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Cumulative Fluoride Exposure: Integrating Systematic Evidence with Analytical Determination in Tea-Based Beverages

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Abstract

Introduction: Fluoride (F^-) plays an important role in dental health, promoting remineralization and inhibiting demineralization through the formation of acid-resistant fluorapatite. Although community water fluoridation has long been considered a major public health achievement, increasing scientific and ethical scrutiny has emerged concerning its systemic use.[1,2] With fluoride now derived from multiple sources, including dental products, drinking water, and beverages, assessment of total intake has become methodologically challenging. **Objective:** This study aimed to investigate the "halo effect" of water fluoridation by combining systematic review evidence with analytical determination of fluoride levels in commonly consumed beverages. **Methods:** A systematic literature review was conducted using PubMed, ScienceDirect, and PubChem to examine fluoride's physicochemical properties, pharmacokinetics, and health outcomes. Fluoride concentrations in teas, herbal infusions (n=14), and iced tea beverages (n=9), were quantified by potentiometry using a fluoride ion-selective electrode (ISE) after standard calibration and sample preparation procedures. **Results:** The literature evidence indicates a narrow therapeutic window for fluoride: optimal intake supports dental caries prevention, whereas chronic exposure above 0.1 mg/kg/day is linked to dental and skeletal fluorosis. Recent EFSA assessments (2024–2025) also report potential neurodevelopmental risks, including reduced IQ in children exposed to water fluoride concentrations above 1.5 mg/L.[3] Analytical results showed fluoride concentrations ranging from 0.1 to 0.5 mg/L in iced tea beverages and up to 1 mg/L in teas and herbal infusions, indicating that these products may represent a relevant source of dietary fluoride exposure. **Conclusion:** F^- exposure should be assessed cumulatively, as beverages, drinking water, and dental products collectively contribute to total intake, particularly in young children, pregnant women and individuals with clinical conditions. The observed variability in fluoride content across teas and infusions underscores the influence of environmental factors, plant origin, infusion preparation methods, and water quality. These findings highlight the need for more comprehensive exposure assessments to inform safe, evidence-based public health policies and recommendations.

Keywords: fluoride exposure; beverage analysis; health risk assessment; neurotoxicity

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