness loss after 14 days.
19.	Babaei N et al., [37] (2021)	60	Artificial saliva	Five types of iron drops Feroglobin® drops, Liposofer® drops, Ferrous sulfate Behsa®, Ferbolin® oral drops	2.54-4.68	Before immersion, and after 1st week, 2nd week	Colour and colour difference by VİTA Easyshade Compact	Iron drops displayed low pH and discolouration.
20.	Nabaa Samir Taha et al., [38] (2021)	64	Not mentioned	2 drugs Salbutamol syrup, Paracetamol syrup	Not mentioned	1 min, 3 times daily for 14 days	Enamel surface microhardness using Vickers hardness test	Salbutamol showed higher erosion than compared with Paracetamol.
21.	Yılmaz N et al., [3] (2022)	84	Electrolyte solution	11 different solutions Antibiotics, Anti-epileptics, Multivitamins, Analgesics, Anxiolytics, Bronchodilators, Sympathomimetics, Oral rinse, Electrolyte solution	2.76 to 6.62	1 min at 8-hour intervals for 1 week	Colour change (ΔE*) values were calculated according to the CIELab system	Systemic or local use of paediatric drugs can cause erosion, caries, and discolouration due to factors like pH, acidity, and viscosity.
22.	Rocha CT et al., [39] (2022)	60	Negative control (distilled water)	Four analgesics (Dalsy®, Magnopyrol®, Paracetamol and tylenol®)	3.89 to 5.29	5 mL of each group solution for 30 min, 4x/day for three days and stored in artificial saliva at 37°c Between immersions and at night	Surface Microhardness Analysis, pH, Titrable acidity	Magnopyrol caused greater enamel softening. Paracetamol caused morphological changes in primary enamel.
23.	Mahmoud N et al., [40] (2022)	80	Artificial saliva	3 medications Depakine syrup, Ventolin syrup, Sansovit syrup	4.2 to 6.8	1 minute 3 times/daily with 6-h separations between for 28 days	Enamel microhardness under SEM	Highest decrease of enamel hardness with drug with lowest pH for primary teeth.

24.	Mukundan D et al., [41] (2023)	80	Distilled water	3 paediatric syrups Multivitamin syrup (Rudimin), Iron syrup (C Pink), Diuretic syrup (Furosemide)	Not mentioned	Once daily for 5 minutes for 21 days	Microhardness (Vickers hardness testing) Roughness (Mitutoyo surface roughness tester) Staining (spectrophotometry)	Paediatric syrups weaken primary tooth enamel and make them vulnerable to caries.

[Table/Fig-2]: Characteristics of included study [3,19-41].

Assessment of Risk of Bias [Table/Fig-3]

The ROB formula was:

ROB=Final score=(Total score×100)/(Number of applicable criteria×2)

Twelve studies [3,21,22,24,25,29,32,33,36,37,39,41] had a low risk of bias, and twelve studies [19,20,23,26-28,30,31,34,35,38,40] had a moderate risk of bias. If the overall score is above 70%, the study is regarded as having a low risk of bias; scores between 50% and 70% indicate a moderate risk, and scores below 50% signify a high risk of bias. The most common risk-of-bias factors were sample size calculation, sampling technique, and allocation concealment. All studies in this systematic review were at moderate to low risk of bias. The overall quality of the studies was high to moderate, denoting clear study design and methods, transparent and pre-specified protocols for high-quality studies, and reasonably defined study designs with moderate protocol clarity for medium-quality studies.

DISCUSSION

Children require specialised medication dosages and formulations due to their unique physiology. Liquid medications are essential for children who cannot swallow pills, offering advantages such as

S. No.	Article	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	FS	%ROB	ROB
1.	KL Girish Babu et al., [19] (2008)	2	0	0	2	2	N/A	0	2	N/A	N/A	N/A	2	10	62.5	MR
2.	Soares DN et al., [20] (2013)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
3.	Scatena C et al., [22] (2014)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
4.	Tupalli AR et al., [23] (2014)	2	0	0	2	2	N/A	0	2	N/A	N/A	N/A	2	10	62.5	MR
5.	Kiran K et al., [21] (2015)	2	0	2	1	2	N/A	0	2	N/A	N/A	2	2	13	72.22	LR
6.	Mali G et al., [24] (2015)	2	0	2	2	2	N/A	2	2	N/A	N/A	2	2	16	88.89	LR
7.	Pasdar N et al., [25] (2015)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
8.	Kulkarni P et al., [26] (2016)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
9.	Cheun S-K et al., [27] (2016)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
10.	Venkataraghavan K et al., [28] (2017)	2	0	0	1	2	N/A	0	2	N/A	N/A	2	2	11	61.11	MR
11.	Zhao D et al., [29] (2017)	2	0	2	2	2	N/A	2	2	N/A	N/A	2	2	16	88.89	LR
12.	Dhawan L et al., [30] (2017)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
13.	Mahmoud E et al., [31] (2018)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
14.	Somayeh Hekmatfar (2018) [32]	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
15.	Feroz S et al., [33] (2018)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
16.	Vakil N et al., [34] (2019)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
17.	Singh RK et al., [35] (2019)	2	0	0	2	2	N/A	0	2	N/A	N/A	N/A	2	10	62.5	MR
18.	Thilak N et al., [36] (2020)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
19.	Babaei N et al., [37] (2021)	2	0	0	2	2	N/A	2	2	N/A	N/A	2	2	14	77.78	LR
20.	Nabaa Samir Taha et al., [38] (2021)	2	0	0	0	2	N/A	0	2	N/A	N/A	2	2	10	62.5	MR
21.	Yılmaz N et al., [3] (2022)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
22.	Rocha CT et al., (2022)[39]	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR
23.	Mahmoud N et al., [40] (2022)	2	0	0	2	2	N/A	0	2	N/A	N/A	2	2	12	66.67	MR
24.	Mukundan D et al., [41] (2023)	2	0	2	2	2	N/A	0	2	N/A	N/A	2	2	14	77.78	LR

[Table/Fig-3]: Assessment of Risk of Bias [3,19-41].
Score 0-Not specified, score 1-Inadequately specified, score 2-Adequately specified. HR: High-risk; MR: Medium-risk; LR: Low-risk

ease of administration, accurate and individualised dosing, rapid absorption, flexible formulations, and specialised compounding. Certain medications, including paediatric drugs and syrups, can adversely affect primary teeth [42]. Parents and professionals must be aware of potential side effects of children's medications, such as dental discoloration, erosion, roughness, and mineral loss. Due to a lack of thorough research on these effects on primary teeth, a systematic review was conducted.

Dental erosion is the gradual, permanent, non-bacterial destruction of tooth structure by acids. Contributing factors include acidic foods and drinks, Gastric Esophageal Reflex Disease (GERD), eating disorders, environmental factors, and medications. Dental erosion has long been identified as a major contributing cause to the loss of tooth structure in children and adolescents, as well as in adults [43-45]. The prevalence of erosion in children ranges from 10 to 80% [46]. Erosion is more common in primary teeth due to histological differences. Frequent syrup use for illnesses can contribute to erosion. Paediatric drug effects on deciduous teeth depend on factors such as pH, viscosity, titratable acidity, sugar content, and contact duration. The acidic nature of medications is an extrinsic source of dental erosion, because weak acids and bases have different solubilities at different pH values, acidic preparations are frequently required to facilitate dispersion of the medication [4]. The acidic nature also improves patient compliance and palatability of the drug formulations [47]. Drug pH varies and is important for formulation and delivery [48]. The optimal drug pH is typically 3-9 for stability and effectiveness [49]. Enamel demineralisation occurs below pH 5.5 [50]. This review found eight studies involving drugs in this critical pH range [20,25,28,32,35-37,39]. The category of drugs with lower pH includes antitussives (e.g., Ascoril-D), analgesics, antipyretics, and some homeopathic medicines such as Saduri [19,21,27,28]. The study by Cheun SK et al., reported that medications with the lowest pH cause the roughest enamel surface [27]. The study by Kiran K et al., stated that inherent pH is the most critical factor for erosion: lower pH causes greater enamel loss, whereas higher pH causes less [21]. Similar findings were seen in the study by Venkatraghavan K, which found that Saduri, having the lowest pH, causes maximum erosion [28]. However, a study by Girish Babu K et al., stated that paediatric liquid medications cause primary enamel erosion regardless of pH [19]. Tooth discoloration or staining is a common concern. Discoloration can be intrinsic or extrinsic and is linked to various systemic or local factors, among other causes [51]. Commonly associated with extrinsic tooth discoloration are iron drops, chlorhexidine, and mouth rinses containing copper salts. The studies by Yılmaz N et al., and Babaei N et al., evaluated color changes due to paediatric liquid iron drop medications [8,37]. The physicochemical properties of some medications, such as iron drops, affect the color of primary teeth. Highly viscous medications adhere to teeth longer, prolonging their presence in the oral cavity [52,53]. As primary teeth are less mineralised than permanent teeth, they are more prone to erosion and staining.

To make paediatric liquid medications more palatable, sugar has been extensively added to them [47]. Sucrose emerged as the most frequently utilised sugar [54]. Most medicines contain fermentable carbohydrates such as sucrose, fructose, and glucose [55]. Among these, sucrose is the most cariogenic [56]. Because of sucrose, paediatric medications have caries-promoting potential [57,58]. Antibiotics, analgesics, and cough syrups stand out as the predominant sugar-containing medications prescribed for children. Even sugar-free medications, due to their acidic nature, can cause dental erosion. This systematic review documents the adverse effects of paediatric drug formulations on primary teeth. The strengths of this systematic review include strict adherence to PRISMA guidelines, a comprehensive search across unrestricted literature, adoption of rigorous methods for qualitative data synthesis, and evaluation of evidence quality through the utilisation of the QUIN tool. Future research should prioritise robust designs with larger samples, well-defined controls, detailed methodology, and careful consideration of specific formulations.

Limitation(s)

The search strategy excluded non-english studies and unpublished data, potentially overlooking relevant evidence. This review focuses solely on in vitro studies due to ethical concerns about deliberately exposing children to medications known or suspected to have adverse effects on primary teeth. The included studies showed considerable variation in design, with differences in sample sizes and methodological limitations, such as the absence of randomisation, blinding, or comparator arms, which may have introduced biases and reduced the generalisability of the findings. Additionally, variability in the measurement of enamel erosion, surface roughness, and discolouration, along with short study periods and a predominant focus on liquid formulations, further restricts comparability and the understanding of long-term effects.

CONCLUSION(S)

The present systematic review confirmed that paediatric liquid medications pose significant risks to primary dentition through erosive and cariogenic mechanisms. The evidence demonstrates consistent patterns of enamel erosion, alterations in surface properties, and discolouration across multiple medication categories. The findings emphasise the need for healthcare providers to consider the oral health implications when prescribing liquid medications for children, particularly for chronic conditions requiring long-term administration. To mitigate these adverse effects, it is strongly recommended that preventive strategies, including fluoride application, proper oral hygiene practices after medication administration, and consideration of sugar-free alternatives when available, be implemented. Future research should focus on developing less erosive and non-cariogenic medication formulations that maintain therapeutic efficacy while minimising oral health risks.

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