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Original Article

Association between Drinking Water Source and Dental Caries Experience among Young Children

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Abstract

Background: Early childhood caries remains a major public health concern influenced by multiple behavioral and environmental factors, particularly fluoride exposure through drinking water. This study investigated the association between primary drinking water source and dental caries experience among young children in Al-Zawia, Libya. **Methods:** A cross-sectional study was conducted among 136 children aged 3–13 years. Dental caries experience was assessed using the deft index for primary dentition and the DMFT index for permanent teeth. Participants were divided into two groups according to their primary drinking water source: the study group (children consuming municipal tap water) and the control group (children consuming bottled water). Fluoride exposure was estimated based on the reported water source. Statistical analysis included independent-samples t-tests and non-parametric tests where appropriate, with statistical significance set at $p < 0.05$. **Results:** The mean caries experience score was significantly higher among bottled water consumers (3.29 ± 2.89) compared to tap water consumers (2.00 ± 2.67). The difference was statistically significant ($t = -2.18$, $p = 0.032$). A substantial proportion of children (70.2%) exhibited caries experience greater than zero. Increasing caries severity was observed with age, particularly among children aged 5–6 years. Bottled water samples showed low fluoride concentrations (0.06–0.30 ppm), below levels considered optimal for caries prevention. **Conclusion:** A significant association was identified between drinking water source and dental caries experience in young children. Consumption of bottled water was associated with higher caries burden, likely due to reduced fluoride exposure compared with municipal tap water. These findings highlight the importance of adequate fluoride exposure in early childhood and support public health strategies promoting optimal fluoride intake to reduce caries risk.

Keywords: Early childhood caries, Bottled water, Bap water, Fluoride

Introduction

Dental caries is one of the most common chronic diseases in the early childhood and persists as a substantial global public health problem [1]. It affects primary (deciduous) teeth and can lead to pain, infection, difficulty in chewing, and reduced quality of life in young children. The development of dental caries is multifactorial, involving dietary habits, oral hygiene practices, fluoride exposure, and environmental influences[2].

Fluoride is widely recognized as a key preventive agent against dental caries due to its ability to enhance enamel resistance and promote remineralization of early lesions, while also reducing bacterial acid production and biofilm activity. These combined mechanisms make fluoride one of the most effective interventions in caries prevention and control[3].

Drinking water source is an important environmental determinant of oral health. Public water supplies are often fluoridated, which helps prevent tooth decay by strengthening enamel and reducing demineralization. In contrast, nonpublic water sources such as bottled water may contain little or no fluoride, potentially reducing protective effects against dental caries in primary teeth[4].

In addition to environmental factors, child health behaviors such as appetite-related concerns may influence oral health outcomes. Appetite worries, including irregular eating patterns, food refusal, or excessive snacking driven by poor appetite regulation, can increase exposure to fermentable carbohydrates and sugary foods, which are known risk factors for dental caries. These behaviors may also reflect underlying nutritional or developmental issues that contribute to poor oral health in young children [5].

.Therefore, this study aims to investigate the association between drinking water source and dental caries experience in deciduous teeth among young children. Understanding these relationships may help in developing preventive strategies targeting both environmental exposure and child dietary behaviors.

Epidemiological investigations comparing the impact of tap versus bottled water consumption on dental caries have primarily focused on variations in systemic fluoride exposure. Recent contemporary research has shifted toward clinical and community-focused trials to isolate these mechanisms. For instance, a 2024 multicenter trial protocol in the United States (the waterBEST trial) is currently investigating whether the introduction of fluoridated bottled water can actively reduce caries

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experience in children relative to non-fluoridated alternatives; preliminary modeling from this protocol suggests a lower expected decay rate within the fluoridated cohort[6], Concurrently, a 2024 collaborative, community-based study conducted in Saudi Arabia and the USA demonstrated that individuals who frequently filtered or otherwise altered their domestic tap water experienced a significant reduction in total fluoride intake, which consequently correlated with an elevated potential risk for dental caries compared to cohorts consuming standard, unaltered municipal tap water[7]. Ultimately, a comprehensive systematic review and meta-analysis published in 2025 corroborated these localized findings, confirming that systemic fluoride exposure—predominantly derived from established community water systems—remains fundamentally associated with a significantly reduced risk of dental caries, thereby reinforcing the robust protective efficacy of fluoridated tap water over characteristically low-fluoride bottled alternatives[8].

Thereby reinforcing the robust protective efficacy of fluoridated tap water over characteristically low-fluoride bottled alternatives [9]. Mirroring these global trends, regional epidemiological evidence from Libya indicates that dental caries remains a prominent public health challenge among school-aged children, particularly within western municipalities such as Al-Zawia

Material and Method

Study design

A cross-sectional study was conducted to assess the relationship between drinking water sources, water fluoride levels, and dental caries experience in both primary and permanent dentitions.

Study setting

The investigation was conducted in Al-Zawia City, Libya, during the period from March 2026 to June 2026, Eligible participants included young children who were cooperative and had a consistent history of utilizing a single primary drinking water source, with no history of systemic fluoride supplementation or chronic illness. A stratified random sampling technique yielded a convenience sample of 136 children, selected based on school accessibility and parental collaboration.

Ethical approval was obtained from the Libyan Medical Research Center's biosafety and bioethics committee, and written informed consent was secured from all parents prior to participation. Data collection was conducted through a structured questionnaire administered during face-to-face interviews with the participants' parents or guardians. The questionnaire collected information on the household's primary drinking water source, including whether the child primarily consumed municipal tap water or bottled water and, if applicable, the specific commercial bottled water brand used. A standardized clinical oral examination was performed by a single dentist using a knee-to-knee position and disposable diagnostic kits.Caries experience was comprehensively assessed using the **deft** index for the primary dentition and the **DMFT** index for permanent teeth. All examinations were conducted in a uniform sequence, and the examiner was blinded to the laboratory water analysis results to minimize bias. Each participant was assigned a unique laboratory code, and all clinical, questionnaire, and laboratory water data were managed in a Microsoft Excel spreadsheet.

Statistical analysis was performed using SPSS version 27. Descriptive statistics, frequency tables, the chi-square test for association, Mann Whitney and Pearson or Spearman correlation coefficients were employed to evaluate the relationships between caries experience scores (**deft** and **DMFT**) and the measured fluoride levels across the different water sources.

Result

The final analytical sample comprised 131 children, with a mean age of 5.73 ± 2.04 years (range: 3–13 years). The study population was predominantly represented by 5-year-old (n = 46) and 6-year-old (n = 36) participants. A substantial burden of dental caries was observed within the cohort. Overall, 70.2% (n = 92) of children exhibited a caries index score greater than zero, corresponding to a mean caries experience score of 2.87 Tab1.

Specifically, caries prevalence rose from 37.5% among 3-year-old children to 61.9% among 4-year-olds and reached its highest levels among 5-year-olds (78.3%) and 6-year-olds (75.0%). A comparable age-related trend was observed for disease severity, with the mean caries index increasing from 0.50 ± 0.76 at age 3 to 3.56 ± 2.86 at age 6. These findings suggest a rapid accumulation of caries experience during the preschool years Fig 1.

A statistically significant positive association was observed between the severity of enamel fluorosis and dental decay (deft-DMFT). Participants classified as Score 0 (n = 54) exhibited a mean caries experience of 2.59, while those having Score 1 (n = 30) and Score 2 (n = 15) demonstrated progressively higher mean caries indices values of 3.23 and 4.40 respectively. This increasing trend continued in Score 3 (n = 4), with a mean caries index of 5.50 and reached its highest level in Score 4 (n = 1), which recorded a caries index score of 8.0. The Kruskal–Wallis test confirmed that these differences were statistically significant (p = 0.0137), indicating a meaningful relationship between fluorosis severity and caries experience fig2.

Participants were categorized according to their primary source of drinking water as either bottled water consumers (n = 95) or tap water consumers (n = 36)fig3. Data regarding participants' primary drinking water sources were collected, and among those who consumed bottled water, the two most prevalent local brands identified were Dajla and Al-Nabaa. The fluoride

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concentrations of these bottled water products were obtained directly from the manufacturers' packaging labels and recorded for analysis. The reported fluoride concentrations were 0.06 ppm for Dajla and 0.30 ppm for Al-Nabaa, indicating that both brands contained relatively low fluoride levels and were below the fluoride concentrations generally recommended by the World Health Organization for optimal dental health (10). The mean caries score was higher among children who primarily consumed bottled water (3.29 ± 2.89) than among those who primarily consumed tap water (2.00 ± 2.67). An independent-samples t-test revealed a statistically significant difference in caries experience between the two groups, $t(123) = -2.18$, $p = 0.032$ Tab 2**.** As the observed p-value was below the predefined significance threshold of 0.05, the null hypothesis of no difference between groups was rejected. These findings indicate that children whose primary source of drinking water was tap water exhibited significantly lower caries experience than those who primarily consumed bottled water.

Table1. Age distribution of the study sample.

Age	Number	percentage
3	11	8.4
4	24	18.31
5	46	35.1
6	36	27.5
7	1	0.8
8	6	4.6
9	2	1.5
10	3	2.3
11	2	1.5
12	4	3.1
13	1	0.8
Total	131	100%

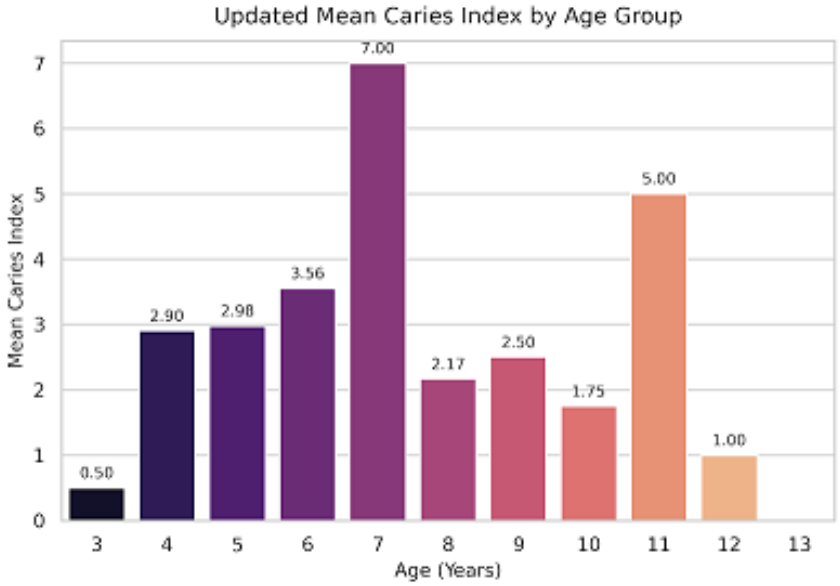

Figure 1. distribution of caries indices according to age groups.

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Table 2. Results of the comparative statistical test between the two water types.

Test Parameter	Value / Range
Mean Difference {Bottle} - {Tap}	1.295
95% Confidence Interval (CI)	0.116, 2,473
Calculated t-statistic	-2.175
Degree of freedom (df)	123
p.value	0,032

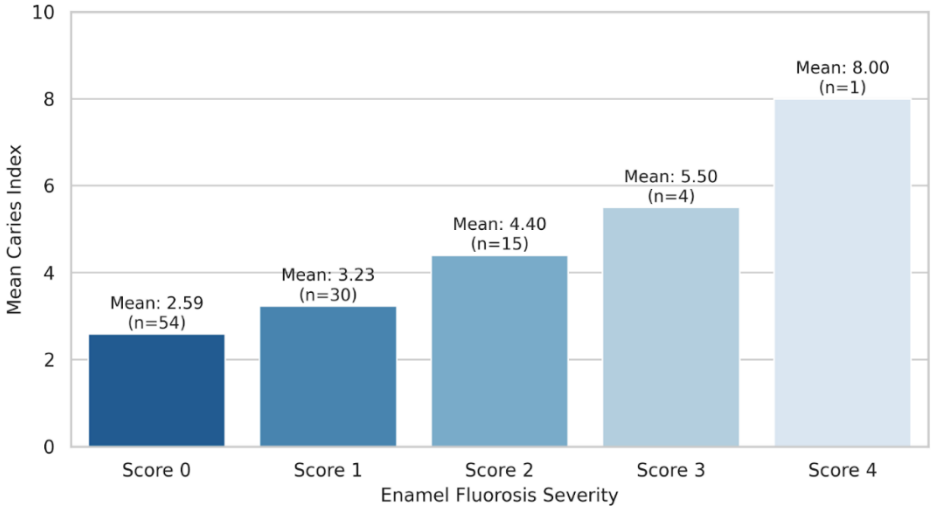

Figure 2. distribution of caries indices through enamel fluorosis scores.

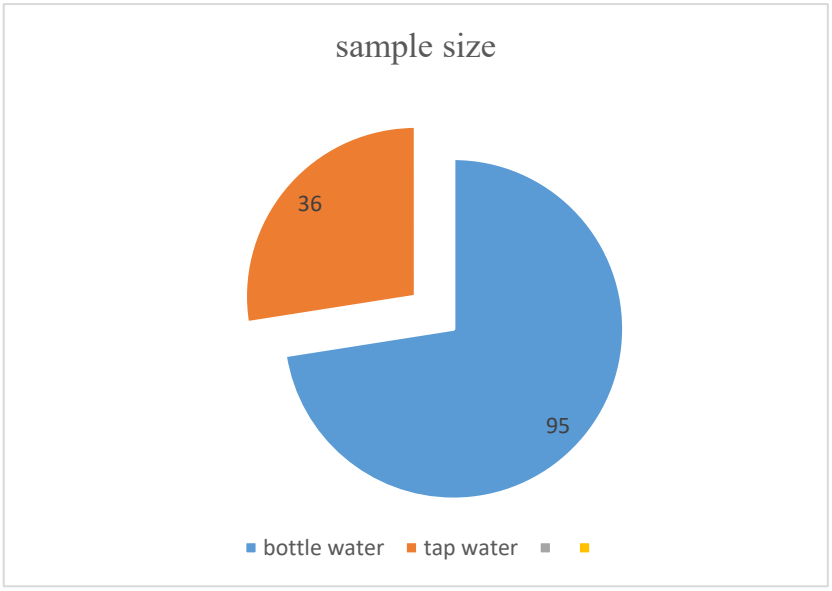

Figure 3. distribution of the study sample according to source of drinking water.

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Discussion

The findings of this study demonstrate a statistically significant association between the type of drinking water source and dental caries experience among young children in Al-Zawia, Libya. Children consuming bottled water showed significantly higher caries index compared with those consuming municipal tap water (Mann–Whitney U = 1419.5, p = 0.0081), suggesting a higher caries burden in the bottled-water group. This aligns with the well-established role of fluoride in caries prevention, where even small differences in long-term fluoride exposure can significantly influence enamel resistance and caries progression in primary teeth[11]. The observed association remained consistent across both parametric and non-parametric testing, strengthening the robustness of the findings.

The results also indicate that variations in fluoride exposure may contribute to the observed differences in oral health outcomes. Tap water in many municipal systems contains controlled levels of fluoride that enhance remineralization and inhibit demineralization of enamel [12], whereas bottled water commonly contains minimal or inconsistent fluoride concentrations [13]. This disparity likely explains the higher dental caries scores observed among children relying on bottled water as their primary drinking source. In addition, the positive association observed between fluorosis severity and caries experience in this study may reflect complex interactions between total fluoride exposure, timing of exposure, and enamel development, rather than a simple linear protective effect.

When compared with previous literature, these findings are consistent with recent international evidence highlighting the protective role of fluoridated tap water. A 2024 randomized trial protocol in the United States (waterBEST study) is currently evaluating whether fluoridated bottled water can reduce caries incidence in children, emphasizing the importance of fluoride availability in drinking water systems(6). Similarly, a 2024 community-based study in Saudi Arabia and the USA reported that reduced fluoride intake from altered or filtered tap water was associated with increased caries risk [7].

Furthermore, a 2025 systematic review and meta-analysis confirmed that community water fluoridation remains strongly associated with reduced dental caries prevalence globally [8].The present findings from Al-Zawia are therefore in agreement with global evidence, reinforcing that children consuming non-fluoridated bottled water may be at greater risk of dental caries compared with those exposed to fluoridated municipal tap water.

Conclusion

In conclusion, this study identified a significant association between drinking water source and dental caries experience among children in Al-Zawia, Libya. Children who primarily consumed bottled water exhibited significantly higher caries scores than those who consumed municipal tap water. The findings support the hypothesis that differences in fluoride exposure from drinking water may influence caries development during early childhood. Furthermore, the high overall prevalence of dental caries observed in the study highlights the substantial burden of oral disease within this population.

Recommendation

Based on the findings of this study, efforts should be made to increase awareness among parents regarding the importance of adequate fluoride exposure for the prevention of dental caries. Regular monitoring of fluoride concentrations in both municipal and commercially available bottled water is recommended. Preventive oral health programs, including oral health education, promotion of proper tooth-brushing practices with fluoridated toothpaste, and routine dental examinations, should be strengthened among preschool and school-aged children. In addition, public health authorities should consider implementing community-based preventive strategies to reduce the burden of dental caries. Further studies involving larger and more representative samples, together with direct measurement of fluoride levels in drinking water, are recommended to better clarify the relationship between water source, fluoride exposure, and dental caries risk.

Conflict of Interest

The authors declare that they have no conflict of interest

Funding status

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