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Maternal Health Literacy, Oral Health Behaviors, and Dental Caries Counts in Children: A Comparison of Poisson, Negative Binomial, and Conway- Maxwell-Poisson Regression Models

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Research Article

Keywords: dental caries, COM-Poisson regression, maternal health literacy, oral health behaviors, count data

Posted Date: August 19th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10406754/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Dental caries remains a major public health problem in childhood. Because caries counts often show non-standard dispersion, selecting an appropriate regression model is essential. This study compared Poisson, negative binomial, and Conway-Maxwell-Poisson regression models to identify factors associated with dental caries counts in children.

Methods

This cross-sectional study was conducted among 470 mother-child pairs aged 4 to 12 years in Hamadan, Iran. Data were collected using structured questionnaires and standardized dental examinations. The outcome was the total number of decayed, missing, and filled teeth. Predictors included child characteristics, oral health behaviors, dietary habits, household income, and maternal health literacy. Model fit was assessed using log-likelihood, AIC, BIC, and RMSE.

Results

The mean caries count was 3.34 and the variance was 3.16, indicating mild underdispersion. The Conway-Maxwell-Poisson model showed the best fit. In the final adjusted model, male sex, sugary snack consumption, and lower household income were associated with higher caries counts, whereas regular toothbrushing, more frequent dental visits, and higher maternal health literacy were associated with lower counts.

Conclusion

The Conway-Maxwell-Poisson model performed better than standard count models for these mildly underdispersed data. Maternal health literacy and oral health behaviors were independently associated with childhood dental caries, highlighting the importance of family-centered preventive interventions.

Introduction

Dental caries remains one of the most prevalent chronic conditions in childhood, posing a global public health concern (1). The World Health Organization (WHO) emphasizes that untreated caries significantly contributes to pain, impaired nutrition, and reduced quality of life (1, 2).

The DMF index is the standard epidemiologic metric for assessing caries experience. However, because this is a count variable, the choice of regression model is vital. Standard Poisson regression relies on the assumption of equidispersion (mean = variance), which is frequently violated in real-world clinical data.

While Negative Binomial regression is commonly used to address overdispersion, it lacks the flexibility to model underdispersed data (3, 4). In contrast, the COM-Poisson distribution introduces a dispersion parameter that allows for greater flexibility, making it well-suited for complex dental count outcomes (5, 6). Recent methodological work has further highlighted the utility of underdispersion models in health research (7, 8).

Furthermore, children's oral health is profoundly influenced by maternal factors. High maternal health literacy facilitates better oral hygiene practices, healthier dietary choices, and regular professional dental care (9–11).

Although dental caries is widely studied in children, fewer studies have evaluated whether conventional count regression models adequately fit caries count outcomes, especially when underdispersion is present. Moreover, evidence on the role of maternal health literacy in childhood caries remains important for planning preventive oral health programs. Therefore, this study aimed to compare Poisson, negative binomial, and Conway–Maxwell–Poisson regression models for dental caries counts among children and to identify behavioral, socioeconomic, and maternal health literacy factors associated with caries experience.

Methods

Study Design and Population

This analytical cross-sectional study was conducted among 470 mother-child pairs in Hamadan, Iran. Children aged 4 to 12 years were included. Clinical examinations were performed by a calibrated dentist to record the total number of decayed, missing due to caries, and filled teeth in both primary and permanent dentitions.

All statistical analyses were performed using R software (R Foundation for Statistical Computing, Vienna, Austria; version 4.3.2). Statistical significance was set at $p < 0.05$.

Data collection

Data were collected using structured questionnaires and standardized dental examinations. The questionnaires captured sociodemographic characteristics, oral hygiene behaviors, dietary habits, and maternal health literacy. Maternal oral health literacy was assessed using the validated Oral Health Literacy–Adult Questionnaire (OHL-AQ). This questionnaire consists of 17 items categorized into four domains: comprehension, numeracy, listening skills, and decision-making. A correct answer in each section was given a score of one, and an incorrect answer or "I don't know" was given a score of zero. The total score ranged from 0 to 17. The cutoff point indicating a "low" OHL level was determined by the score of the lowest quintile, which was less than 13(12). The Persian version of this questionnaire has been validated and found to be reliable in previous studies(13).

Children's oral health behavior was assessed using five questions, including toothbrushing frequency and duration, flossing frequency, sugary snack consumption, and annual dental check-up visits. The closest answer to the correct response received the highest score, while the furthest received the lowest. Total scores were categorized into three levels: scores between 5 and 9 indicated weak performance, scores between 10 and 19 indicated average performance, and scores higher than 20 indicated strong performance. The questions in this questionnaire were developed based on a review of relevant literature and existing studies(14, 15). Dental caries experience was recorded using the DMFT/dmft index(1). The scoring method for questions related to children's oral health behavior is provided in the appendix (Appendix 1).

Variables

The outcome variable was the total caries count. Predictor variables included child sex and age, maternal age, maternal education, maternal employment status, household income, toothbrushing behavior, dental visit frequency, sugary snack consumption, and maternal health literacy.

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics and caries counts. Poisson, Negative Binomial, and COM-Poisson regression models were fitted to assess the association between predictors and caries counts. Model performance was compared using log-likelihood, AIC, BIC, and RMSE. Because the observed outcome showed mild underdispersion, the COM-Poisson model was selected as the primary inferential model. Regression coefficients, relative risks, and 95% confidence intervals were reported. A p-value of less than 0.05 was considered statistically significant.

Results

The mean caries count was 3.34 (SD = 1.78), showing a slight underdispersion (Variance/Mean ratio = 0.94). As shown in Table 3, the COM-Poisson model achieved the best fit with the lowest AIC (1746.398) and BIC (1829.453).

Table 1
Sociodemographic characteristics of participating mothers

Variable	Category	Caries-free (dmft/DMFT = 0) n (%)	Caries-affected (dmft/DMFT > 0) n (%)
Maternal age	< 35 years	149 (73.0)	119 (44.7)
	35–45 years	42 (20.6)	122 (45.9)
	≥ 46 years	13 (6.4)	25 (9.4)
Maternal education	Below diploma	60 (29.4)	47 (17.7)
	High school diploma	75 (36.8)	102 (38.3)
	University degree	69 (33.8)	117 (44.0)
Maternal employment	Housewife	138 (67.6)	141 (53.0)
	Employed	58 (28.4)	109 (41.0)
	Student	8 (3.9)	16 (6.0)
Household income	Low (< 10m Tomans)	58 (28.4)	75 (28.2)
	Middle (10–15m Tomans)	78 (38.2)	79 (29.7)
	High (≥ 16m Tomans)	68 (33.3)	112 (42.1)

Table 2
Demographic characteristics of participating children

Variable	Category	Caries-free (dmft/DMFT = 0) n (%)	Caries-affected (dmft/DMFT > 0) n (%)
Age	4–5	0 (0.0)	2 (0.8)
	6	53 (26.0)	66 (24.8)
	7	32 (15.7)	44 (16.6)
	8	32 (15.7)	39 (14.7)
	9	35 (17.2)	28 (10.5)
	10	22 (10.8)	26 (9.8)
	11	10 (4.9)	30 (11.3)
	12	20 (9.8)	31 (11.7)
Sex	Female	91 (44.6)	135 (50.8)
	Male	113 (55.4)	131 (49.2)
Older sibling	Yes	119 (58.3)	153 (57.5)
	No	85 (41.7)	113 (42.5)

Table 3
Comparison of model fit

Model	LogLik	AIC	BIC	RMSE
COM-Poisson	-853.199	1746.398	1829.453	1.519
Poisson	-865.795	1769.591	1848.492	1.521
Negative binomial	-865.799	1771.597	1854.652	1.521

β, regression coefficient; LogLik, log-likelihood; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; RMSE, Root Mean Square Error

The final COM-Poisson regression model showed that toothbrushing, male sex, dental visits, sugary snack consumption, maternal health literacy, and household income were significantly associated with dental caries counts Table 4.

[Insert Table 4 **here]**

Table 4
Final COM-Poisson model for dental caries count

Variable	β	SE	p-value	RR	95% CI for RR
Toothbrushing	-0.230	0.037	< 0.001	0.79	0.74–0.85
Male sex vs female	0.206	0.066	0.002	1.23	1.08–1.40
Dental visits	-0.091	0.028	0.001	0.91	0.87–0.96
Sugary snack consumption	0.118	0.045	0.009	1.12	1.03–1.23
Maternal health literacy	-0.033	0.013	0.009	0.97	0.94–0.99
Household income	-0.115	0.041	0.006	0.89	0.82–0.97

β, Regression coefficient; SE, Standard error; RR, Relative risk; CI, Confidence interval

Discussion

This study compared three count regression models for childhood dental caries data and found that the Conway–Maxwell–Poisson model provided a better fit than the conventional Poisson and negative binomial models. This finding is consistent with the observed mild underdispersion in caries counts. The results suggest that flexible count models may be useful in oral epidemiological studies when the distributional assumptions of standard models are not fully met.

Beyond the methodological finding, this study identified several modifiable and socioeconomic factors associated with dental caries counts. Regular toothbrushing, more frequent dental attendance, higher maternal health literacy, and higher household income were associated with lower caries counts, whereas sugary snack consumption was associated with higher caries counts. These findings support the importance of preventive oral health behaviors and family-level determinants in childhood caries prevention.

In the final adjusted model, toothbrushing was significantly associated with lower caries counts. The estimated rate ratio indicated that higher toothbrushing frequency or better toothbrushing behavior was associated with a lower expected number of carious teeth. This finding is consistent with previous evidence showing that regular toothbrushing is an important preventive behavior against dental caries (16).

Maternal health literacy was also associated with lower caries counts in children. Mothers with higher health literacy may better understand oral health recommendations, support healthier dietary practices, encourage toothbrushing, and seek timely dental care for their children. This finding is consistent with previous studies emphasizing the role of parental oral health literacy in children’s oral health outcomes (9–11).

Sugary snack consumption was positively associated with caries counts, which is consistent with the well-established role of fermentable carbohydrates in the caries process. Frequent intake of sugary snacks increases acid production by oral bacteria and promotes demineralization of tooth structure.

Household income was another significant factor associated with dental caries. Children from lower-income households had higher caries counts, suggesting that socioeconomic barriers may limit access to dental services, preventive products, and healthier dietary choices. This finding is consistent with previous evidence linking socioeconomic inequality with dental caries burden (17).

The fitted COM-Poisson model may also be useful for risk stratification. Children with poor toothbrushing habits, high sugary snack consumption, irregular dental attendance, and mothers with lower health literacy may represent a higher-risk group and may benefit from targeted preventive interventions in primary healthcare settings.

Strengths and limitations

A strength of this study was the comparison of multiple count regression models using several model-fit indices, allowing the statistical approach to be matched to the distributional characteristics of the dental caries outcome. The study also considered maternal health literacy alongside behavioral and socioeconomic factors, providing a broader perspective on determinants of childhood caries.

This study has limitations. First, the cross-sectional design prevents causal inference. Second, some behavioral variables were self-reported by mothers and may be affected by recall or social desirability bias. Third, the outcome was modeled as a total caries count; if the number of teeth at risk differs substantially between children, future studies should consider offset terms or age-specific dentition analyses. Fourth, the study was conducted in Hamadan, Iran, and the findings may not be generalizable to all child populations. Future longitudinal and multicenter studies are recommended to confirm these findings.

Conclusion

The Conway–Maxwell–Poisson model provided the best fit for mildly underdispersed dental caries count data in this sample of children. Maternal health literacy, toothbrushing, dental attendance, sugary snack consumption, household income, and child sex were independently associated with caries counts. These findings emphasize the need for oral health promotion programs that combine parental health literacy improvement with practical preventive strategies targeting children’s oral hygiene, diet, and access to dental care.

Abbreviations

DMFT: Decayed, Missing, and Filled Teeth

AIC: Akaike Information Criterion

BIC: Bayesian Information Criterion

RMSE: Root Mean Square Error

COM-Poisson: Conway–Maxwell–Poisson

RR: Relative Risk

CI: Confidence Interval

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Hamadan University of Medical Sciences, Hamadan, Iran (Ethics code: IR.UMSHA.REC.1402.151). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all participating mothers before data collection.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by Hamadan University of Medical Sciences. The funder had no role in the design of the study, data collection, analysis, interpretation of data, or writing of the manuscript.

Author Contribution

OKP and SSN contributed to data collection and manuscript drafting. LT and TM designed the study and performed the statistical analyses. MA contributed to interpretation of results and public health implications. All authors critically revised the manuscript and approved the final version.

Acknowledgements

The authors thank all participating mothers and children and the staff of the comprehensive health service centers in Hamadan for their cooperation.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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