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Microplastics and Pediatric Oral Health: An Emerging Concern

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Abstract
Objective: *To review the available evidence regarding exposure to microplastics and nanoplastics relevant to children and to evaluate their potential effects on the oral environment, including saliva, oral tissues, gingival cells, dental biofilms, and dental healthcare products.*
Methodology: *A literature search was undertaken of the published literature over the last 10 years, from January 2017 to August 2026. Studies investigating microplastic or nanoplastic exposure relevant to the oral cavity, pediatric populations, oral healthcare products, dental materials, or biological effects on oral tissues were considered. Human observational studies, in-vitro studies, and experimental studies were included. Reviews, editorials, commentaries, and studies unrelated to oral exposure or oral tissues were excluded. Due to substantial heterogeneity in populations, exposure sources, particle characteristics, analytical methods, and outcomes, a narrative synthesis of the available evidence was undertaken.*
Results: *The available evidence indicates that children may encounter micro- and nanoplastics through oral behaviours and environmental sources. Microplastic particles have been identified in saliva and on the hands of young children, and nanosized plastic particles have been detected in saliva following interaction with plastic objects. Microplastics or polymer signatures have also been reported in oral healthcare products, including toothbrushes, toothpastes, mouthwash, dental floss, and toothpowder. Experimental studies indicate that selected microplastics can be internalized by human gingival fibroblasts and may induce cellular stress, inflammatory signalling, apoptosis, and altered cellular migration. Microplastics have also been identified in human dental calculus. However, direct clinical evidence linking microplastic exposure with dental caries, periodontal disease, gingivitis, enamel defects, or other pediatric oral diseases remains insufficient.*
Conclusion: *Microplastics represent an emerging environmental exposure of potential relevance to pediatric oral health. Current evidence demonstrates exposure and biological plausibility but does not establish causation between pediatric oral disease and microplastic exposure. Standardized pediatric studies, oral microbiome investigations, longitudinal cohorts, and clinically relevant exposure-response studies are required.*
Keywords: *children; microplastics; nanoplastics; dental caries; gingiva; oral health; oral microbiome; pediatric dentistry; saliva.*

I. INTRODUCTION

Modern life has been transformed by plastics. Its versatility, durability, low cost, and resistance to degradation have resulted in extensive use in food packaging, toys, textiles, household products, healthcare products, and dental materials. The same characteristics that make plastic useful, however, also contribute to its persistence in the environment. Nanoplastics (NPs) are commonly described as particles below 1 μm and microplastics (MPs) are generally defined as plastic particles smaller than 5 mm[1]. These particles may be intentionally manufactured at small dimensions or may arise secondarily through fragmentation, degradation and mechanical wear of larger plastic materials. They are now detected in water, household dust, food, air and an increasing number of human biological samples.[2]

Human exposure may occur through inhalation, ingestion and dermal contact. The discovery of plastic particles in human tissues has intensified interest in their potential biological effects, including inflammation, oxidative stress, cellular dysfunction, and interference with biological barriers.[3] However, the extent to which these experimental observations translate into clinically meaningful disease remains uncertain.

Children may represent a particularly important population in this context. Their higher intake relative to body mass, developing organs and immune systems, frequent hand-to-mouth behaviour, and interaction with plastic toys and household products may increase opportunities for exposure.[4] A recent review of micro- and nanoplastics in children's health emphasized the potential vulnerability of early life to repeated exposure, while also highlighting major gaps in evidence regarding long-term clinical consequences.[5]

The oral cavity deserves particular consideration because it is both a biologically active interface and a major route of exposure. Materials entering through ingestion encounter saliva, dental biofilms, oral mucosa gingival tissues, and resident microorganisms before reaching the gastrointestinal tract. Microplastics may also enter the oral environment through toothbrushes, toothpastes, orthodontic appliances, restorative materials, dental floss, mouthwash and other polymer-containing dental products.[6]

Recent evidence has begun to move the subject from theoretical concern toward direct observation. Microplastics have been identified in saliva and on the hands of young children,[7] and a recent study of children aged 4–6 years detected nanosized plastic particles in saliva following interaction with plastic items.[8] Microplastics have also been identified in human dental calculus, with experimental evidence suggesting cytotoxic and inflammatory effects on human gingival fibroblasts.[9] Nevertheless, the presence of microplastics in the oral environment does not necessarily mean that they cause dental disease. The distinction between exposure, biological plausibility, and clinically demonstrated harm is critical.

Therefore, the present narrative review aimed to synthesize the current evidence regarding microplastic and nanoplastic exposure relevant to pediatric oral health and to evaluate the available evidence concerning their potential effects on oral tissues, saliva, oral microorganisms, and dental healthcare products. The discussion emphasizes the distinction between demonstrated exposure, biological plausibility, and clinically established disease.

NARRATIVE SYNTHESIS OF THE EVIDENCE

1. Microplastics in children

Evidence directly involving children is particularly important.

Amiri et al. evaluated 100 children aged 3–6 years attending kindergartens in Iran and examined microplastics in saliva and on the hands. A total of 716 microplastic particles were identified, with most particles smaller than 100 μm. Micro-Raman spectroscopy identified nylon, polystyrene and low-density polyethylene among the analysed particles. The investigators also reported increases in microplastic numbers in saliva and on hands after kindergarten exposure.[7]

Jalan and Ramesh evaluated 31 children aged 4–6 years and investigated nanosized plastics in saliva following interaction with plastic objects. Scanning electron microscopy, Fourier-transform infrared spectroscopy, and X-ray diffraction were used. Nanosized plastic particles were detected in all saliva samples, with polypropylene, polyethylene and polyvinyl chloride reported among the predominant materials.[8]

These studies provide an important shift in the literature: micro- and nanosized plastic particles are not merely theoretical contaminants to which children may be exposed; they have been detected in biological material from children. However, detection does not demonstrate toxicity or disease. Neither study established that the detected particles caused dental caries, periodontal disease, gingivitis or developmental abnormalities.

Evidence from pediatric human studies: Amiri et al. and Jalan and Ramesh reported micro- or nanosized plastic particles in samples from children. These studies establish exposure but do not demonstrate clinical oral disease.

Evidence from human oral tissue and experimental models: Wu et al. identified microplastics in human dental calculus and assessed polyethylene micro- and nanoplastics in gingival fibroblasts. Caputi et al. and Di Cintio et al. investigated cellular responses in in-vitro models. These experimental findings should be distinguished from pediatric clinical evidence.

2. Microplastics in Oral Healthcare Products

Oral healthcare products represent a particularly relevant source of potential exposure because they are used directly and repeatedly within the oral cavity.

Protyusha et al. investigated toothpastes, toothbrushes, toothpowder, mouthwash, dental floss, and mouth-freshener sprays distributed in India. Microplastics were detected in all categories examined. Toothbrushes demonstrated the highest reported particle counts, while multiple polymers—including polyethylene, polyamide, polyethylene terephthalate, and polybutylene terephthalate—were identified.[6] The investigators estimated substantial potential community-level emissions and individual annual exposure. These estimates, however, represent particle release rather than absorbed biological dose and should therefore not be interpreted as evidence of clinical toxicity.

An earlier Indian study examining ten commercial toothpastes reported microplastic concentrations ranging from 0.2% to 0.9% by weight and identified cellophane, polypropylene, polyvinyl chloride, and polyamide.[10] More recently, Chengappa et al. examined 20 commercially available Indian toothpastes using FTIR-ATR. Polyamide, polyethylene, and polypropylene signatures were identified in all 20 samples.[11]

The repeated identification of plastic particles or polymer signatures in oral-care products is relevant to pediatric dentistry because children may use toothbrushes and toothpaste daily for many years. Nevertheless, the presence of polymeric particles within a product should not automatically be equated with a clinically harmful exposure.

The particle size, bioavailability, quantity, polymer chemistry, additives, exposure duration, and ability to cross biological barriers are all relevant.

3. Microplastics and gingival cells

The biological effects of microplastics on gingival cells are an emerging area of research.

Caputi et al. investigated the effects of environmental microplastics on human gingival fibroblasts and reported activation of inflammatory pathways following exposure.[12] Di Cintio et al. subsequently demonstrated that polystyrene microplastics could be internalized by human gingival fibroblasts. Their proteomic analysis identified changes involving cellular pathways related to motility, inflammation, metabolism, and survival.[13]

These findings suggest that oral connective-tissue cells are biologically capable of interacting with microplastic particles. However, most importantly, these experiments were performed under controlled laboratory conditions. The concentrations and exposure periods cannot simply be extrapolated to routine exposure in children. Therefore, the findings establish biological plausibility rather than clinical causation.

4. Microplastics in Human Dental Calculus

A recent development in this field was the identification of micro- and nanoplastics in human dental calculus.

Wu et al. detected 26 types of microplastics in human dental calculus. Polyethylene, polyamide and polyurethane were among the predominant polymers. In-vitro exposure of human gingival fibroblasts to polyethylene micro- and nanoplastics was associated with reduced cell viability, impaired cell migration, apoptosis, and activation of NF-κB-associated inflammatory signalling, including increased expression of IL-1β and IL-6.[9] However, these experimental findings cannot be directly extrapolated to real-world exposure conditions in children.

This finding is particularly relevant to periodontology because dental calculus represents a persistent mineralized oral biofilm environment. However, the study didn't demonstrate that microplastics caused periodontitis in humans. The presence of microplastics within calculus could reflect environmental exposure, retention within biofilm, product exposure, or incorporation during mineralization. Whether this accumulation is biologically important remains to be established.

5. Microplastic release from dental materials

Dental treatment itself may represent another potential source of microplastic exposure.

Quinzi et al. demonstrated the release of microplastics from clear orthodontic aligners after seven days of exposure to artificial saliva with simulated mechanical friction. Raman microspectroscopy and scanning electron microscopy identified particles predominantly in the 5–20 μm range, with differences among aligner types.[14]

A subsequent study examining microplastic release during dental procedures and denture wear reported that denture-related processes could release particles into artificial saliva and that grinding of resin-based materials generated airborne or deposited particles. The study also reported oxidative and inflammatory effects in cellular models.[15]

These findings are relevant to pediatric dentistry because children and adolescents increasingly receive orthodontic appliances and polymer-based dental materials. However, evidence regarding actual intraoral exposure during routine pediatric use remains insufficient.

Author/year	Study design	Population/model	Exposure/source	Particle/ polymer	Main finding	Clinical relevance/ limitation
Amiri et al., 2025	Pediatric observational	100 children aged 3–6 years	Saliva and hands	Nylon, polystyrene, low-density polyethylene	Microplastics detected; 716 particles reported	Demonstrates exposure; no clinical disease outcome assessed
Jalan and Ramesh, 2025	Pediatric observational/experimental exposure	31 children aged 4–6 years	Saliva after interaction with plastic items	Polypropylene, polyethylene, polyvinyl chloride reported	Nanosized plastic particles detected in saliva samples	Demonstrates potential exposure; no clinical disease outcome assessed
Wu et al., 2025	Human oral tissue study and in-vitro experiment	Human dental calculus; human gingival fibroblasts	Dental calculus; experimental cell exposure	Polyamide, polyethylene, polyurethane in calculus; polyethylene MNPs in cell model	Particles identified in calculus; experimental exposure associated with reduced viability, impaired migration, apoptosis and inflammatory signalling	Human tissue detection and cell effects do not establish pediatric disease causation

Caputi et al., 2022	In-vitro cellular study	Human gingival fibroblasts	Environmental microplastics	Microplastics; polymer details should be checked in original article	Inflammatory pathway effects reported	Laboratory model; real-world pediatric exposure relevance uncertain
Di Cintio et al., 2025	In-vitro cellular study	Human gingival fibroblasts	Experimental exposure	Polystyrene microplastics	Cellular uptake and molecular changes; limited cytotoxicity and altered cellular pathways reported	Experimental findings cannot be directly extrapolated to children
Protyusha et al., 2024	Product-analysis study	Commercial oral healthcare products	Toothbrushes, toothpaste, toothpowder, mouthwash, floss, sprays	Polyethylene, polyamide, PET, PBT and other reported polymers	Microplastics detected across examined product categories	Indicates a potential source of exposure; absorbed dose and clinical effects not established
Madhumitha et al., 2022	Product-analysis study	10 commercial toothpastes	Toothpaste	Cellophane, polypropylene, PVC, polyamide	Particles reported at 0.2–0.9% by weight	Product detection does not establish biological dose or toxicity
Chengappa et al., 2026	In-vitro/product analysis	20 commercially available Indian toothpastes	Toothpaste	Polyamide, polyethylene, polypropylene signatures	Polymer signatures identified in all 20 samples	Product analysis; clinical outcomes not assessed
Quinzi et al., 2023	In-vitro material-release study	Clear orthodontic aligners	Artificial saliva with simulated mechanical friction	Particles predominantly 5–20 µm; polymer details depend on aligner	Microplastic release reported after seven days	Artificial conditions; pediatric intraoral dose and clinical effects uncertain
Chen et al., 2025	Experimental dental-material study	Denture wear/cleaning and resin grinding models	Artificial saliva and dental procedures/material processing	Microplastics released from dental materials	Particle release and cellular inflammatory effects reported	Exposure model does not establish disease risk in pediatric patients

II. DISCUSSION

The present review highlights an emerging but incompletely understood relationship between microplastic exposure and pediatric oral health.

The evidence can currently be divided into three levels:

1. Demonstrated exposure

Microplastics have been detected in oral healthcare products and in saliva from children.[6–8] The detection of particles in children's saliva demonstrates that exposure can reach the oral biological environment. However, detection demonstrates the presence of particles and does not, by itself, establish biologically relevant dose or toxicity.

2. Biological interaction is plausible

Microplastics have been detected in human dental calculus, and experimental studies demonstrate cellular internalization and inflammatory responses in gingival fibroblasts.[9,12,13] These findings demonstrate biological plausibility but do not establish comparable effects at real-world exposure levels in children.

3. Clinical disease association remains unproven

There is currently insufficient evidence to conclude that microplastics cause dental caries, periodontitis, gingivitis, enamel defects, or impaired dental development.

Much of the available biological evidence derives from adult tissues, in-vitro models, or dental-material studies rather than pediatric clinical populations. Therefore, extrapolation to children should be undertaken cautiously.

This third point should remain central to the interpretation of the literature.

Implications for pediatric periodontal health

From a periodontal perspective, a potentially relevant mechanism is chronic low-grade interaction between retained plastic particles, gingival tissues, dental biofilm and host inflammatory pathways.

The oral cavity contains a highly diverse microbial ecosystem. Dental plaque is a structured biofilm in which microbial communities interact with host tissues and dietary substrates.

Microplastics may theoretically influence this environment by:

- providing surfaces for microbial attachment;
- altering biofilm architecture;
- carrying adsorbed environmental contaminants;
- interacting with salivary proteins;
- inducing oxidative stress in resident cells; and
- modifying inflammatory signalling.

However, direct human evidence demonstrating that microplastics alter the pediatric oral microbiome is insufficient. Therefore, the hypothesis that microplastics contribute to periodontal inflammation remains plausible but unconfirmed till now.

Implications for dental caries

The same caution applies to dental caries.

Dental caries is a multifactorial biofilm-mediated disease involving microbial ecology, salivary factors, dietary carbohydrates, fluoride exposure, tooth susceptibility, and behavioural and socioeconomic determinants. It would be inappropriate to describe microplastics as a new established cause of early childhood caries (ECC).

Instead, future studies should investigate whether microplastic exposure can modify:

- cariogenic biofilm composition;
- bacterial adhesion;
- extracellular polymeric substance formation;
- salivary buffering capacity;
- salivary antimicrobial proteins;
- enamel surface characteristics; or
- interactions between plastic particles and dietary sugars.

At present, there is no adequate evidence to establish a causal pathway from microplastic exposure to ECC.

Microplastics and the developing dentition

Childhood is characterized by active tooth development and maturation.

The possibility that environmental microplastics could influence developing enamel or dentin warrants further investigation. However, direct evidence is currently lacking. Research should determine whether particles or their associated chemicals can reach developing dental tissues and whether exposure during critical developmental windows has measurable effects.

The recent pediatric literature emphasizes that children may be particularly vulnerable to environmental micro- and nanoplastics because of developmental biology and repeated exposure.[5] Nevertheless, this general pediatric vulnerability cannot be assumed to represent a specific risk to developing teeth.

Oral Healthcare Products: A Potential Source of Exposure

The findings regarding toothbrushes and toothpastes are particularly relevant to preventive dentistry. Indian studies have demonstrated microplastic contamination or polymeric particles in commercially available oral healthcare products.[6,10,11]

At present, the evidence is not strong enough to justify established evidence-based oral hygiene recommendations. Fluoride toothpaste remains one of the most effective measures for preventing dental caries so parents should not discontinue fluoride toothpaste because of concerns about microplastics.

Instead, future research should aim to identify oral-care products with lower particle shedding while preserving established clinical benefits. This distinction is particularly important in pediatric dentistry, where poorly supported changes in preventive recommendations could inadvertently increase caries risk.

Dental materials and pediatric practice

Modern pediatric dentistry relies on numerous polymer-containing materials. Restorative composites, fissure sealants, orthodontic appliances, impression materials, and other devices may contain synthetic polymers.

Evidence of microplastic release from orthodontic aligners and dental procedures suggests that material degradation deserves further investigation.[14,15] However, the presence of particle release does not automatically indicate unacceptable clinical risk.

The appropriate response should be continued material surveillance, development of standardized testing protocols, and assessment of particle release under realistic oral conditions.

III. STRENGTHS AND LIMITATIONS

This review addresses a rapidly emerging topic at the intersection of pediatric dentistry and environmental health and incorporates recent evidence involving children, oral healthcare products, dental tissues, and oral cells.

However, several limitations should be acknowledged. First, the available evidence is limited and heterogeneous. Second, many studies are laboratory-based and therefore cannot establish clinical causation. Third, the definition and analytical detection of microplastics vary considerably between studies. Fourth, pediatric clinical outcome data remain scarce. Fifth, quantitative meta-analysis was not possible because of differences in exposures, populations, methods, and outcomes.

The conclusions should therefore be interpreted as evidence mapping and biological synthesis rather than proof of a causal relationship.

IV. CONCLUSION

Children may encounter micro- and nanoplastic particles through environmental, consumer-product, and healthcare-related sources. Emerging evidence demonstrates that micro- and nanosized plastic particles can reach the oral cavity and can be detected in children's saliva and oral healthcare products. Experimental studies further indicate that selected particles can interact with gingival fibroblasts and activate cellular pathways associated with inflammation and altered cell function. Nevertheless, the current evidence does not establish microplastics as an etiological factor for gingivitis, periodontitis, dental caries, enamel defects, or other pediatric oral diseases.

For pediatric dentists, microplastics represent an emerging environmental health issue and an important research opportunity rather than a reason to alter established preventive dental practices. Future studies should move beyond demonstrating the presence of particles and determine whether exposure is associated with clinically meaningful changes in the developing oral environment.

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