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Review Article

Triclosan and Oral Health: Is the Antimicrobial Worth the Systemic Trade-off?

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ABSTRACT:
Background: Triclosan (TCS) is a chlorinated phenolic compound historically formulated into many oral care products for its plaque- and gingivitis-reducing effects.Recent toxicological and population-based studies have increasingly questioned its long-term safety and environmental stability. **Objective:** This review consolidates recent findings (2022–2025) on triclosan's adverse effects on human health and the environment and evaluates viable alternatives for oral health care. **Methods:** Literature from 2022–2025 indexed in PubMed and Scopus was analysed, with focus on human and animal research addressing immunological, endocrine, reproductive, renal, and microbiome impacts, as well as relevant clinical trials in oral health. **Results:** While toothpastes containing triclosan show slight decreases in plaque formation and gingival inflammation, accumulating evidence links prolonged use to allergic reactions, reduced semen parameters, renal toxicity, oxidative stress, and altered gut flora.Animal studies further suggest exacerbation of colitis and potential endocrine disruption. Environmental accumulation and bacterial cross-resistance amplify concerns. In contrast, stannous fluoride, cetylpyridinium chloride, zinc-arginine, nano-hydroxyapatite, and botanical formulations show comparable antimicrobial or remineralization efficacy with superior safety profiles. **Conclusion:** Although triclosan continues to be allowed in certain oral formulations, its potential systemic and ecological harms appear to overshadow its modest therapeutic value.Dental professionals should promote mechanical plaque control and adopt safer, evidence-based alternatives. Ongoing human studies focusing on microbiome interaction and systemic toxicity are essential to guide regulatory and clinical policy.
Keywords: Triclosan, Oral health, Endocrine disruption, Microbiome, Toxicology, Toothpaste alternatives

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INTRODUCTION

Since its introduction in the 1960s, triclosan (TCS) has been widely used in consumer goods, particularly in select oral hygiene products.Initially regarded for its antiplaque benefits, triclosan's long-term safety has become a growing concern.This review summarizes recent evidence (2022–2025) on triclosan's adverse effects in humans and animals, explores mechanistic insights, and outlines alternative antimicrobial strategies for oral health.

1. Clinical efficacy in oral health

Toothpastes containing 0.3 % triclosan with a copolymer and fluoride have shown modest benefits in clinical trials. A randomized trial in peri-implantitis patients over two years reported stabilization of clinical attachment levels and reductions in bleeding and probing depth in the triclosan group versus fluoride-only control[1]. A systematic review and meta-analysis of randomized trials found reduced bleeding on probing at 3 and 6 months, and shallower probing depth with triclosan toothpaste, though plaque index and gingival index differences were minimal and evidence certainty was low[2].

2. Emerging adverse effects

2.1 Immunologic and dermatologic

A prospective 2025 cohort following mother–child pairs reported higher incidences of eczema and allergic symptoms among children with elevated maternal triclosan exposure, indicating possible interference with immune regulation and skin

microbiota[3]. This suggests interference with skin microbial communities or developing immune regulation.

2.2 Reproductive toxicity

A 2024 systematic review and meta-analysis of human studies (n = 1,312 men) demonstrated that triclosan exposure was significantly associated with **lower sperm concentration** (SMD ≈ –0.42) and markedly **reduced motility** (SMD ≈ –1.30)[4]. Mechanistic studies suggest oxidative stress as a mediator.

2.3 Nephrotoxicity and gut microbiota disturbance

In a 2022 murine study, chronic exposure (50 mg/kg over 10 weeks) led to kidney structural damage, elevated serum urea and creatinine, increased oxidative stress markers, and transcriptomic changes in inflammatory and metabolic pathways. Gut microbiota composition was also significantly altered, linking dysbiosis with renal injury[5].

2.4 Gastrointestinal inflammation and carcinogenesis

Rodent models show that triclosan aggravates colitis and accelerates colon tumorigenesis in susceptible mice through microbial community disruption and inflammatory pathways[6]. Although these exposures exceed typical human levels, they highlight potential risk via chronic low-dose ingestion.

2.5 Endocrine, thyroid and cardiovascular effects

A 2023 review summarized endocrine disruption potentialweak estrogenic and androgenic activity observed in vitro and animal models, with uncertain human relevance. Human data on thyroid and cardiovascular endpoints remain limited but indicate possible perturbation of hormonal homeostasis[7].

3. Mechanisms of toxicity

Multiple mechanisms underpin triclosan's adverse profile:

- **Endocrine disruption**: triclosan interacts with estrogen and androgen receptors, potentially altering hormonal signaling.
- **Oxidative stress and inflammation**: renal and reproductive toxicity appears mediated via reactive oxygen species and pro-inflammatory gene expression.
- **Microbiome disruption**: both skin and gut microbial communities are sensitive to triclosan, impairing immune maturation and barrier function.
- **Antimicrobial resistance**: low-dose exposure may induce bacterial efflux pumps and cross-resistance to antibiotics such as tetracycline and norfloxacin[8].

4. Environmental and ecological concerns

Triclosan is identified as a "contaminant of emerging concern" (CEC). Even though wastewater treatment plants remove much of it, substantial quantities escape and deposit in surface waters, affecting algae, aquatic bacteria, and higher organisms. Degradation by-products like methyl-triclosan and chlorophenols persist and may bioaccumulate in ecosystems[8]

5. Alternatives to triclosan in toothpaste

5.1 Chemical agents

- **Stannous fluoride** (SnF_2) remains well-supported for its dual antimicrobial and anti-inflammatory properties, showing similar gingival outcomes to triclosan formulations without equivalent safety concerns[4].
- **Cetylpyridinium chloride (CPC)** and **zinc-arginine** formulations also show comparable efficacy to triclosan-containing pastes, with fewer safety concerns.

5.2 Natural and botanical agents

A scoping review contrasted chemical antimicrobials with herbal alternatives such as aloe vera, clove, cinnamon, oregano, chamomile, and calendula extracts exhibit notable antibacterial and anti-inflammatory effects against key oral pathogens and may serve as biocompatible adjuncts to chemical agents.

5.3 Innovative Approaches

Other emerging strategies include **nanohydroxyapatite** and **bio-ceramic** toothpastes, which show remineralization and mild antimicrobial effects. A 2023 systematic review confirmed the remineralizing potential of nano-hydroxyapatite in early enamel lesions and white spot reduction in orthodontic patients[9].Additionally, **ozone therapy in aqueous form** shows promise in **biofilm disruption**, **gingivitis control**, and **wound healing**, although clinical trials remain limited and methodological quality varies[10].

6. Balanced clinical perspective

6.1 Efficacy vs. risk

Triclosan toothpaste confers modest benefits in plaque and gingivitis controland potential peri-implant stability benefits—but the **clinical advantage over safer alternatives is marginal**. Its known systemic and environmental risks raise questions on risk–benefit balance, especially for long-term use.

6.2 Patient populations at risk

Children (due to immune and developmental sensitivity), men concerned about fertility, patients with renal or hepatic conditions, and individuals with allergic predisposition should avoid triclosan-containing products.

6.3 Regulatory context

While triclosan was banned from antibacterial soaps in the United States in 2016, it remains allowed in some toothpastes where manufacturers demonstrated

efficacy. However, increasing scrutiny and evolving evidence may prompt further restrictions.

7. Future directions and recommendations

- **Human clinical trials** with long-term follow-up are needed to confirm reproductive, endocrine, immune, and renal effects at real-world exposure levels.
- Investment in **green antimicrobial design** targeting effective oral biofilm inhibition without resistance or ecological accumulation.
- **Microbiome-focused trials** to study how oral and gut microbial shifts influence systemic health.
- Public education to prioritize mechanical cleaning and promote toothpaste options that deliver safety and efficacy without triclosan.

CONCLUSION

Triclosan in toothpaste may offer slight advantages for plaque, gingival bleeding, or peri-implant maintenance—but mounting evidence links it to **allergic eczema in children, impaired semen quality, nephrotoxicity, microbial dysbiosis, endocrine disruption**, and ecological harm. Safer, equally effective alternatives (e.g. stannous fluoride, CPC, zinc-arginine, botanical agents) are available. Dental professionals should adopt a forward-thinking, evidence-based approach: Favor proven antimicrobial agents with stronger safety profiles, emphasize mechanical plaque control, and counsel patients transparently.

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