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Original Article

Dental Caries Experience and Unmet Treatment Need Among Community-Dwelling Orphaned Children in Benghazi, Libya: A Comparative Study

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Abstract

Background : Community-dwelling orphaned children represent the largest proportion of the global orphan population, yet their oral health has received little attention compared with institutionalised orphans. This study compared dental caries experience, unmet treatment need, and dental service utilisation between community-dwelling orphaned and non-orphaned children in Benghazi, Libya. **Methods:**A comparative cross-sectional study was conducted among 156 children aged 6–12 years, including 50 community-dwelling orphaned children and 106 non-orphaned children. Demographic characteristics were obtained through carer interviews. Dental caries were assessed using World Health Organization criteria and recorded as dmft/DMFT indices. Unmet treatment needs were evaluated using the Care Index. Multivariable negative binomial regression was performed to examine the independent association between orphan status and caries after adjustment for age, sex, family income, and dental attendance.**Results:** Primary dentition caries experience did not differ significantly between orphaned and non-orphaned children (mean dmft: 3.66 ± 3.26 vs. 4.04 ± 3.24; p = 0.472). In contrast, orphaned children demonstrated significantly higher permanent dentition caries experience (mean DMFT: 0.94 ± 1.25 vs. 0.45 ± 1.09; p = 0.003) and a higher prevalence of permanent caries (44.0% vs. 21.7%; p = 0.007), alongside greater financial hardship and lower dental service utilisation. Care Index values were extremely low in both groups, with only 1 of 22 orphaned and 3 of 23 non-orphaned children with permanent caries having received any restoration. After multivariable adjustment, orphan status was no longer independently associated with DMFT, whereas age remained the only significant predictor of caries experience. **Conclusions:**Community-dwelling orphaned children exhibited a greater burden of untreated permanent dental caries than their non-orphaned peers. However, the universally low Care Index observed in both groups suggests that inadequate access to restorative dental care represents a broader health-system challenge extending beyond orphanhood.

Keywords: Pediatric Dentistry; Dental Caries; Orphans; Community-Dwelling; Care Index; Social Determinants of Health; Libya.

Introduction

Despite decades of advances in preventive dentistry, dental caries remains the most prevalent and largely untreated chronic condition of childhood [1], with the greatest burden concentrated in populations least equipped to address it, where preventive infrastructure is limited and the treatment gap is profound [2]. Globally, untreated caries in primary dentition affects an estimated 532 million children, while untreated caries in the permanent dentition represents the single most prevalent condition in the Global Burden of Disease Study, affecting more than 2.3 billion individuals worldwide [2]. Dental caries adversely affects multiple domains of children's lives, including pain experience, nutritional status, growth, school attendance, and oral health-related quality of life [3, 4].

The distribution of dental caries follows well-established social gradients shaped by broader social determinants of health. Socioeconomic disadvantages, low parental educational attainment, limited access to preventive dental services, suboptimal oral hygiene practices, and diets high in ferme

ntable carbohydrates are consistently documented risk factors across diverse paediatric populations [5, 6]. The caregiving environment is equally influential, as parental supervision of oral hygiene, dietary oversight, and dental attendance patterns are heavily mediated by family structure and household economic stability [7]. Consequently, children raised in socioeconomically disadvantaged or disrupted caregiving environments experience heightened caries risk and substantial unmet treatment needs [8, 9]. These inequalities extend beyond individual behaviours to reflect structural determinants including poverty, housing conditions, and healthcare accessibility that shape oral health patterns throughout early life [10].

UNICEF estimates that approximately 152 million children worldwide are classified as orphans, defined as

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children having lost one or both parents, with the overwhelming majority living in low- and middle-income countries [11]. Most orphaned children continue to live within families or community settings with a surviving parent, relatives, or other carers rather than in institutional care [12]. A growing body of literature has examined oral health among institutionalised orphaned children, consistently reporting higher caries prevalence, elevated dmft and DMFT scores, greater treatment needs, and poorer oral hygiene compared with children living in conventional family settings [13,14,15].Although community-dwelling orphans remain within extended family or community networks, many continue to experience persistent socioeconomic hardship, inconsistent access to healthcare, and psychosocial adversity, all of which may influence oral health outcomes [16,17].Beyond dental caries, a recent multinational case-control study conducted across six countries, demonstrated significantly higher prevalences of developmental enamel defects, molar incisor hypomineralisation (MIH), and hypomineralised second primary molars (HSPM) among orphaned children, suggesting that early-life adversity and disrupted caregiving may adversely affect both oral health and dental development [18].

The Libyan context provides a particularly important setting in which to investigate these questions. Years of political instability and armed conflict have disrupted healthcare delivery and exacerbated inequalities in access to health services [19]. A recent systematic review and meta-analysis of 17 studies reported a pooled permanent-dentition caries prevalence of 64.7% and a mean DMFT score of 2.58 among Libyan schoolchildren while highlighting considerable methodological heterogeneity and the limited geographical coverage of existing evidence, which has been derived predominantly from Benghazi [20]. Local studies have similarly documented elevated levels of dental caries and substantial unmet treatment needs among children [21,22], while more recent evidence suggests that conflict exposure and displacement further increase the burden of untreated disease [22]. Furthermore, to our knowledge, no published study has investigated dental caries burden and unmet treatment need among community-dwelling orphaned children in Libya. Existing Libyan evidence is limited to school-based surveys and conflict-affected populations and has rarely incorporated psychosocial determinants or quantified restorative care using the Care Index. Consequently, it remains unclear whether orphanhood contributes to oral health inequalities beyond those attributable to broader socioeconomic disadvantages.

The present comparative cross-sectional study evaluated dental caries experience, unmet treatment need, and restorative care utilisation between community-dwelling orphaned children and non-orphaned children living with both parents in Benghazi, Libya. A secondary objective was to examine whether household income and dental attendance observed differences in oral health outcomes. It was hypothesised that community-dwelling orphaned children would exhibit a significantly higher permanent-dentition caries burden and greater unmet treatment need than non-orphaned controls. It was further hypothesised that Care Index values would be uniformly low across both groups, reflecting systemic barriers to paediatric dental care within Benghazi.

Material and Method

Study Design and Setting

This comparative cross-sectional study was conducted in Benghazi, Libya, to compare the burden of dental caries and unmet treatment needs between community-dwelling orphaned children and nonorphaned children living with both parents. The study was reported in accordance with the strengthening of the reporting of observational studies in epidemiology (STROBE) guidelines [23]. Data collection was undertaken between Jan and May 2024 at registered non-governmental organisations (NGOs) for the study group and the control group at the University of Benghazi public dental clinic. Ethical approval was obtained from the research ethics committee of the university under the approval (No, 0157). Before participation, an informed consent was obtained from the legal guardians, and also a verbal assent was obtained from children whenever appropriate. The study was conducted in accordance with the Declaration of Helsinki; the confidentiality and anonymity of all participants were maintained throughout the study.

Participants and Eligibility Criteria

Two groups of children aged 6–12 years were enrolled in this study. The orphan group comprised community-dwelling children identified through registered non-governmental organisations (NGOs) in Benghazi, having lost one or both parents and residing in family-based care (with a surviving parent or relative). The comparison group consisted of non-orphaned children residing with both biological parents.

Inclusion Criteria

- Aged 6–12 years.
- Resided in the community within Benghazi, Libya.
- Met the group classification criteria.
- Able to undergo a comprehensive clinical oral examination.
- Obtained written informed consent from the child's parent, legal guardian, or primary carer alongside verbal child assent where appropriate.

Exclusion Criteria

- Resided in institutional care facilities (e.g., social care home foundations) to ensure a homogeneous community-based orphan sample.
- Diagnosed with systemic medical conditions or developmental disorders that could influence oral health outcomes or preclude a reliable clinical examination.
- Had incomplete questionnaire or interview data.

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- Declined informed consent from the parent/guardian or verbal assent from the child

Sample Size and Recruitment

A consecutive convenience sampling approach was adopted, and no *a priori* sample size calculation was performed. All eligible orphaned children registered with participating community-based charitable organisations and nongovernmental organisations (NGOs) in Benghazi were invited to participate. Nonorphaned comparison children were recruited consecutively from the University of Benghazi public dental clinic during the same period, ensuring the achieved sample represents the accessible population. Participating organisations were identified by the relevant authorities. Announcements describing the research purposes and free treatment options for all participants were displayed at the organisations' premises and shared on their official social media platforms two weeks before data collection. Only children who met the inclusion criteria were enrolled. Recruitment was extended by one month (30 days) due to a lower-than-expected initial response rate.

Data Collection

Data were collected using a structured questionnaire administered through carer or guardian interviews, followed by a standardised clinical dental examination:

Demographic and social characteristics

Demographic and socioeconomic information, including age, sex, household income, and dental care utilisation was collected for all participants. For orphaned children, information was obtained from the accompanying carer or NGO caseworker, whereas parents provided information for the comparison group.

Clinical Examination

Clinical examinations were independently conducted by two calibrated paediatric dentists who completed standardised training and calibration before the start of data collection. Training sessions were conducted at the University of Benghazi, involving one session discussing dental caries (dmft/DMFT) diagnostic criteria according to World Health Organization (WHO) criteria 5th edition [24], followed by two clinical calibration sessions on a separate group of 20 children (not included in the study) at three-week intervals. Diagnostic consistency was evaluated using Cohen's Kappa, yielding an intra-examiner reliability value of 0.96 and an inter-examiner reliability value of 0.90, indicating high diagnostic reproducibility.

Participants were examined while seated in a dental chair under adequate artificial operating light using plane mouth mirrors and community periodontal index (CPI) or ball-ended probes. Standard infection control procedures were followed throughout, and teeth were cleaned with sterile gauze to remove gross debris and facilitate visual inspection. Caries experience was recorded using the dmft index for the primary dentition and the DMFT index for the permanent dentition in accordance with WHO diagnostic criteria. The decayed, missing, and filled components were recorded separately for each participant. Unmet treatment needs were evaluated using the Care Index, calculated as ft/dmft × 100 for the primary dentition and FT/DMFT × 100 for the permanent dentition, representing the proportion of caries experience that received restorative treatment with higher values indicating greater access to restorative dental care and lower levels of unmet treatment need. The Care Index was computed individually for each child with caries experience (dmft > 0 or DMFT > 0) and averaged within groups; caries-free children were excluded from this calculation.

Statistical Analysis

Data were analysed using SPSS (version 29.0). Descriptive statistics, including means, standard deviations, and frequencies, were used to summarise participant characteristics and caries indices. Group differences in continuous variables were evaluated using Welch's independent t-test for age and the Mann-Whitney U test for non-normally distributed variables, including caries indices. The Chi-square test was used to compare categorical variables between groups, including caries prevalence (dmft > 0 and DMFT > 0), family income category, and dental care utilisation. Negative binomial regression models were constructed separately for dmft and DMFT to adjust for potential confounders. Each model included living status (orphan vs. non-orphan), age, sex, family income and dental visit history as independent variables. Results are reported as incidence rate ratios (IRR) with 95% confidence intervals. A stratified analysis by age group was also conducted to explore whether the association between orphan status and caries experience differed across age bands. A p-value of ≤ .05 was considered statistically significant.

Results

Sample Characteristics

A total of 156 children (comprising 50 community-dwelling orphans and 106 non-orphans) participated in this study. The orphan group was significantly older than the non-orphan group (9.40 ± 1.87 versus 8.53 ± 1.74 years; p = 0.007). However, no statistically significant difference was observed in sex distribution between the cohorts, with males accounting for 60.0% of the orphan group and 46.2% of the non-orphan group (p = 0.152) (Table 1).

Table 1. Demographic characteristics of the study groups.

Characteristic	Orphans (n=50)	Non-orphans (n=106)	p-value
Age, years, mean ± SD	9.40 ± 1.87	8.53 ± 1.74	0.007**

***p < 0.01, Welch's independent t-test (age); Chi-square test (sex).*

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Male, n (%)	30 (60.0%)	49 (46.2%)	0.152
Female, n (%)	20 (40.0%)	57 (53.8%)	

Dental Caries Burden and Prevalence

The dental caries indices for primary and permanent dentition are presented in Table 2, and caries prevalence is summarised in Table 3. Figures 1 and 2 illustrate the mean caries scores and prevalence for both groups, respectively. In the primary dentition, caries experience did not differ significantly between orphaned and non-orphaned children. The mean dmft score was similar in both groups (3.66 ± 3.26 vs. 4.04 ± 3.24; p = 0.472), with no significant differences observed across individual index components. Similarly, the prevalence of primary dental caries was comparable between groups (72.0% vs. 81.1%; p = 0.279) (Tables 2 and 3). In contrast, the permanent dentition revealed a significantly higher caries burden among orphaned children. The mean DMFT score was more than twice as high in orphans as in non-orphans (0.94 ± 1.25 vs. 0.45 ± 1.09; p = 0.003). This disparity was driven almost entirely by the decayed component (DT) (0.90 ± 1.25 vs. 0.37 ± 0.91; p = 0.001), whereas missing and filled teeth were rare across both groups. Correspondingly, the prevalence of permanent caries was approximately twice as high among orphaned children (44.0% vs. 21.7%; p = 0.007) (Tables 2 and 3, Figures 1 and 2).

Table 2. Caries indices (mean ± SD) by group.

Index (mean ± SD)	Orphans (n=50)	Non-orphans (n=106)	Mann-Whitney p
dt (decayed, primary)	2.76 ± 2.73	3.19 ± 2.88	0.362
mt (missing, primary)	0.80 ± 1.40	0.62 ± 1.39	0.270
ft (filled, primary)	0.10 ± 0.36	0.23 ± 0.96	0.980
dmft total (primary)	3.66 ± 3.26	4.04 ± 3.24	0.472
DT (decayed, permanent)	0.90 ± 1.25	0.37 ± 0.91	0.001**
MT (missing, permanent)	0.02 ± 0.14	0.02 ± 0.14	0.968
FT (filled, permanent)	0.02 ± 0.14	0.07 ± 0.42	0.755
DMFT total (permanent)	0.94 ± 1.25	0.45 ± 1.09	0.003**

*d/D = decayed; m/M = missing due to caries; f/F = filled; lower case = primary dentition, upper case = permanent dentition. **p < 0.01, Mann-Whitney U test.*

Table 3. Prevalence of caries experience by group.

Outcome	Orphans (n=50)	Non-orphans (n=106)	Chi-square p
Primary caries (dmft > 0), n (%)	36 (72.0)	86 (81.1)	0.279
Permanent caries (DMFT > 0), n (%)	22 (44.0)	23 (21.7)	0.007**

***p < 0.01, Chi-square test.*

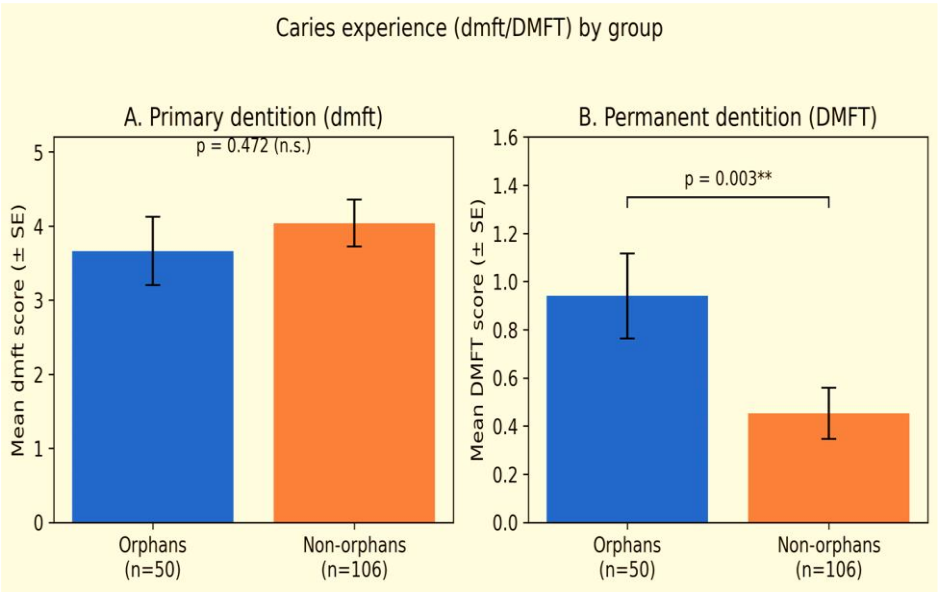


*Figure 1. Mean primary (dmft) and permanent (DMFT) dentition caries scores by group. Error bars represent ±1 SE. **p*

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< 0.01, Mann-Whitney U test.

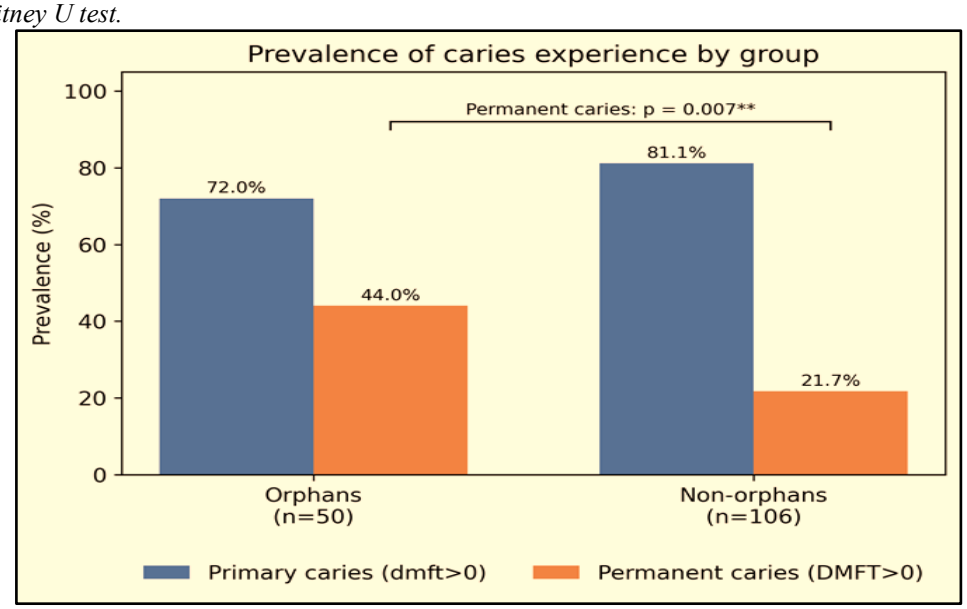


Figure 2. Proportion of children with any caries experience (dmft > 0 or DMFT > 0) by group.
**p < 0.01, Chi-square test.

Socioeconomic Determinants, Dental Service Utilization, and Care Index

Comparisons of social determinants, dental-care utilisation, and the Care Index between the two groups are presented in Table 4 and illustrated in Figure 3. Marked socioeconomic disparities were observed between the study cohorts. Orphaned children were significantly more likely to live in households experiencing financial hardship, with none of the orphan families reporting the ability to save or invest (overall χ^2p = 0.001). In addition, orphaned children were significantly less likely to have ever attended a dental clinic than their non-orphaned peers (50.0% vs. 67.9%; p = 0.048), although the prevalence of a previous toothache history did not differ significantly between the groups (p = 0.204).

Table 4. Social determinants, dental-care utilisation, and Care Index by group.

	Variable	Orphans (n=50)	Non-orphans (n=106)	- p-value
Family Income	In debt, n (%)	18 (36.0%)	14 (13.2%)	0.001**[a]
	Meets routine expenses, n (%)	25 (50.0%)	67 (63.2%)	
	Meets routine expenses and emergencies, n (%)	7 (14.0%)	12 (11.3%)	
	Able to save/invest, n (%)	0 (0.0)	13 (12.3%)	
Ever visited dental clinic, n (%)		25 (50.0%)	72 (67.9%)	0.048*
History of toothache, n (%)		28 (56.0%)	72 (67.9%)	0.204[b]
Care Index primary (%), mean ± SD		2.2 ± 6.4 (n=36)	6.8 ± 23.2 (n=86)	0.875
Care Index permanent (%), mean ± SD		4.5 ± 21.3 (n=22)	10.6 ± 29.6 (n=23)	0.346
Children with ≥1 restored primary tooth, n/N (%)		4/36 (11.1)	8/86 (9.3)	0.747[c]
Children with ≥1 restored permanent tooth, n/N (%)		1/22 (4.5)	3/23 (13.0)	0.608[c]

***p < 0.01, Mann-Whitney U or Chi-square test as appropriate. [a]Overall chi-square test across all income categories, not specific to the row shown. [b]One caregiver response of "I do not know" was grouped with "no." [c] Fisher's exact test.*

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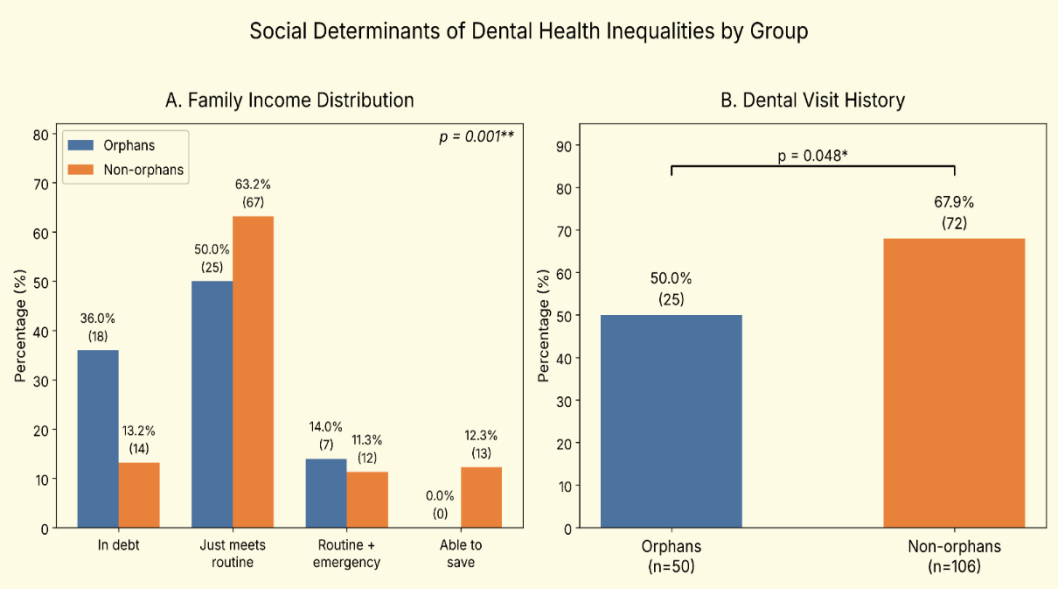


Figure 3. Panel A: family income distribution by group. Panel B: proportion of children who had ever attended a dental clinic. *p < 0.05, **p < 0.01.

The Care Index, reflecting the proportion of overall caries experience that had received restorative treatment, was exceptionally low across both groups. No statistically significant differences were observed between orphaned and non-orphaned children in either the primary dentition (2.2 ± 6.4% vs. 6.8 ± 23.2%; p = 0.875) or the permanent dentition (4.5 ± 21.3% vs. 10.6 ± 29.6%; p = 0.346). These findings underscore a substantial unmet need for restorative dental care in both populations. Restorative treatment was rare in absolute terms: only 1 of 22 orphaned children and 3 of 23 non-orphaned children with permanent caries had received any restoration, with corresponding figures of 4 of 36 and 8 of 86 in the primary dentition. Care Index values are therefore based on very few restorative events and are presented as descriptive.

Multivariable Regression and Age-Stratified Analyses

The results of the expanded negative binomial regression models for primary (dmft) and permanent (DMFT) caries indices are summarised in Table 5. After adjusting for orphan status, age, sex, family income, and dental visit history, age emerged as the sole independent predictor of caries experience. Each additional year of age was associated with a 21% decrease in the expected primary dentition caries count (IRR = 0.79, 95% CI 0.71–0.88) and a 36% increase in the expected permanent dentition caries count (IRR = 1.36, 95% CI 1.16–1.60). Although orphaned children had a higher unadjusted permanent caries experience, the association between orphan status and DMFT was attenuated after adjustment and was no longer statistically significant (IRR = 1.52, 95% CI 0.73–3.16; p = 0.265). Similarly, sex, family income, and dental visit history were not independently associated with either dmft or DMFT scores.

Age-stratified analysis (Figure 4) showed higher mean DMFT among orphaned children in both age bands, with the difference most marked at 9–12 years (1.18 ± 1.38 vs. 0.64 ± 1.41) compared with 6–8 years (0.47 ± 0.80 vs. 0.29 ± 0.65), supporting the trend observed in the unadjusted analyses.

Table 5. Expanded negative binomial regression models for dmft and DMFT, adjusted for age, sex, family income, and dental-visit history (n = 156).

Predictor	IRR (dmft)	95% CI	IRR (DMFT)	95% CI	p (dmft)/p (DMFT)
Orphan vs Non-orphan	1.09	0.65–1.83	1.52	0.73–3.16	0.744 / 0.265
Age (per year)	0.79	0.71–0.88	1.36	1.16–1.60	<0.001 / <0.001
Gender (Male=1)	1.02	0.71–1.47	0.97	0.56–1.67	0.906 / 0.914
Family income	0.89	0.70–1.12	0.97	0.68–1.39	0.314 / 0.871
Dental visit history	1.05	0.71–1.55	1.01	0.55–1.85	0.800 / 0.972

IRR = incidence rate ratio (reference: Non-orphan, Female, lowest income category). p-values shown as dmft p / DMFT p.

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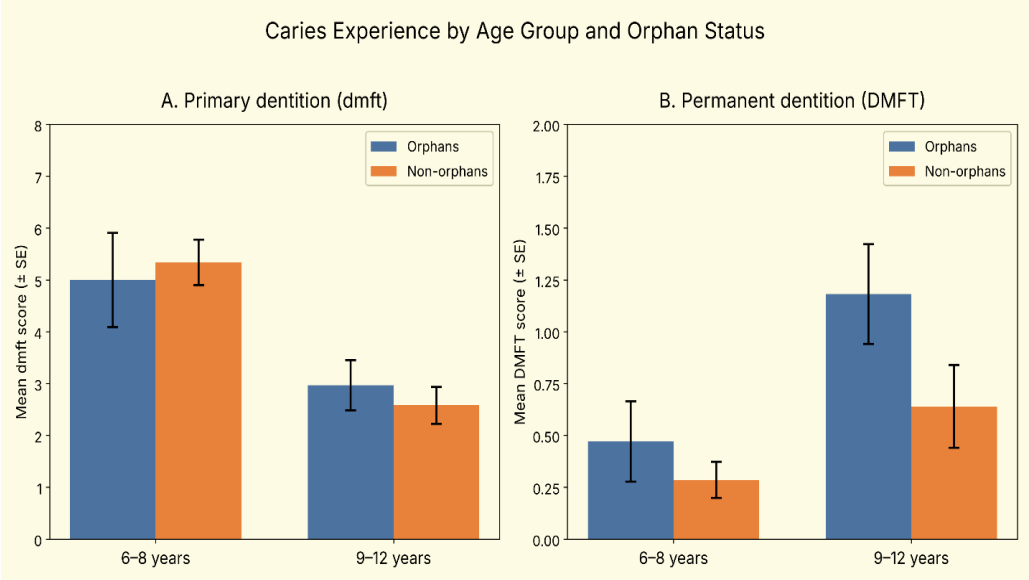


Figure 4. Mean dmft (Panel A) and DMFT (Panel B) stratified by age group (6–8 years and 9–12 years) and orphan status. Error bars represent ±1 SE.

Discussion

The present study evaluated the caries experience, social determinants, and dental care utilisation among community-dwelling orphaned and non-orphaned children in Benghazi. In unadjusted analyses, orphaned children demonstrated a significantly higher permanent-dentition caries burden and prevalence than their non-orphaned peers, driven almost entirely by untreated decay, whereas primary dentition caries experience did not differ significantly. Orphaned children were also disproportionately exposed to financial hardship and reported lower rates of dental clinic attendance. However, after multivariable adjustment, the group difference in permanent caries experience was attenuated to non-significance, with age emerging as the sole independent predictor. Notably, near-zero Care Index values were observed across both groups, indicating a widespread, systemic unmet treatment need that exists independently of orphan status.

In unadjusted analyses, orphaned children exhibited a greater permanent caries burden (DMFT) than non-orphaned children. However, following multivariable adjustment for age, sex, family income, and dental visit history, this disparity was no longer statistically significant (IRR = 1.52, 95% CI 0.73–3.16, p = 0.265), and age was identified as the only independent predictor. This attenuation likely reflects the cumulative nature of the DMFT index: older children have more erupted permanent teeth and a longer period of caries exposure. Although a higher crude caries burden among orphaned children has been reported in other populations [13, 16], where reliance on emergency care rather than routine prevention is common, our findings indicate that age accounts for the primary variance in permanent caries accumulation.

The near-zero Care Index values observed in both study cohorts demonstrate that exceptionally few decayed teeth had received restorative intervention, pointing to a systemic failure in delivering restorative dental care to children in Benghazi regardless of family structure. Comparable unmet treatment needs have been documented among Libyan children generally [21, 22] and institutionalised orphaned populations regionally, who similarly exhibit high caries experience alongside minimal restorative care [25]. Notably, by examining community-dwelling rather than institutionalised orphans, the present study extends these observations to a less-studied demographic. This universal treatment gap—rather than the orphan versus non-orphan disparity—represents the most robust and policy-relevant finding of this investigation.

The socioeconomic findings further illuminate these patterns. Orphaned children's families faced marked financial hardship, with higher rates of debt and an inability to save or invest, which likely contributes to lower dental attendance given that much of Libya's dental care framework is privatised. Such structural determinants shape oral health behaviours and access [26-28]. Although family income did not independently predict caries after multivariable adjustment—likely due to overlapping socioeconomic pathways and modest sample size—the underlying structural context remains critical. Libya's oral healthcare system is heavily privatised, with public sector services largely restricted

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to emergency management and extractions and lacking targeted public health policies for vulnerable groups [29]. Consequently, families unable to afford private restorative treatment face significant barriers, directly corroborating the negligible Care Index values observed in both study groups.

While this study provides important insights into an under-recognised population, several limitations must be acknowledged. The cross-sectional design precludes causal inference, and non-probability sampling from clinical and non-governmental organisation (NGO) sources may limit generalisability. Parental educational attainment — an established determinant of childhood caries — was recorded only for the non-orphaned group and could therefore not be compared between cohorts. Furthermore, orphan status was defined by living arrangements (living with a single parent or relative) rather than verified parental death, reflecting family structure rather than confirmed orphanhood. Additionally, dietary and sugar-intake data were not collected; given evidence that conflict-related shifts in dietary sugar availability impact caries levels in this region [30], this represents a key unmeasured confounder.

In summary, while orphaned children bore a higher crude burden of permanent caries and economic disadvantage, multivariable modelling demonstrated that age was the primary independent driver of caries experience in this cohort. Crucially, the near-zero Care Index across both groups highlights a pervasive regional treatment gap in restorative care. Addressing these oral health disparities requires structural healthcare solutions that extend beyond basic emergency interventions.

Conclusion

While initial unadjusted analyses indicated elevated permanent caries experience among orphaned children, age rather than orphan status proved to be the key independent predictor of caries accumulation. Overarching this finding is the near-zero Care Index observed across both groups, exposing a severe, systemic deficit in paediatric restorative dental care in Benghazi. Given that Libya's oral healthcare delivery relies heavily on private practices, economic hardship poses a major barrier to preventive and restorative attendance. Mitigating this public health crisis requires targeted national strategies, including school-based preventive programmes and strengthened public-sector dental infrastructure, to achieve equitable oral health outcomes for all children.

Conflicts of Interest: The authors declare no conflict of interest.

Ethical Approval: This study was approved by the University of Benghazi ethical committee. Also, written informed consent was obtained from all participants.

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Declaration on the Use of Artificial Intelligence: During the drafting of this manuscript, the authors utilised Claude (Anthropic; Claude 3.5 Sonnet) solely to refine language clarity and correct grammatical errors. The final text was thoroughly reviewed and edited by the authors, who maintain absolute responsibility for the content, precision, and integrity of the work. Artificial intelligence was not employed in data generation, analysis, or the formulation of scientific conclusions.

Authorship contribution statement:

Sarah Fakron: Methodology, validation, writing – original draft, writing – review & editing.

Asma Albaraesi: Formal analysis, writing – original draft, writing – review & editing.

Iman Elareibi: Methodology, validation, writing – original draft, writing – review & editing.

Heba Sabbagh: Conceptualisation, methodology, review & editing.

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