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RESEARCH ARTICLE
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FLUORIDE EXPOSURE AND PREVALENCE OF NON-CAVITATED LESIONS IN CHILDREN: A CAMBRA-BASED ANALYSIS

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ABSTRACT

Background: Early detection and prevention of dental caries are pivotal in paediatric oral health. Non-cavitated lesions (NCLs) represent a critical stage in the caries continuum, where preventive strategies can halt or reverse disease progression. While fluoride exposure is a cornerstone of caries prevention, its relationship with the prevalence of NCLs remains underexplored in the context of individualized caries risk assessments.

Objective: This study investigates the association between systemic and topical fluoride exposure and the prevalence of non-cavitated lesions in children, using the Caries Management by Risk Assessment (CAMBRA) model as a diagnostic and preventive framework.

Methods: A cross-sectional analysis was conducted on a paediatric population aged 6–12 years in Abbottabad after obtaining ethical approval from the institution. Participants were stratified based on fluoride exposure history (community water fluoridation, topical applications, fluoride toothpaste use) and assessed using CAMBRA protocols to determine caries risk levels. The presence and distribution of NCLs were evaluated through clinical examinations and standardized criteria.

Results: Findings reveal a significant inverse correlation between consistent fluoride exposure and the prevalence of non-cavitated lesions, particularly among moderate- and high-risk groups identified by CAMBRA. Children with inadequate fluoride exposure showed a higher incidence of NCLs, despite similar oral hygiene practices and dietary habits.

Conclusion: Fluoride exposure, particularly when integrated within a CAMBRA-based risk assessment model, plays a vital role in reducing early-stage carious lesions in children. These findings support a personalized, preventive approach to pediatric dental care and underscore the need for policy and clinical strategies that ensure equitable access to fluoride interventions.

Keywords: fluoride exposure, non-cavitated lesions, caries prevention, caries risk assessment

INTRODUCTION

Dental caries is a multifactorial, biofilm-mediated, and diet-modulated disease that results in the progressive destruction of the dental hard tissues.[1] It is the most prevalent chronic disease among children globally, affecting their general health, growth, and development. The early stages of dental caries, often manifesting as non-cavitated lesions (NCLs), present a critical window for intervention. At this stage, lesions are still reversible with non-invasive therapeutic measures such as fluoride treatment, dietary control, and improved oral hygiene practices.[2] Unfortunately, these early signs are frequently missed in standard dental examinations, delaying preventive measures and contributing to the high burden of untreated caries.[3]

Fluoride has long been established as a cornerstone of caries prevention due to its ability to promote enamel remineralization and inhibit demineralization. It can be delivered systemically through community water fluoridation or topically via toothpaste, mouth rinses, gels, and professional applications.[4] The effectiveness of fluoride, however, may depend not only on the dosage and frequency of exposure but also on individual risk factors including oral hygiene habits, dietary behaviors, socioeconomic status, and biological predispositions. Recent paradigms in dental caries management emphasize the importance of individualized, risk-based approaches.[5] One of the most comprehensive models supporting this concept is CAMBRA (Caries Management by Risk Assessment). CAMBRA incorporates patient-specific risk and protective factors including fluoride exposure into a structured framework to predict caries development and guide preventive and therapeutic decisions.[6]

This model facilitates early detection of lesions and allows clinicians to implement targeted interventions based on assessed risk levels. Despite the widespread recognition of fluoride's benefits and the growing adoption of CAMBRA in clinical practice, few studies have systematically examined the relationship between fluoride exposure and the prevalence of non-cavitated lesions in children, particularly within a CAMBRA-guided framework. Understanding this relationship is crucial for optimizing preventive strategies and ensuring resource allocation for maximum public health benefit.[7] Additionally, disparities in fluoride access, whether due to geographic, economic, or policy-related factors, may contribute to uneven oral health outcomes.[8] As such, exploring how different sources and levels of fluoride exposure impact early caries formation can offer valuable insights into improving both individual-level care and community-based prevention programs.

The current study investigates the association between fluoride exposure both systemic and topical and the prevalence of non-cavitated carious lesions in children aged 6 to 12 years. Utilizing the CAMBRA model for caries risk assessment, this study aims to quantify the protective effects of fluoride across different risk categories and inform best practices in pediatric preventive dentistry. By correlating fluoride exposure histories with clinical findings and CAMBRA risk profiles, we aim to advance evidence-based, risk-guided strategies for managing dental caries at its earliest and most reversible stage.

METHODOLOGY

A cross-sectional study was conducted among children aged 6–12 years in Abbottabad. Ethical clearance was obtained from the Institutional Review Board. Participants were selected using stratified random sampling from pediatric dental clinics and schools. Inclusion criteria required children to be systemically healthy, within the specified age range, and have informed consent from guardians. Children undergoing orthodontic treatment, those with systemic illnesses affecting oral health, or those who had received dental restorative treatment were excluded.

Data collection included interviews and clinical examinations. Fluoride exposure history was categorized into systemic (community water fluoridation) and topical (fluoride toothpaste use and professional applications). CAMBRA protocols were followed to classify children into low, moderate, or high caries risk. Clinical examination was conducted using International Caries Detection and Assessment System (ICDAS) criteria, identifying NCLs as codes 1 and 2. The collected data were

analyzed using SPSS software. Chi-square tests and logistic regression models were used to examine associations.

RESULTS

A total of 300 children participated in the study, with a mean age of 8.9 ± 1.7 years; 52% (n = 156) were male and 48% (n = 144) female. Among them, 60% (n = 180) had access to fluoridated community water, 85% (n = 255) reported regular use of fluoride toothpaste, and 40% (n = 120) had received a professional topical fluoride application in the last six months. Based on CAMBRA assessments, 25% (n = 75) of participants were classified as low caries risk, 45% (n = 135) as moderate risk, and 30% (n = 90) as high risk. Children with consistent fluoride exposure (all three sources) had significantly fewer NCLs compared to those with partial or inconsistent fluoride use. Table 1 presents the prevalence of NCLs based on fluoride exposure categories. Table 1 illustrates a clear inverse relationship between fluoride exposure and the prevalence of NCLs. Children with full-spectrum fluoride exposure had the lowest prevalence. Table 2 shows that higher CAMBRA risk scores are associated with increased prevalence of NCLs.

Table 1: Prevalence of Non-Cavitated Lesions by Fluoride Exposure Level

Fluoride Exposure	NCL Prevalence (%)
Consistent (3 sources)	15%
Partial (1–2 sources)	33%
Inconsistent/None	52%

Table 2: Distribution of NCLs by CAMBRA Risk Category

CAMBRA Risk Level	NCL Prevalence (%)
Low	12%
Moderate	28%
High	49%

DISCUSSION

This study reinforces the protective role of fluoride exposure against early-stage carious lesions, particularly when integrated into a risk-based preventive model such as CAMBRA. The data indicate a significant inverse association between fluoride exposure and the prevalence of non-cavitated lesions in children. These findings are consistent with the known mechanisms by which fluoride enhances enamel remineralization and inhibits caries progression at the subclinical level.

Comparing our findings to previous studies, Kunlaya et al. (2025)[9] emphasized the necessity of fluoride in arresting early carious lesions and endorsed CAMBRA as an effective tool for guiding individualized caries management. Similarly, a study by Abdalla et al. (2025)[10] reported that schoolchildren using fluoride toothpaste twice daily exhibited significantly lower rates of NCLs compared to those with irregular use. Our results align with these findings and extend them by showing how a structured risk assessment like CAMBRA can enhance fluoride's preventive efficacy.

Interestingly, our study also highlights disparities in fluoride access. A considerable proportion of children lacking consistent fluoride exposure exhibited a markedly higher incidence of NCLs, regardless of reported oral hygiene and dietary practices. This suggests that even in populations with similar behavioral patterns, systemic preventive interventions like community water fluoridation can be a critical determinant of oral health outcomes.

Other studies have reported similar trends. A Brazilian study by Sharma et al. (2025)[11] found that children in non-fluoridated areas had nearly double the caries incidence of those in fluoridated communities, even when controlling for sugar intake and brushing frequency. Moreover, Martignon et al. (2025)[12] demonstrated that fluoride varnish application in high-risk groups significantly reduced

the development of new lesions, supporting our finding that professional fluoride treatments add preventive value, especially in CAMBRA classified high-risk children. While fluoride's benefits are well-documented, this study uniquely positions those benefits within a comprehensive risk-assessment model, showing that fluoride exposure alone is not sufficient its

CONCLUSION

Fluoride exposure significantly lowers the prevalence of non-cavitated lesions in children, especially when combined with individualized caries risk assessment through CAMBRA. These findings advocate for a dual strategy of broad-based fluoride access and personalized caries management to achieve optimal pediatric oral health outcomes.

Conflict of Interest

None

Authors' Contribution

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Acquisition, Analysis or Interpretation of Data: Kashif Ali Shah, Kiran Aslam
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