Correlation between demographic and environmental factors and dental caries prevalence in a remote Indonesian coastal community: a cross-sectional study

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Received: 21 January 2026
Revised: 16 Februari 2026
Accepted: 20 March 2026
Published: 31 March 2026
DOI: 10.24198/pjd.vol38no1.68102

p-ISSN 1979-0201
e-ISSN 2549-6212

Citation:
Masyhudi, M, Candra, KP, Handayani, E, Ahmad, I, Bujang, K. Correlation between demographic and environmental factors and dental caries prevalence in a remote Indonesian coastal community: a cross-sectional study. Padjajaran J. Dent. Month. 2026; 38(1): 133-141.

ABSTRACT

Introduction: Dental caries is a significant global health concern. Factors such as socioeconomic status, diet, oral hygiene, and access to dental care influence its prevalence. Limited information exists on dental health in remote sea-floating villages. This study aimed to analyze the correlation between demographic and environmental factors and dental caries prevalence in a sea-floating community. **Methods:** This cross-sectional study was conducted in Malahing Village, a sea-floating village located adjacent to the Makassar Strait, 4 km east of Bontang city. Seventy-two respondents aged 5–59 years were examined for the DMFT index, while intrinsic factors (demographic and dental health behaviors) and extrinsic factors (environmental and dental health services) were collected via questionnaires. Data were analyzed using descriptive univariate analysis to determine variable characteristics and Spearman's correlation analysis. **Results:** Dental caries prevalence was 98.61%, with a DMFT index of 10.01. Age (r=0.564, p=0.001), education (r=0.370, p=0.002), and occupation (r=0.273, p=0.020) showed strong, moderate, and weak positive correlations, respectively. Rainwater exposure (r=-0.353, p=0.003) showed a moderate negative correlation. Sex, dental health behaviors, water source, and dental visits were not significantly correlated with caries prevalence. Adults showed highest prevalence (66.67%) but low DMFT index (1.00). Government employees had high DMFT scores (4.61). Twice-daily brushing was uncommon (66.67%) among individuals with high DMFT scores (6.15). Patients who never visited a dentist (44.44%) showed high DMFT scores (8.33). **Conclusions:** In this underserved coastal community, demographic disadvantages and environmental exposures, particularly water sources, combined with limited dental care contribute to an elevated caries burden compared to the national and international levels. Despite complex associations with environmental factors, rainwater exposure showed negative correlation with caries prevalence, highlighting measurement challenges. The high proportion of patients never visited a dentist, low oral health awareness, and nonstandard water management highlight critical service gaps.

KEYWORDS

DMFT, bontang city, malahing village, coastal community

INTRODUCTION

Dental caries is the most common oral disease and the leading cause of tooth loss worldwide.[1,2] In recent years, according to the World Health Organization (WHO) criteria, dental caries has affected approximately 90% of the population, with approximately 68% affecting children.[3] According to 'Aisy,[4] there was a significant relationship between diet and dental caries incidence among children. Based on The Global Burden of Disease Study in 2016, dental and oral health problems, especially dental caries, are diseases experienced by almost half of the

world's population, namely 3.58 billion people, and the Marcenes Study (2017) reported that the incidence of caries in permanent teeth that are not treated is the most common condition that affects 2.5 billion people worldwide.[5] Basic Health Research (Riskesdas) in 2018 stated that the largest proportion of dental problems in Indonesia is dental caries (45.3%), with prevalence also reported in East Kalimantan (48.4%) and Samarinda (46.42%).[6]

The prevalence of dental caries is generally higher and continues to increase in low- and middle-income countries due to changing lifestyles and limited access to dental care, while high-income countries have experienced a decline due to preventive measures and better oral health practices.[7] The multifactorial nature of dental caries and its persistently high prevalence, especially in low- and middle-income countries, underscores the need for continued efforts in prevention, early intervention, and improved access to dental care globally.[2,8]

Public health interventions should focus on education, prevention, and treatment to reduce the impact of individual risk factors while addressing broader socioeconomic determinants.[9] Developing effective strategies for underserved communities requires consideration of the complexity of socioeconomic dynamics and engagement of various stakeholders, including policymakers, dental professionals, and community members.[10]

Previous studies have consistently demonstrated that age,[11,12] socioeconomic status,[11,13] and oral hygiene practices[14] are significantly associated with the prevalence of dental caries in various populations. These findings underscore the importance of targeted interventions and policies addressing these risk factors to reduce the burden of dental caries. However, some studies have reported conflicting results. For example, Macharia *et al.*[15] found that oral hygiene practices did not influence oral health and dental caries status among visually impaired adolescents. However, most studies support an association between these factors and caries prevalence.

No study has specifically addressed sea-floating communities, and only a few have examined coastal communities in relation to dental caries. Investigating these aspects in coastal populations could reveal unique risk factors or protective elements related to their specific lifestyle, diet, or access to dental care, potentially informing targeted prevention strategies and providing valuable insights for these communities. Several studies have shown that environmental and socio-behavioral factors play significant roles in determining oral health outcomes.

Elamin *et al.*[11] found that rural nursery locations were associated with higher dental caries rates among UAE children than urban nurseries. There are variations in the prevalence of dental caries between urban and semi-urban areas in Croatia[16] and Nepal[17], with children in semi-urban areas having a higher prevalence of dental caries. This highlights the importance of considering the unique environmental and social factors present in coastal regions, which may differ from those in inland urban areas.

This study represents one of the first reports on dental caries prevalence in a remote sea-floating coastal community adjacent to the mainland within a humid rainforest climate. This study aims to analyze the correlation between demographic and environmental factors and the dental caries prevalence in the sea-floating community.

METHODS

This study employed an analytical observational design with a cross-sectional approach. Respondents were drawn from 261 individuals residing in Malahing Village. The number of respondents was calculated using the Slovin formula with a 5% margin of error, resulting in a minimum sample size of 70 (95% confidence level).[18,19] In this study, a total of 72 respondents aged 6-53 years were recruited through voluntary sampling. Inclusion and exclusion criteria were applied,

including individuals who had lived in Malahing Village since childhood and those permanently living in Malahing Village.

This study was conducted in Malahing Village, located in the Tanjung Laut Sub-district, Bontang Selatan District, Bontang City, East Kalimantan Province, Indonesia (Figure 1). The village is located at 0°06'55"N 117°31'46"E (Google Earth) adjacent to the Makassar-Strait with a water depth of 5-10 m, and is a remote sea-floating village, currently being developed as a tourism destination by the Bontang City Government, having previously functioned as a fishing village.[20,21] The village is approximately 4 km from the mainland and can be reached by a motorboat in approximately 20-25 minutes.[22] The climate in the region is humid tropical rainforest,[23] with an average of 15 rainy days per month and a rainfall intensity of 185-208 mm cubic.[24]

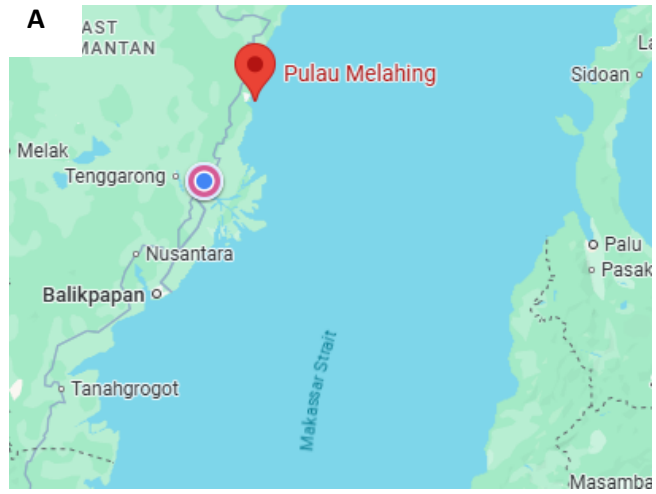

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Figure 1. Malahing Village as the study site. A: The village is located approximately 4 km East of Bontang city coast on the mainland (Kalimantan Island). B, C, and D: Malahing Island is located behind (west of) the village. Participants were recruited through voluntary sampling and surveyed accordingly.

Dental and oral examinations were conducted in November 2023 by clinical dental students, accompanied by a dentist. Intrinsic data (demographic factors and dental health behaviors) were obtained using self-developed questionnaires, including respondent identity, type of drinking water source, history of dental health service, oral hygiene practice, food consumption knowledge and behavior, and dental health behavior.

Simultaneously, extrinsic data (environmental factors, such as rainwater exposure and drinking water resources, as well as dental health services) were collected. Data collection was conducted using interviewer-administered questionnaires. Trained dental students conducted dental examinations and oral cavity assessments with the assistance of dentists. The research data included primary information about sex, age, education, occupation, water sources, dental cleaning tools, tooth brushing frequency, dentist services, and dental caries scores, while data collection for dental caries assessment was based on the DMFT index.

Oral diagnostic instruments were used to determine the number of cavities (D), missing teeth (M), and fillings (F), and the DMFT index was calculated using the WHO- recommended formula,[25] DMFT index = (Samples DMFT Score) / (Number of Samples tested). The DMFT index value range was categorized into five groups according to dental caries prevalence: very low (0.0–1.1), low (1.2–2.6), moderate (2.7–4.4), high (4.5–6.5), and very high (>6.6).[25]

The instruments used in this study included questionnaires and oral diagnostic tools. The Dental and Oral Health Behavior Questionnaire consisted of ten questions divided into two categories: six positive questions ("yes" responses scored as 1 and "no" responses scored as 0), and four negative questions ("yes" responses scored as 0 and "no" responses scored as 1). The questionnaire demonstrated acceptable validity of 0.6.

Researchers visited the residents' homes to identify participants meeting the inclusion criteria (individuals who had lived in Malahing Village since childhood) and exclusion criteria (those not permanently living in the Malahing Village). Informed consent was obtained from all eligible participants. Participant identities were recorded, and interviews were conducted using questionnaires. Dental caries status (DMFT) was assessed by calculating the number of decayed, missing, and filled teeth using oral diagnostic instruments.

Data were analyzed descriptively (univariate) and associatively (bivariate). Univariate analysis was performed to describe the community's dental health profile and the participants' demographic characteristics. Bivariate analysis (Spearman's Correlation) was conducted to assess relationships between variables, particularly between the community's dental health profile and

demographic characteristics. The χ^2 test was used for nominal data (sex). Data analysis was performed using SPSS version 25.

RESULTS

In the sea-floating community studied, a higher prevalence (98.61%) of dental caries was observed (Table 1). Demographic factors significantly correlated ($p<0.05$) with dental caries in Malahing Village included age, occupation, and education, while among environmental factors, only rainwater exposure showed a significant association. Age showed a strong positive correlation ($r=0.564$, $p=0.000$), education had a moderate positive correlation ($r=0.370$, $p=0.002$), and occupation had a weak positive correlation ($r=0.273$, $p=0.020$) with dental caries. In addition, rainwater exposure showed a moderate negative correlation ($r=-0.353$; $p=0.003$) with dental caries prevalence.

Table 1. Correlation between environmental factors and the prevalence of dental caries in coastal communities in Malahing Village (n=72).

Factors	Prevalence (%)	DMFT Index	Criteria	Spearman correlation [except *) using χ^2]	
Intrinsic				r	p
Demographic					
Sex*)				-0.46	0.699
Male	43 (59.72)	5.92	High		
Female	29 (38.89)	4.10	Moderate		
Age				0.564	0.000
Children, 5-11 years old	16 (20.83)	1.56	Low		
Adolescents, 12-18 years old	8 (11.11)	0.44	Very low		
Adults, 19-59 years old	48 (66.67)	1.00	Very low		
Work				0.273	0.020
Students	24 (31.94)	2.00	Low		
Government Employee	25 (34.72)	4.61	High		
Fishermen	9 (12.50)	1.10	Very low		
Housewives	10 (13.89)	1.81	Low		
Private sector workers	4 (5.56)	0.50	Very low		
Education				0.370	0.002
Not attending school	29 (38.89)	3.06	Moderate		
Elementary School	7 (9.72)	0.78	Very low		
Junior High School	25 (34.72)	3.93	Moderate		
Senior High School	5 (6.94)	0.83	Very low		
Higher Education	3 (4.17)	0.69	Very low		
Habit					
Tooth-cleaning methods				-0.058	0.637
Toothbrush	38 (52.78)	4.99	High		
Toothbrush, Toothpick	18 (23.61)	3.21	Moderate		
Toothbrush, Dental floss	5 (6.94)	0.32	Very low		
Toothbrush, Dental floss, Toothpick	5 (6.94)	0.57	Very low		
Toothbrush, Dental floss, Siwak	1 (1.39)	0.18	Very low		
Toothpick	1 (1.39)	0.10	Very low		
Toothbrush, Toothpick, Siwak	1 (1.39)	0.08	Very low		
Frequency of tooth brushing				0.182	0.134
Once a day	4 (5.56)	0.58	Very low		
Twice a day	49 (66.67)	6.15	High		
Three times a day	16 (22.22)	2.71	Moderate		
Extrinsic (Environment)				r	p
Rainwater Exposure				-0.353	0.003
Consumed rainwater	39 (56.50)	4.36	High		
Did not consume rainwater	30 (43.50)	4.90	High		
Drinking water sources				-0.230	0.068
Rainwater	24 (37.5)	3.33	Moderate		
Water from local water company**	13 (20.30)	2.08	Low		
Bottled water	3 (4.70)	0.61	Very low		
Groundwater***	9 (14.10)	1.46	Low		
Rainwater and water from Local Water Company	11 (17.20)	0.89	Very low		
Rainwater and Bottled Water	4 (6.30)	0.17	Very low		
Dentists visit frequency				0.128	0.288
Never	32 (44.44)	8.33	Very high		
> last 3 years	21 (29.17)	7.00	Very high		
Last 2-5 years	17 (23.61)	4.00	Moderate		
Last 1-2 years	9 (12.50)	2.88	Moderate		
Last 6 months	6 (8.33)	2.42	Low		
< last 6 months	16 (22.22)	4.83	High		

Notes: *) χ^2; **) Tap water (clean water) from Bontang City has been available from the mainland since 2022 by pipe installation, as it was previously transported by boat; ***) transported by boat.

Conversely, other demographic factors, such as sex ($p=0.699$), tooth cleaning methods ($p=0.637$), and frequency of tooth brushing ($p=0.134$) were not significantly associated with dental caries in the sea-floating village community. In addition, environmental factors, namely drinking water sources

(p=0.068) and dental visits (p=0.228), were not significantly correlated with dental caries prevalence.

A notable proportion of participants were adults (19-59 years), comprising 66.67% of the sample, and had a very low DMFT index (1.00). The DMFT index was used to describe the dental caries profile in the community.[26] Government employees had a high DMFT index (4.61). Twice-daily tooth brushing was the most common (66.67%), yet it was associated with a high DMFT index (6.15). Approximately 44.44% of the population had never visited a dentist and showed a very high DMFT index (8.33). The environmental conditions in Malahing Village include limited access to dental care services, low awareness of the importance of oral health, reliance on acidic rainwater, and challenges in water management in meeting health standards.

Table 2. Profile of teeth decay types and its correlation (decay) with missing and filling in the community of Malahing Village (*n=72*)

Types of teeth decay	Total (%)	Median	Range	Spearman correlation (*r*, *p*)	
				Missing	Filled
Decayed teeth	556 (77.12%)	7	0-26	0.008, 0.949	0.144, 0.229
Missing teeth	160 (22.19%)	1	0-25		
Filled teeth	5 (0.69%)	0	0-1		

Note: DMFT index = 10.01

A DMFT index of 10.1 (very high) (Tables 2) was determined in the sea-floating community studied. The DMFT was calculated as the median. Decayed teeth were the most prevalent issue, followed by missing teeth, whereas fillings are relatively uncommon. The types of dental caries were independent of each other: decayed-missing teeth (p=0.949) and decayed-filled teeth (p=0.229).

DISCUSSION

This study is one of the first to document the dental caries profile of a floating sea community. The prevalence of dental caries in our study population (98%) was significantly higher than the average Indonesian population, reported at 68.59%.[27] The severity of dental caries indicates potential issues related to access to dental care.

In this study, age was the most significant factor affecting dental health in this population. The highest prevalence was observed among adults (19-59 years), reaching 66.67% despite having very low cavity levels (DMFT index = 1.0). The strong positive correlation between age and dental caries (r=0.564; p=0.000) supports the hypothesis that the risk of dental caries increases with age. These findings are in line with a previous report by Moca *et al.,*[28] which showed that age can impact the development of dental caries in first permanent molars. Kato *et al.*[29] and Kapil *et al.*[12] reported that the positive correlation between age and dental caries may be influenced by oral hygiene practices, dietary habits, and socioeconomic status. However, this study showed that oral hygiene practices were not significantly correlated.

This study showed that occupation and education were positively correlated with the prevalence of dental caries. Zhang *et al.*[30] and Kato *et al.*[29] reported similar evidence that parental occupation and household income, along with education, all significantly influence dental caries prevalence among children. These findings underscore the importance of considering education as a key factor in oral health interventions and policies aimed at reducing dental caries, particularly in children. Qin *et al.*[31] stated that demographic and regional differences correlate differently with the prevalence of dental caries, and untreated dental caries remain a major global public health challenge. Aggressive

intervention strategies at both administrative and academic levels, based on dynamic changes, are required.

In this study, a higher prevalence of dental caries was observed among respondents who brushed their teeth more frequently (at least twice daily) compared to those who brushed once daily. Previous studies have reported the opposite finding, where increased tooth brushing frequency is associated with reduced caries risk[32–34], however, experimental studies have demonstrated that tooth abrasion is influenced not only by the abrasivity of toothpaste but also by excessive brushing force.[35] This finding underscores the necessity of educational interventions focused on proper brushing techniques and habits to enhance overall dental health. The practice of brushing teeth with adequate frequency, when executed with improper technique—such as excessive force or the use of a hard-bristled toothbrush—can contribute to tooth damage and potentially increase susceptibility to dental caries.[34,36]

Tap water from mainland Bontang City has been available since 2022. However, not all households have access due to financial constraints. In Malahing Village, rainwater consumers tended to have a higher prevalence of dental caries than non-consumers. This may be attributed to the mildly low pH of the rainwater in Malahing Village. Acidic beverages with lower pHs can promote enamel erosion through initial acid etching.[37] Prakash *et al.*[38] reported that the rainfall pH has become an environmental concern over the past century, with an average pH of approximately 5.6. However, in some regions, acidity levels show a broader range. Qu and Han[39] reported that in urban and industrial areas in China, anthropogenic emissions of sulfur and nitrogen oxides lead to acid-rain formation.

Preventive measures are needed for individuals who rely on rainwater, as they demonstrated higher caries prevalence and DMFT scores. Some reports have described in detail that addition of fluoride in drinking water prevents the dental caries prevalence.[40,41] Individuals consuming rainwater may need to rely on alternative fluoride sources, such as fluoride-containing toothpaste,[42] to maintain their oral health and prevent dental caries. Additionally, policy initiatives in Bontang City should prioritize expanding access to tap water to effectively mitigate dental caries in this community. Improving oral health education and reducing reliance on untreated rainwater may further help mitigate dental caries in this population.

Malahing Village is a sea-floating community with a population of 261 people. By using the number of 72 respondents of 126 residents in the village, this study should show accurate results as the number of the respondents was fulfil the category of having 95% confidence level (accuracy) while using the Slovin formula.[18,19] However, some reports recommend at least 100 respondents in a survey study.[43] Nonetheless, Piovesana and Senior[44] emphasized that using 50 samples is sufficient to obtain a stable mean and standard deviation in normally distributed data, and a minimum confidence level of 90% should be applied.

A limitation of this study is its cross-sectional design, which precludes establishing causality between the identified factors and dental caries.[45,46] Further investigation into the reasons behind these patterns and targeted interventions is warranted improve overall dental health in this community.

CONCLUSION

The study shows that in this underserved coastal community, demographic disadvantages and environmental exposures, particularly those related to water sources, combine with limited preventive and restorative dental care to create a significantly elevated caries burden compared to national and international levels. Despite some complex and non-significant associations with environmental factors, rainwater exposure showed a notable negative correlation with caries prevalence, underscoring challenges in exposure measurement and potential

confounding factors. The high proportion of individuals who have never visited a dentist, coupled with low oral health awareness and nonstandard water management, highlights critical service and prevention gaps.

The implications of this research are that these findings support the urgent need for targeted interventions, including expanding reliable tap-water access, enhancing oral health education focused on proper brushing techniques and fluoride use, and improving the reach of dental services. Given the cross-sectional design, causal relationships cannot be established, emphasizing the need for longitudinal follow-up studies and intervention assessments to effectively address dental health disparities in this population.

Acknowledgement: Our gratitude to LP2M of Mulawarman University
Author Contributions: Conceptualization, K.P.C., M.M.; Methodology, K.P.C., M.M.; Investigation, M.M.; Data curation, M.M.; Validation, M.M., K.P.C., E.H.H., I.A.; Analysis Data, M.M., K.P.C.; Visualization, M.M.; Writing original draft preparation, M.M., K.P.C.; Reviewing and editing manuscript, K.P.C., E.H.H., I.A., K.B.; Supervision, K.P.C., E.H.H., I.A.; Project administration, K.P.C. All authors have read and agreed to the published version of the manuscript.
Funding: This study was conducted under grant by the Ministry of Higher Education and Research of the Republic of Indonesia No.644/UN17.L1/HK/2024.
Institutional Review Board Statement: This study was approved by the Ethics Committee of the Mulawarman University of Medical Faculty (No. 252/JEPK-FK/XII/2023).
Informed Consent Statement: "Informed consent was obtained from all the participants involved in this study.
Data Availability Statement: Data supporting reported results can be found in the results section of the article manuscript.
Conflicts of Interest: The authors declare no conflict of interest.

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