

Original Article

Association Between Beverage Consumption Patterns and Oral Sensitivity Among Adults in Karachi: A Cross-Sectional Study

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ABSTRACT

Background: Acidic and sugar-containing beverages may contribute to erosive tooth wear, dental caries, and dentine-related sensitivity, although evidence regarding these associations among Pakistani adults remains limited. **Objective:** To describe beverage-consumption patterns and examine the association between acidic-beverage consumption frequency and self-reported tooth sensitivity, dental caries, and tooth erosion among adults in Karachi. **Methods:** An analytical cross-sectional online survey included 375 adults aged ≥18 years recruited through non-probability convenience sampling. A structured self-administered questionnaire assessed sociodemographic characteristics, beverage-consumption patterns, and self-reported oral-health outcomes. Descriptive statistics and Pearson's chi-square tests were applied, with $p < 0.05$ considered statistically significant. **Results:** Among participants with available frequency data, 181/369 (49.1%) consumed acidic beverages 1-3 times weekly and 263/369 (71.3%) consumed them at least weekly. Tooth sensitivity was reported by 110/375 (29.3%), dental caries within the previous 12 months by 119/375 (31.7%), and tooth erosion by 44/372 (11.8%). Acidic-beverage frequency was not significantly associated with tooth sensitivity [$\chi^2(8)=11.338$, $p=0.183$], dental caries [$\chi^2(4)=2.729$, $p=0.604$], or tooth erosion [$\chi^2(8)=13.942$, $p=0.083$]. **Conclusion:** Acidic-beverage consumption was common, but consumption frequency was not significantly associated with the assessed self-reported oral-health outcomes in this cross-sectional sample. **Keywords:** Acidic beverages; beverage consumption; dentin sensitivity; dental caries; tooth erosion; cross-sectional study.

INTRODUCTION

Oral sensitivity is a common dental complaint that can interfere with eating, drinking, toothbrushing, and other routine oral-health activities. One of its principal clinical presentations is dentine hypersensitivity, typically characterized by a short, sharp pain arising from exposed dentine in response to thermal, evaporative, tactile, osmotic, or chemical stimuli. Its occurrence among adults has been associated with several dental and behavioral factors, including conditions that result in dentine exposure (1). The widely accepted hydrodynamic theory

proposes that external stimuli induce movement of fluid within open dentinal tubules, thereby activating pulpal nerve responses and producing the characteristic transient pain of dentine hypersensitivity (2).

Dietary exposure is particularly relevant because many commonly consumed beverages contain acids, sugars, or both. Acidic beverages include carbonated soft drinks, energy and sports drinks, packaged fruit juices, flavored beverages, and other products containing naturally occurring or added acids such as citric, phosphoric, carbonic, malic, or ascorbic acid. Repeated exposure of dental hard tissues to low-pH beverages can promote enamel demineralization and erosive surface changes, particularly when exposure is frequent or prolonged (3). Previous research has also demonstrated that awareness of dental erosion and beverage-related oral-health risks does not necessarily correspond with lower consumption of potentially erosive beverages, highlighting the importance of examining actual consumption behavior rather than knowledge alone (4).

The oral health effects of beverages may depend not only on beverage type but also on the manner and frequency of consumption. Repeated sipping, prolonged contact with the teeth, holding a beverage in the mouth, and consuming acidic drinks outside mealtimes may increase the duration of acid exposure and contribute to erosive tooth wear. Dietary acid exposure has also been associated with dentine hypersensitivity, particularly when erosive wear contributes to the exposure of cervical dentine (5). Observational evidence indicates that cervical dentine hypersensitivity is multifactorial and may be influenced by several behavioral and oral conditions in addition to dietary exposure (6). Experimental research further supports biological plausibility, as energy drinks have been shown to alter root-dentine surfaces and remove the smear layer, potentially increasing dentinal-tubule exposure to external stimuli (7).

Beverage consumption may also have implications beyond dentine hypersensitivity. Sugar-containing drinks can contribute to a cariogenic oral environment, whereas acidic beverages may contribute to erosive tooth wear; although these processes may coexist, dental caries and erosion have distinct biological mechanisms. Epidemiological research has reported associations between beverage consumption patterns and dental problems, including caries, erosion, and sensitivity, particularly among adolescents and young adults (8). Evidence from Pakistan has similarly documented substantial consumption of sweetened beverages among young adults together with self-reported oral-health problems (9). Studies among Pakistani student populations have also reported relationships between fizzy-drink consumption and dental sensitivity (10), as well as associations between beverage use and outcomes such as caries, sensitivity, plaque or calculus formation, and tooth staining (11). These findings indicate that beverage-related oral-health behaviors warrant further investigation within local populations, while also recognizing that differences in sampling, exposure definitions, and outcome measurement can influence observed associations.

Despite the biological plausibility and existing epidemiological evidence, important uncertainties remain regarding beverage consumption and oral sensitivity among adults in Pakistan. Much of the available local evidence has focused on students or young adults, and previous studies have commonly examined broad beverage categories without simultaneously describing several characteristics of consumption, such as frequency, duration, amount, added sugar, and temperature. In addition, oral sensitivity has received less focused attention than dental caries or erosive tooth wear. Because dentine hypersensitivity and other self-reported oral-health outcomes are multifactorial, evaluating beverage exposure within a clearly defined population may provide useful descriptive and analytical evidence, although cross-sectional data cannot establish temporal or causal relationships.

Accordingly, this analytical cross-sectional study aimed to describe beverage consumption patterns among adults recruited in Karachi, Pakistan, and to examine the association between the frequency of acidic beverage consumption and self-reported tooth sensitivity. Self-reported dental caries were diagnosed within the previous 12 months, and self-reported tooth erosion or worn-down teeth were evaluated as secondary oral-health outcomes. The study was intended to determine whether differences in acidic-beverage consumption frequency were associated with these outcomes within the surveyed population and to provide baseline evidence for future studies using objective clinical assessment and more comprehensive control of potential confounding factors.

MATERIALS AND METHODS

This analytical cross-sectional study was conducted over a six-month period in Karachi, Pakistan, to evaluate the relationship between beverage consumption patterns and self-reported oral-health outcomes among adults. A

cross-sectional design was used because beverage-consumption characteristics and oral-health outcomes were assessed concurrently within the study population. The target population comprised adults aged 18 years or older who were willing to participate voluntarily and were able to understand and complete the online questionnaire. Individuals were eligible if they were aged ≥ 18 years, could comprehend the survey questions, and provided electronic informed consent before participation. Participants undergoing active dental treatment that could influence oral sensitivity, those with diagnosed oral conditions considered likely to affect dental sensitivity, those with systemic conditions that could influence oral health or pain perception, substantially incomplete questionnaires, and duplicate submissions identified during data screening were excluded from the analysis.

Participants were recruited using a non-probability convenience-sampling approach through online platforms and social-media networks during the study period. The questionnaire was distributed electronically to eligible adults, and participation was voluntary. An electronic information and consent statement was presented at the beginning of the survey, and participants were required to indicate their willingness to participate before proceeding with the questionnaire. No personally identifiable information was collected, and responses were obtained anonymously. These procedures were intended to maintain participant confidentiality and reduce concerns related to disclosure of personal information.

The required sample size was estimated using the single-population proportion formula, $n = Z^2 p(1 - p)/d^2$, assuming a 95% confidence level ($Z = 1.96$), an expected proportion of 50% in the absence of an established local estimate, and a 5% margin of error. This calculation yielded a minimum estimated sample of approximately 384 participants. Considering recruitment feasibility and the anticipated response during the study period, a practical recruitment target of approximately 375 participants was adopted, and 375 participants were included in the final study sample.

Data were collected using a structured, self-administered questionnaire developed following review of relevant literature concerning beverage-consumption behaviors, oral-health practices, and oral sensitivity. The questionnaire comprised four principal domains covering sociodemographic characteristics, beverage-consumption patterns, oral-hygiene behaviors, and awareness and experience of oral sensitivity and related oral-health outcomes. Before administration, the questionnaire was reviewed by senior faculty members for face validity, with attention to clarity, relevance, and completeness. The finalized questionnaire was then administered electronically using an online survey format.

Beverage consumption was evaluated using several self-reported characteristics, including beverage type, frequency of acidic-beverage consumption, duration of consumption, average quantity consumed per occasion, addition of sugar, usual beverage temperature, and related drinking habits. Acidic beverages were considered beverages with acidic characteristics attributable to naturally occurring or added acids and included commonly consumed products such as carbonated soft drinks, energy and sports drinks, packaged fruit juices, flavored beverages, iced teas, and sparkling drinks. Frequency of acidic-beverage consumption was categorized as never or rarely, one to three times per week, four to six times per week, daily, or more than once daily. Duration of consumption, amount consumed per occasion, addition of sugar, and usual consumption temperature were recorded using the predefined response categories included in the questionnaire.

Self-reported tooth sensitivity was designated as the primary outcome. Participants classified their experience of tooth sensitivity using the questionnaire response categories of yes, no, or maybe. Secondary oral-health outcomes included self-reported dental caries diagnosed during the preceding 12 months and self-reported tooth erosion or worn-down teeth. The latter outcome reflected participants' reports of having been informed by a dentist about worn-down teeth and was categorized as yes, no, or not sure. All oral-health outcomes were therefore based on participant report rather than direct clinical examination. Sociodemographic characteristics and oral-hygiene information were also collected as potentially relevant contextual variables.

Several procedures were used to support data quality during collection and analysis. Participation was anonymous, substantially incomplete questionnaires were excluded, and submissions identified as duplicates during data screening were removed. Questionnaire items were reviewed before administration for clarity and relevance. For questionnaires retained in the final dataset, analyses were based on the available responses for each study variable; consequently, the analytical denominator could vary between variables when individual item responses were missing. No imputation of missing responses was reported.

Data were entered and analyzed using IBM SPSS Statistics version 27.0. Participant characteristics, beverage-consumption patterns, and oral-health outcomes were summarized using descriptive statistics. Categorical variables were presented as frequencies and percentages, while means and standard deviations were planned for continuous variables where applicable. The principal inferential analysis examined associations between frequency of acidic-beverage consumption and the study outcomes. Pearson's chi-square test was used to evaluate associations between categorical beverage-frequency groups and self-reported tooth sensitivity, dental caries diagnosed within the previous 12 months, and self-reported tooth erosion. All tests were two-sided, and a p-value <0.05 was considered statistically significant. The reported analyses were unadjusted; although demographic and oral-hygiene variables were collected, no multivariable confounder-adjusted model or subgroup analysis was performed.

Ethical approval was obtained from the PRIDE Center of Research and Learning Institute Ethical Review Board Committee before data collection (Reference No. PRIDE/ERB/2026/099). Participation was voluntary, and electronic informed consent was obtained before completion of the questionnaire. No personally identifiable information was collected, participant responses were maintained confidentially, and study data were analyzed and reported in aggregate form to protect participant privacy.

RESULTS

A total of 375 participants were included in the study. Sociodemographic characteristics are presented in Table 1. Among the 374 participants with available age data, 269 (71.9%) were aged 18–25 years and 79 (21.1%) were aged 26–35 years. Females comprised 235 (62.7%) of the overall sample. Nearly half of participants were undergraduates (183/375, 48.8%) and students (185/375, 49.3%).

Table 1. Sociodemographic Characteristics of Participants

Variable	Category	n (%)
Age, years (N=374)	18–25	269 (71.9)
	26–35	79 (21.1)
	36–45	13 (3.5)
	>45	13 (3.5)
Gender (N=375)	Female	235 (62.7)
	Male	140 (37.3)
Educational level (N=375)	Undergraduate	183 (48.8)
	Graduate	147 (39.2)
	Postgraduate	32 (8.5)
	Secondary	13 (3.5)
Occupation (N=375)	Student	185 (49.3)
	Employed	142 (37.9)
	Self-employed	25 (6.7)
	Unemployed	23 (6.1)

Beverage-consumption characteristics are summarized in Table 2. Among the 369 participants with available data on acidic-beverage frequency, 181 (49.1%) consumed acidic beverages one to three times per week, while 106 (28.7%) reported never or rarely consuming them. Overall, 263 of 369 participants (71.3%) reported consuming acidic beverages at least once per week, and 39 (10.6%) reported consumption at least daily. Long-term exposure was common, with 157 of 375 participants (41.9%) reporting consumption for more than five years. Most participants consumed approximately one glass or cup per occasion (213/375, 56.8%), 127 of 374 (34.0%) reported adding sugar, and 202 of 375 (53.9%) usually consumed cold beverages.

Table 2. Beverage-Consumption Characteristics

Variable	Category	n (%)
Frequency of acidic-beverage consumption (N=369)	Never/rarely	106 (28.7)
	1–3 times/week	181 (49.1)
	4–6 times/week	43 (11.7)
	Daily	30 (8.1)
	>1 time/day	9 (2.4)
Duration of consumption (N=375)	<1 year	40 (10.7)
	1–3 years	96 (25.6)
	3–5 years	82 (21.9)
	>5 years	157 (41.9)

Variable	Category	n (%)
Average amount per occasion (N=375)	<1 glass/cup	116 (30.9)
	1 glass/cup, approximately 250 mL	213 (56.8)
	≥2 glasses/cups	46 (12.3)
Added sugar (N=374)	No	247 (66.0)
	Yes	127 (34.0)
Usual beverage temperature (N=375)	Cold	202 (53.9)
	Room temperature	91 (24.3)
	Hot	82 (21.9)

Self-reported oral-health outcomes are shown in Table 3. Tooth sensitivity was reported by 110 of 375 participants (29.3%), while a further 84 (22.4%) selected the response category “maybe.” Dental caries diagnosed during the preceding 12 months was reported by 119 participants (31.7%). Among the 372 participants with available information on tooth erosion or worn-down teeth, 44 (11.8%) reported a positive history and 49 (13.2%) were uncertain.

Table 3. Self-Reported Oral-Health Outcomes

Outcome	Response	n (%)
Tooth sensitivity (N=375)	No	181 (48.3)
	Yes	110 (29.3)
	Maybe	84 (22.4)
Dental caries are diagnosed within previous 12 months (N=375)	No	256 (68.3)
	Yes	119 (31.7)
Tooth erosion/worn-down teeth (N=372)	No	279 (75.0)
	Not sure	49 (13.2)
	Yes	44 (11.8)

The associations between acidic-beverage consumption frequency and the three oral-health outcomes are presented in Table 4. No statistically significant association was identified between acidic-beverage frequency and self-reported tooth sensitivity, $\chi^2(8)=11.338$, $p=0.183$. Based on the analytical sample of 369 participants with available beverage-frequency data, the corresponding Cramér’s V was 0.124, indicating a small unadjusted association. Acidic-beverage frequency was also not associated with dental caries diagnosed within the previous 12 months, $\chi^2(4)=2.729$, $p=0.604$; the derived Cramér’s V was 0.086. The association with self-reported tooth erosion was likewise not statistically significant, $\chi^2(8)=13.942$, $p=0.083$. Although this was the smallest p-value among the three comparisons, it remained above the prespecified significance threshold of 0.05.

Table 4. Association Between Acidic-Beverage Consumption Frequency and Self-Reported Oral-Health Outcomes

Exposure	Outcome	χ^2	df	p-value
Acidic-beverage consumption frequency	Tooth sensitivity	11.338	8	0.183
Acidic-beverage consumption frequency	Dental caries diagnosis	2.729	4	0.604
Acidic-beverage consumption frequency	Tooth erosion/worn-down teeth	13.942	8	0.083

χ^2 , Pearson chi-square statistic; df, degrees of freedom. Statistical significance was defined as $p<0.05$.

DISCUSSION

The present study showed that acidic-beverage consumption was common among the surveyed adults, with regular and long-term intake reported by a substantial proportion of participants. However, frequency of acidic-beverage consumption was not significantly associated with self-reported tooth sensitivity, dental caries diagnosed during the preceding 12 months, or self-reported tooth erosion. The observed associations with tooth sensitivity and dental caries were small in magnitude, suggesting that consumption frequency alone may not adequately characterize the relationship between beverage exposure and these multifactorial oral-health outcomes. These findings should therefore be interpreted as evidence of an absence of a detectable association within this cross-sectional convenience sample rather than evidence that acidic beverages have no relevance to dental health.

The frequency of self-reported tooth sensitivity and dental caries observed in the present sample was somewhat lower than that reported in a cross-sectional study of young adults in Peshawar, where 41.7% reported tooth sensitivity and 41.1% reported dental caries (9). Previous Pakistani studies have also reported relationships between fizzy-drink consumption and dental sensitivity among students (10), as well as associations between beverage consumption and a range of self-reported oral-health problems (11). Similarly, beverage-consumption patterns have been associated with dental caries and tooth erosion among Iranian adolescents (8). The absence of statistically

significant associations in the present study therefore differs from some previous regional findings. Differences in population composition, age distribution, beverage classification, exposure intensity, outcome definitions, and analytical approaches may partly explain these discrepancies. In particular, the current sample consisted predominantly of young adults and students, and the principal inferential analysis categorized exposure only according to frequency rather than incorporating the broader pattern of beverage consumption.

Despite the null statistical associations observed in this study, a biological basis exists for concern regarding repeated exposure to acidic beverages. Carbonated and other acidic drinks can expose enamel to low-pH conditions that favor mineral dissolution and progressive erosive changes, particularly when contact is repeated or prolonged (3). Experimental evidence has demonstrated structural alterations of enamel following acidic-beverage exposure (12), while in-vitro investigations have also documented reductions in enamel surface hardness and ultrastructural changes after exposure to erosive beverages (13). Reviews of dental erosion similarly identify repeated acidic exposure as an important component of erosive tooth wear and emphasize the relevance of preventive measures aimed at reducing repeated acid challenges (14,15). When erosion progresses sufficiently to expose dentine, open dentinal tubules may facilitate fluid movement in response to thermal or chemical stimuli, providing a plausible pathway for dentine hypersensitivity (2,5,7).

The relationship between beverages and dental caries should nevertheless be distinguished from erosive tooth wear. Dental erosion primarily involves chemical dissolution of dental hard tissue by non-bacterial acids, whereas caries is a biofilm-mediated process strongly influenced by fermentable carbohydrate exposure. Sugar-containing beverages may contribute to repeated substrate availability for cariogenic microorganisms, but the resulting risk depends on the frequency and duration of sugar exposure together with oral hygiene, fluoride exposure, salivary factors, and other behavioral characteristics. A cross-sectional study among adolescents in Iraq, for example, identified an association between sugar-sweetened beverage consumption and greater caries experience after considering additional oral-health factors (16). Consequently, classifying beverages principally by acidic-beverage frequency may not capture the distinct exposure characteristics that are most relevant to caries development.

Several characteristics documented in the present study may be important even though they were not incorporated into the principal inferential analysis. Participants differed in duration of beverage use, amount consumed per occasion, addition of sugar, and beverage temperature, and the questionnaire also sought information on drinking behaviors. Previous research indicates that dietary-acid exposure may interact with behavioral factors such as the frequency and timing of consumption and toothbrushing practices in relation to erosive wear and hypersensitivity (5). Thus, two participants within the same weekly frequency category could experience substantially different patterns of tooth exposure depending on beverage type, volume, acidity, sipping duration, timing relative to meals, and other oral-health behaviors. The current finding therefore suggests more specifically that the broad frequency categories used in this study were not independently associated with the self-reported outcomes, rather than establishing that all dimensions of beverage consumption are unrelated to oral health.

Outcome measurement may also have contributed to the lack of detectable associations. Tooth sensitivity was self-reported using yes, no, and maybe response categories, with the uncertain category accounting for a substantial proportion of participants. Such classification may include transient sensitivity from causes other than dentine hypersensitivity and may dilute differences between exposure groups. Similarly, tooth erosion was based on a participant-reported history of being informed about worn-down teeth rather than direct examination using a standardized erosive-wear index. Dental caries was based on reported diagnosis during the previous 12 months rather than contemporaneous clinical assessment. Because early erosive lesions and caries may remain unrecognized by participants, nondifferential outcome misclassification could have reduced the ability to identify underlying associations. This is particularly relevant because clinically assessed dentine hypersensitivity is known to be influenced by multiple local and behavioral factors (1,6).

The findings also have implications for oral-health promotion. The high frequency and long duration of acidic-beverage consumption observed in this sample indicate that beverage-related dietary behaviors are common among the predominantly young adult participants. However, because this study did not demonstrate a statistically significant exposure–outcome association, it cannot establish that modifying beverage frequency alone would reduce tooth sensitivity, caries, or erosion in this population. Preventive advice should instead remain consistent with the broader evidence base supporting reduced repeated exposure to erosive or sugar-containing beverages,

appropriate oral-hygiene practices, and routine dental assessment where symptoms or visible tooth wear occur (3,14). Previous survey evidence also indicates that awareness of beverage-related erosion does not necessarily translate into protective consumption practices, highlighting the importance of practical behavioral guidance rather than education based solely on risk awareness (4).

The study has several strengths, including examination of a locally relevant dietary exposure, inclusion of multiple descriptive characteristics of beverage consumption, assessment of several oral-health outcomes, and recruitment of a relatively large sample. Nevertheless, important limitations should guide interpretation. The cross-sectional design prevents determination of temporal sequence or causality. Non-probability online convenience sampling and the predominance of younger, highly educated participants limit generalizability to the broader adult population of Karachi. Beverage exposure and oral-health outcomes were self-reported, and the questionnaire was subjected to face validation rather than comprehensive psychometric validation or clinical confirmation. The principal analysis considered acidic-beverage frequency without adjustment for potential confounding variables or simultaneous evaluation of beverage quantity, duration, sugar addition, oral-hygiene practices, fluoride exposure, salivary characteristics, or other relevant factors. Item-level missing responses resulted in different analytical denominators, while the smallest high-frequency beverage category contained relatively few participants, potentially limiting statistical precision. Future research using probability-based recruitment, validated exposure assessment, standardized clinical measures of dentine hypersensitivity, caries and erosive tooth wear, and appropriately adjusted multivariable analyses would provide a more definitive evaluation of the relationship between beverage-consumption patterns and oral health.

CONCLUSION

Acidic-beverage consumption was common among the adults surveyed in Karachi, and self-reported tooth sensitivity and dental caries were also frequent; however, acidic-beverage consumption frequency was not significantly associated with self-reported tooth sensitivity, dental caries diagnosed within the previous 12 months, or self-reported tooth erosion. These findings indicate that beverage-consumption frequency alone did not explain variation in the assessed oral-health outcomes within this cross-sectional sample and support interpreting oral sensitivity and related dental outcomes as multifactorial conditions that require more comprehensive exposure and clinical assessment.

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