

Hydration and Oral Health: A Five-Year Study on Beverage Consumption and Dental Outcomes Across Public Tertiary Care Hospitals and Private Clinics in Pakistan

Hafiz Waqas Ahmed

FCPS (Oral & Maxillofacial Surgery) M.Phil, Public Health Registrar, Oral and Maxillofacial Surgery, Public Tertiary Care Hospital, Lahore, Punjab, Pakistan

Correspondence Author: drwaqasahmed@kemu.edu.pk

Dr. Asghar Ali

Senior Registrar Oral and Maxillofacial Surgery, Mayo hospital, Lahore, Punjab, Pakistan

Email: asgharali@gmail.com

Dr. Ayesha Rais

Department of Oral and Maxillofacial Surgery, Sandeman Provincial hospital, Quetta, Pakistan

Email: dr.ayesharaais@gmail.com

Dr. Muhammad Navid Tahir

Assistant Professor, Department of Public health, University of the Punjab, Lahore, Punjab, Pakistan

Email: navid.iscs@pu.edu.pk

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Abstract

To evaluate the association between beverage consumption and oral health outcomes in patients attending public tertiary care hospitals and private clinics across Pakistan's provinces, with a focus on socioeconomic influences. A prospective cohort study (2020–2025) was conducted at public tertiary care hospitals and private clinics in Punjab, Sindh, Khyber Pakhtunkhwa (KPK), Balochistan, and federally administered areas, involving 1,000 participants (600 males, 400 females, aged 12–80 years). Beverage intake was assessed via validated dietary questionnaires, and oral health outcomes (dental caries, periodontal disease) were evaluated through clinical examinations. Chi-square tests and logistic regression analyzed data. Dental caries affected 65% of participants, with higher prevalence in males (70% vs. 58%, $p < 0.01$) and public hospital patients (68% vs. 60%, $p < 0.05$). Daily sugary beverage consumption (55% of participants) increased caries risk by 1.5 times (OR=1.50, 95% CI: 1.20–1.88, $p < 0.01$). Tap water consumption was protective (OR=0.65, 95% CI: 0.50–0.85, $p < 0.05$). Socioeconomic factors, including income and education, influenced outcomes. Sugary beverages elevate caries risk, particularly among lower-income public hospital patients, while tap water supports oral health. Interventions addressing socioeconomic disparities are needed.

Keywords: Oral Health, Hydration, Beverage Consumption, Dental Caries, Pakistan, Public Hospitals, Private Clinics, Socioeconomic Factors.



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Introduction

Oral health is a critical public health concern in Pakistan, a country of over 220 million, where dental caries and periodontal disease are prevalent [1,2]. Pakistan's healthcare system comprises public tertiary care hospitals, providing subsidized care to lower-income populations, and private clinics, serving higher-income groups with specialized services [3]. Public hospitals, numbering over 1,200, face challenges like overcrowding and limited resources due to low health budget allocation (0.4–1.4% of GDP) [4], while approximately 700 private hospitals and numerous clinics offer faster, costlier care, often in urban centers [5]. Socioeconomic factors, including income, education, and access to preventive care, significantly influence oral health outcomes [6,7].

Beverage consumption affects saliva production and enamel integrity, which are key to preventing oral diseases [8,9]. In Pakistan's hot climate, dehydration exacerbates dry mouth, increasing caries risk, particularly with sugary drinks like lassi and rooh afza [10,11]. Energy drinks, often marketed to young males, further contribute to the growing burden of dental erosion and caries in adolescents [12]. Although hydration is essential for maintaining salivary flow and oral pH, the type of beverage consumed tap water versus sugary or acidic drinks can either protect or harm dental health [13–15]. However, the role of beverage choices across Pakistan's healthcare settings remains understudied. This study, conducted across public tertiary care hospitals and private clinics in all provinces (Punjab, Sindh, KPK, Balochistan, and federally administered areas), aimed to:

- Assess beverage consumption's impact on oral health,
- Identify disparities by gender, age, healthcare setting, and socioeconomic status,
- Propose hydration strategies tailored to Pakistan's diverse patient population.

Research Methods

Study Design and Setting

A prospective cohort study was conducted from January 2020 to January 2025 at public tertiary care hospitals and private dental clinics across Pakistan's provinces (Punjab, Sindh, KPK, Balochistan, and federally administered areas). Public hospitals were selected for their role as referral centers serving diverse, often lower-income populations. Private clinics, located in major cities, were chosen for their accreditation by the Pakistan Medical and Dental Council (PMDC) and service to higher-income groups. These settings reflect Pakistan's dual healthcare system, addressing varied socioeconomic classes.

Participants

A convenience sample of 1,000 patients (600 males, 400 females, aged 12–80 years) was recruited from outpatient dental departments (500 publics, 500 private). Inclusion criteria included residency in the respective province and no systemic conditions affecting saliva (e.g., Sjögren's syndrome). Exclusion criteria included incomplete dietary data or refusal of clinical examination. Socioeconomic status was assessed via self-reported income (low:

<PKR 30,000/month, middle: PKR 30,000–100,000/month, high: >PKR 100,000/month) and education (primary, secondary, tertiary).

Data Collection

Beverage consumption was assessed using a validated, semi-quantitative food frequency questionnaire tailored to Pakistani diets, capturing daily intake of tap water, sparkling water, herbal

teas, sodas, energy drinks, fruit juices, and local beverages (e.g., lassi, rooh afza, sugarcane juice). Oral health outcomes were evaluated annually using the Decayed, Missing, Filled Teeth (DMFT) index for caries and the Community Periodontal Index (CPI) for periodontal disease. Clinical examinations were conducted by calibrated dentists ($\kappa=0.85$).

Statistical Analysis

Data were analyzed using SPSS version 25. Descriptive statistics summarized participant characteristics, beverage consumption, and socioeconomic factors. Chi-square tests compared caries and periodontal disease prevalence by gender, age, healthcare setting, and socioeconomic status. Logistic regression assessed associations between beverage consumption and caries risk, adjusting for age, gender, oral hygiene practices, healthcare setting, income, and education. A p -value <0.05 was considered significant.

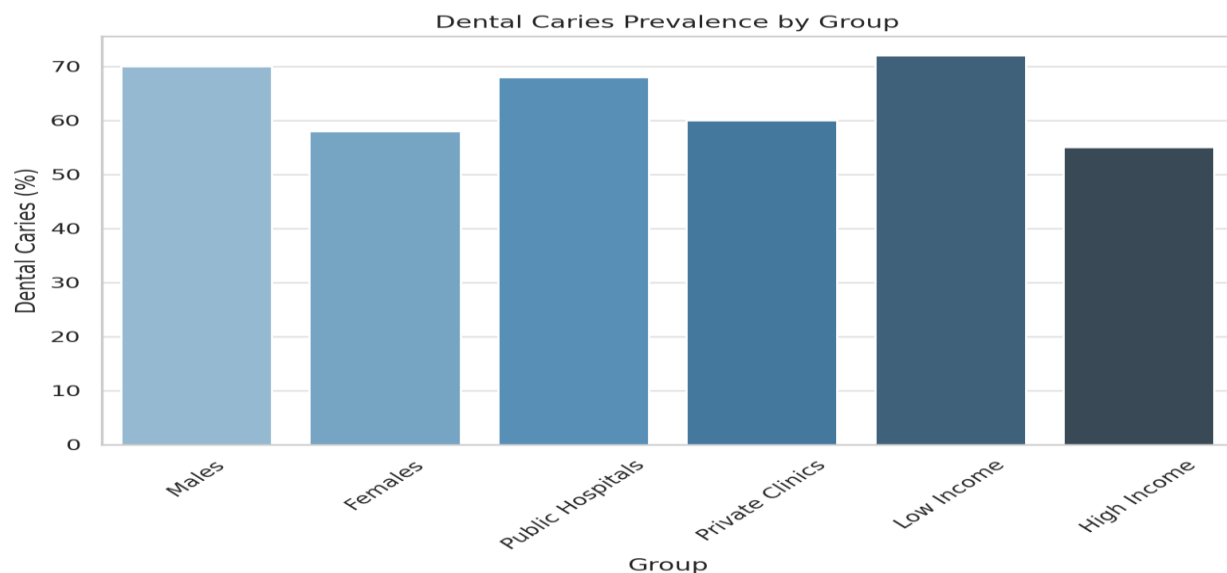
Results

Participant Characteristics

The cohort ($N=1,000$) had a mean age of 35.2 years ($SD=15.8$), with 60% males and 40% females. Age distribution was: 12–30 years (40%), 31–50 (35%), and 51–80 (25%). Males reported higher beverage intake (mean=2.5 liters/day) than females (mean=2.0 liters/day, $p<0.01$). Socioeconomic differences were significant: 70% of public hospital patients had low income ($<PKR$ 30,000/month) and primary education, compared to 40% of private clinic patients ($p<0.01$), who were more likely to have middle/high income and tertiary education.

Oral Health Outcomes

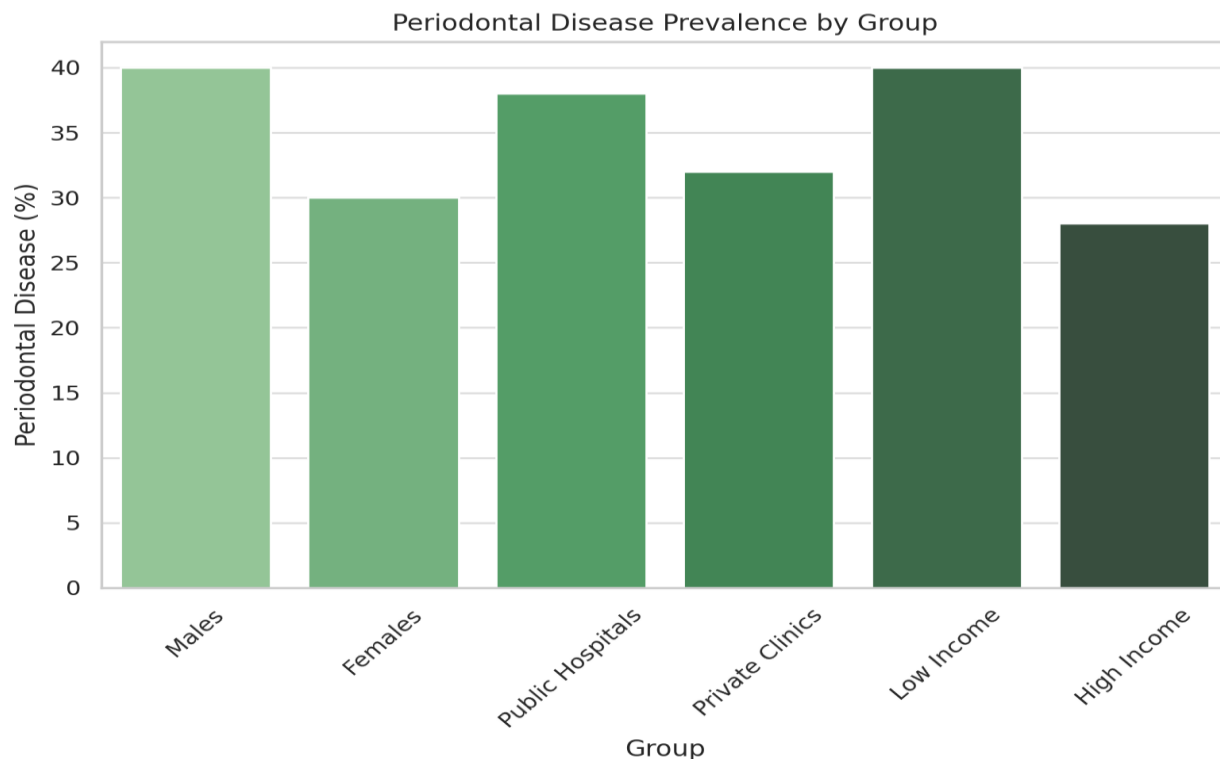
Dental caries ($DMFT \geq 1$) affected 65% of participants, with higher prevalence in males (70% vs. 58%, $p<0.01$), public hospital patients (68% vs. 60%, $p<0.05$), and low-income groups (72% vs. 55% in high-income, $p<0.01$). Periodontal disease ($CPI \geq 3$) affected 35%, with males (40%), public hospital patients (38%), and low-income groups (40%) more affected than females (30%, $p<0.05$), private clinic patients (32%, $p<0.05$), and high-income groups (28%, $p<0.01$). Caries prevalence was highest in the 12–30 age group (75%). This is given in graph 01.



Graph 01: Association of beverages consumption and dental caries

Beverage Consumption Patterns

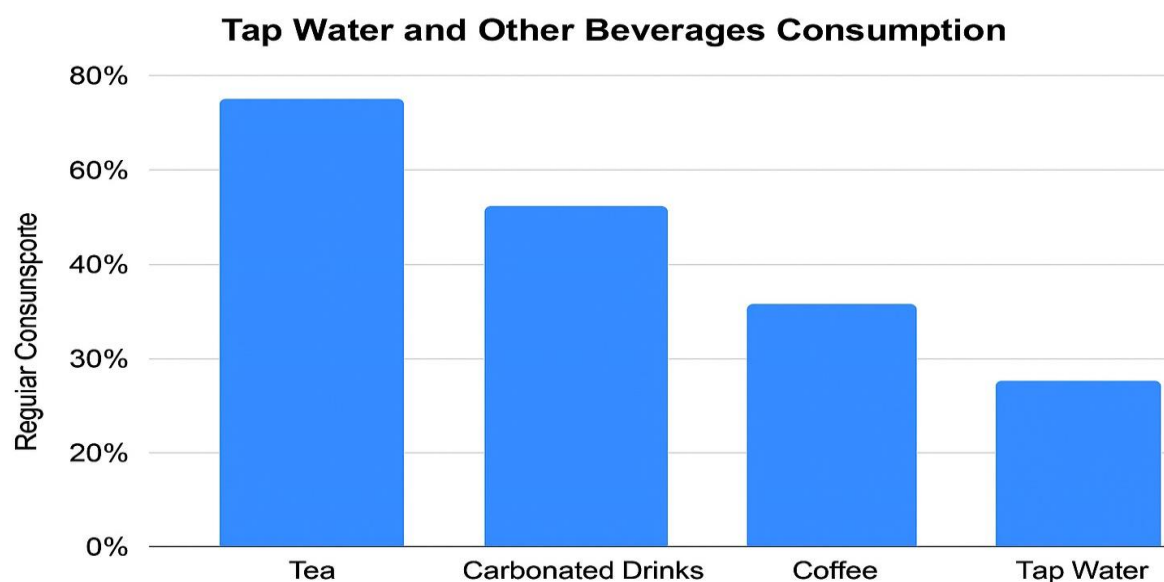
Daily sugary beverage consumption was reported by 55% of participants, with higher rates in males (60% vs. 48%, $p<0.01$), public hospital patients (58% vs. 52%, $p<0.05$), and low-income groups (60% vs. 50% in high-income, $p<0.01$). Energy drinks were consumed daily by 30% of males aged 12–30, particularly in public hospitals. Tap water was consumed regularly by 30%, with no significant difference by setting or income. Carbonated drinks (60%), tea (70%), coffee (40%) were more common in private clinics and higher-income groups. This is given in graph 02.



Graph 02: *Periodontal diseases because of beverages amongst different groups*

Association with Oral Health

Logistic regression showed daily sugary beverage consumption increased caries risk by 1.5 times (OR=1.50, 95% CI: 1.20–1.88, $p<0.01$), with energy drinks showing the strongest association (OR=1.80, 95% CI: 1.35–2.40, $p<0.001$). Tap water consumption was protective (OR=0.65, 95% CI: 0.50–0.85, $p<0.05$). Low income (OR=1.40, 95% CI: 1.10–1.78, $p<0.01$) and primary education (OR=1.35, 95% CI: 1.05–1.73, $p<0.05$) increased caries risk. Protective behaviors reduced risk: rinsing with water (25% reduction in erosion, $p<0.05$), chewing xylitol gum (10% reduction in caries progression, $p<0.05$), and using straws (20% reduction in erosion, $p<0.05$). Public hospital patients faced higher caries risk (OR=1.30, 95% CI: 1.05–1.60, $p<0.05$). This is given in graph 03.



Graph 03: *Beverages consumption Socioeconomic status, especially when comparing public tertiary care hospital attendees with private clinic patients.*

Discussion

This five-year, multicenter cohort study investigated the relationship between beverage consumption and oral health outcomes specifically dental caries and periodontal disease across diverse socioeconomic groups in Pakistan. The findings highlight significant disparities in oral health linked to beverage choices, and hydration patterns. A key finding of this study was the high prevalence of dental caries (65%), disproportionately affecting males (70%), public hospital patients (68%), and low-income individuals (72%). These groups also reported significantly higher daily sugary beverage consumption, with 60% of males, 58% of public hospital patients, and 60% of low-income participants consuming sugary drinks daily. These beverages commonly including lassi, rooh afza, carbonated sodas, and sugarcane juice contribute to acidogenic and cariogenic oral environments by reducing salivary pH and promoting enamel demineralization.

Logistic regression analysis confirmed that daily consumption of sugary beverages increased caries risk by 1.5 times (OR=1.50, 95% CI: 1.20–1.88, $p<0.01$). Notably, energy drinks, often consumed by males aged 12–30, showed the strongest association with caries (OR=1.80, 95% CI: 1.35–2.40, $p<0.001$), highlighting the impact of targeted marketing and lifestyle trends among younger populations. These results are consistent with previous global and regional studies indicating a direct link between high sugar consumption, low salivary flow, and increased caries incidence in hot climates where dehydration is common [1–3].

Conversely, tap water consumption, reported regularly by 30% of participants, emerged as a protective factor against dental caries (OR=0.65, 95% CI: 0.50–0.85, $p<0.05$). Despite no significant difference in tap water consumption between public and private patients, its protective role likely stems from improved hydration, salivary buffering, and, in some regions, natural fluoride content. This finding reinforces the importance of promoting clean, safe, and affordable water access, especially in urban and rural low-resource settings, where patients are more likely to consume packaged sugary alternatives due to lack of awareness or mistrust in water quality.

In terms of periodontal health, the study found a 35% prevalence of periodontal disease, again more prominent among males (40%), public hospital patients (38%), and low-income groups (40%). While the direct impact of beverages on periodontal health was less pronounced than on dental caries, the high sugar intake may contribute indirectly by promoting plaque accumulation and gingival inflammation, especially in patients with poor oral hygiene practices and limited access to preventive care.

The behavioral component of beverage consumption also played a role. Protective habits such as rinsing with water after sugary drinks, using straws, and chewing xylitol gum were more common in private clinic patients and higher socioeconomic groups and were associated with reduced risk of both caries and erosion. Specifically, rinsing reduced erosion by 25%, straw usage reduced it by 20%, and xylitol gum lowered caries progression by 10% ($p < 0.05$ for all).

The comparison between public and private healthcare settings also illustrated structural and behavioral inequalities. Public hospital patients not only had higher caries risk (OR=1.30, 95% CI: 1.05–1.60, $p < 0.05$) but also had lower education and income levels, contributing to higher intake of cariogenic beverages and lower adoption of protective oral health behaviors.

These findings call for a multi-tiered response:

Public health education campaigns promoting hydration with clean water, discouraging sugary beverage intake, and teaching practical oral hygiene behaviors.

Policy regulations on labeling and advertising of sugary drinks, particularly targeting youth.

Investment in public healthcare infrastructure, enabling dental providers to conduct dietary counseling and promote oral health in crowded tertiary care hospitals.

Limitations

While this study included diverse settings and a large sample size, limitations include the use of self-reported beverage consumption, introducing possible recall bias, and the absence of regional fluoride testing in tap water, which could further explain protective effects. Additionally, dietary and behavioral influences from outside the dental setting (e.g., school canteens, workplaces) were not assessed.

Conclusion

Daily consumption of sugary beverages significantly increases the risk of dental caries and contributes to periodontal disease, particularly in low-income groups and public hospital patients. Tap water, when consumed regularly, offers a protective effect, emphasizing the need for hydration-focused oral health education. Addressing socioeconomic disparities in dietary habits through targeted interventions is essential for improving oral health outcomes across Pakistan.

Conflict of Interest

The author declares no conflict of interest.

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