ASSOCIATION BETWEEN EARLY CHILDHOOD CARIES AND MALNUTRITION IN A SUB-URBAN POPULATION IN NIGERIA

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Abstract

Background To determine the association between malnutrition and early childhood caries (ECC) in preschool children resident in sub-urban, Nigeria. Methods This is a secondary analysis of a cross sectional study with data generated through a household setting. Variables (sex, frequency of sugar consumption, maternal knowledge of oral hygiene, oral hygiene status) associated with ECC in a primary study conducted in the Ile-Ife, Nigeria, were adjusted for using Poisson regression analysis. Results Of the 370 pre-school children, 20 (5.4%) were underweight, 20 (5.4%) were overweight, 67 (18.1%) were wasting, and 120 (32.4%) were stunted. Factors associated positively or negatively with ECC were stunted, underweight, overweight and fair oral hygiene. The prevalence of ECC was lower in children who were stunted (APR: 0.16), almost seven times higher in children who were overweight (APR: 6.88), and predictively absent in children who were underweight (APR: 0) when compared with children who had normal weight. Non-significant risk indicators for ECC included consuming sugar between meals three times a day or more (APR: 2.18), having low socioeconomic status (APR: 2.4) and being female (APR: 2.9). Conclusions For this study population, the indicators of malnutrition – being stunted, underweight, overweight - and fair oral hygiene were risk indicators for ECC, while the frequency of sugar consumption was not a significant risk indicator. Further studies are needed to identify if there are other mediators of an association between ECC and nutrition apart from sugar consumption.

Background

Early childhood caries (ECC) – defined as caries in children under 6 years of age who had one or more decayed, missing or filled primary tooth [1] - raises concern because of the possible link with malnutrition defined as little or too much of some nutrients. ECC leads to pain when not managed, and the pain contributes to poor feeding, nutrient deficiency [2-4] and growth failure (underweight, stunted and wasted) [5-8]. Also, children with ECC have high levels of pro-inflammatory cytokines [9], which trigger a cascade of inflammatory processes [10-12] associated with impaired growth [13-16] and obesity inducing mechanisms [17,18]. Obesity and stunting also cause changes in the salivary glands and the composition of saliva, thereby increasing the risk for ECC by lowering salivary pH and increasing the accumulation of triacylglycerol in the glands [19].

The association between ECC and malnutrition is however, not clear. Although a few studies have found an association between ECC, body mass index (BMI) [20-24] and growth failure [25-32] others have found no associations.(33-38) Also, while large population-based studies found no association between BMI and ECC [33, 39-41] longitudinal studies have indicated that malnutrition causes ECC [42], ECC causes stunting, and underweights have more ECC [43], ECC and obesity are both risk factors for type 2 diabetes [44]. Severe ECC is associated with micronutrient deficiencies such as iron deficiency anemia(45,46) which reduces salivary flow; [3,47] vitamin D [2,4,48,49] vitamin A, calcium and albumin deficiencies which causes enamel hypoplasia/hypomineralization [50,51], and lose of the protective effect of iron, vitamins and zinc for the teeth.(52)

Malnutrition accounted for 21% to 50% of under-5 deaths and a large proportion of morbidity [53,54] in low and middle-income countries in 2017. Malnutrition also contributes to under-5 mortality in Nigeria [55, 56]. The prevalence of malnutrition in Nigeria is higher in rural than in urban areas [57]. For a developing country like Nigeria [58], identifying factors that contribute to malnutrition may help enhance the design of comprehensive programs to tackle the problem.

The studies on the association between malnutrition and caries in Nigeria were conducted in children older than preschoolers [20,59]. These studies were school-based and found no association between BMI and caries. School based studies in Nigeria have a problem of representativeness because only 35.6% of children aged 36-59 months receive early childhood education [60] making the samples non-representative of the general population. Consequently, we have conducted a secondary data analysis of a population-based survey of a semi-urban population in Nigeria, to determine if there was any association between ECC and malnutrition in preschool children. Our hypothesis is that there is no association between ECC and nutritional status of preschool children in Ile-Ife, Nigeria.

Method

This study was a secondary analysis of data generated through a population based survey, to determine the association between digit sucking, caries and periodontitis in 6 month-olds to 12-year-olds resident in Ile-Ife [61,62]. The methodology has been reported in a prior study [63].

ECC status: The dmft was identified according to the World Health Organization (WHO) criteria [64]. The dmft score was obtained by adding the d, m and f scores for each child less than 6 years of age. The dmft score was dichotomized into 0= ECC absent and >0= ECC present.

Nutritional status: Nutritional status was assessed based on weight and height of each child according to the International Society for the Advancement of Kinanthropometry standard protocol [65]. Weight was measured in kilograms with an electronic weighing scale and recorded to the nearest tenth of a kilogram. The weighing scale was zero-balanced before the child stepped on it. Each child removed heavy items of clothing and mounted the scale bare footed, standing still and looking straight. Measurements were recorded after fluctuations on the digital screen had stopped.

Children’s height was measured in meters with an anthropometer-calibrated customized stadiometer. Each child was asked to step on the standiometer bare footed. Height was the maximum vertical distance from the feet to the vertex of the head, with the head held parallel to the Frankfort plane [66]. In this position, the child looked straight, with arms hanging naturally by the sides and both heels together touching the base of the stadiometer. The heels, buttocks and upper part of the back and back of the head were in contact with the stadiometer. The headpiece was brought down to contact the vertex of the head. The measurement was read to the nearest tenth of a centimeter and converted to a fraction of meter.

Nutritional status was determined according to criteria used by the WHO: height (H), age (A) and weight (W) [66]. Children whose H/A Z-score was below minus two standard deviations from the median of the WHO reference population were considered stunted. Children whose W/H Z-score was below minus two standard deviations from the reference population median were considered wasted. Children whose W/A was below minus two standard deviations from the reference population median were classified as underweight. Children whose W/Z-score was plus one standard deviations from the reference median were considered overweight, and those who were two standard deviations from the reference median were considered obese.

Oral hygiene status: Oral hygiene status was assessed with the index of Greene and Vermillion [67]. Good oral hygiene was graded from 0.0 to 1.2; fair oral hygiene from 1.3 to 3.0; and poor oral hygiene from 3.1 and above.

Socioeconomic Status: Socioeconomic status was assessed because of its role as a determinant of malnutrition [68]. It was measured according to a classification validated for use in Nigeria. The index combines the mother's education and the father's occupation to obtain five socio-economic classes for children [69]. Class 1 indicates upper class, class II upper middle class, class III middle class, class IV lower middle class, and class V lower class. For the present analysis, these classes were regrouped into three: high (upper and upper middle classes), middle (middle class) and low (lower middle and lower classes).

Mothers' knowledge of oral health: Folayan et al [63] described how data on mothers' knowledge of oral health were collected and handled. The same data were used for this study. Briefly, data were collected using a tool with a possible score ranging from 8 to 40. Scores of 21 and above were categorized as good oral health knowledge and scores of 20 and below were categorized as poor oral health knowledge.

Cariogenic diet: The frequency of consumption of sugary snacks between main meals was collected with a tool described in detail by Folayan et al [70]. Consumption of sugary snacks between main meals three times a day or more is a significant risk factor for ECC [63)].

Sample size and sampling: The estimated sample size for an ECC prevalence of 6.6% with a 3% margin of error and a confidence level of 95% precision was 263. There were 370 data points extracted for this analysis, which exceeded the needed minimum sample for this study. We therefore has adequate sample size to determine an association between ECC and malnutrition.

The primary data were collected using a three-level cluster sampling procedure. This involved an initial random selection of enumeration areas within the Ife Central local government area, then the selection of every third household on each street in the enumeration areas, and finally selection of eligible individuals within the households. Details on the sampling process have been discussed in the primary study [61].

Data analysis: Socio-demographic profile of participants in the present study and in the original study were compared by use chi-square test to establish comparability and ensure that the present sample is representative of the target population like the original sample.

The association between nutritional status and ECC presence (yes/ no) and confounding variables (age, sex, socio-economic status, frequency of sugar consumption between meals, oral hygiene status and maternal knowledge of oral health) was determined with the chi-square test or Fisher's test where appropriate.

Multivariable Poisson regression models were used to assess the relationship between exposure (nutritional status) and confounders on the outcome variable (presence of ECC measured by prevalence ratio: ECC PR). A modified theoretical model outlined by Folayan et al [63)], was used to assess how various indicators explained ECC PR when they were grouped into blocks. Factors were grouped under three blocks and were successively introduced, one block at a time. Each model included the block of nutritional status (WAZ, HAZ and WHZ) as this was the variable assessed for being a risk indicator for ECC. Other blocks moved into the next model if the p value was $\leq$ 0.2. Model 1 included only the block of nutritional status, while Model 2 included the block of nutritional status and the block of socio-economic and demographic factors (age was excluded because of possible collinearity since it was used to compute nutrition status) since these factors could influence caries and nutritional status. Model 3 included variables that met the inclusion criteria for the next model and they were known moderator variables of the association between ECC and malnutrition namely mother's knowledge of oral health, frequency of daily consumption of sugar and oral hygiene index. At the introduction of a new block with its factor(s), the variables of all blocks were adjusted simultaneously for each other to produce adjusted prevalence ratios (APRs). To avoid sparse data bias [71] introduced by the low prevalence of ECC, underweight, overweight or their combination, we used robust variance estimation [72].

The cross tabulations were generated with IBM SPSS version 23. The test of association was conducted with Stata 15. The Poisson regression analysis was conducted using Stata 14. The test of significant was set at $p \leq 0.05$.

Ethics consideration: Ethical approval for the study was obtained from the Health Research Ethics Committee of the Obafemi Awolowo University Teaching Hospitals' Complex Ile-Ife (ERC/2013/07/14). The primary study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Institute of Public Health-Health Research Ethics Committee. Written informed consent was obtained from all subjects/patients.

Results

Although 497 preschool children were recruited into the primary study, only 370 (74.4%) with data on nutritional status were included in this analysis. Of the 370 pre-school children, 20 (5.4%) were underweight, 20 (5.4%) were overweight, 67 (18.1%) were wasting, and 120 (32.4%) were stunted.

Table 1 shows the socio-demographic profile of the study participants in the primary study and this study. There was no significant difference in the age (p=0.89), sex (p=0.69), socioeconomic status (p=0.19) and the prevalence of ECC (p=0.19) of the children in the primary study and the current study.

Factors associated with ECC: Table 2 shows the factors associated with ECC. ECC was significantly associated with only age (p=0.02): ECC prevalence was highest in the age group 48-59 months.

Risk indicators for ECC: Table 3 shows the results of the Poisson regression models with robust variance estimation because of sparse data. The significant risk indicators for ECC were stunted, underweight, overweight and fair oral hygiene. None of the study participants had poor oral hygiene. In Model 3 where all confounders were controlled for, the prevalence of ECC was 66% lower in children who were stunted (APR: 0.14; 95% CI: 0.03-0.69; p=0.02) and almost seven times higher in children who were overweight (APR: 6.88; CI: 1.83-25.85; p<0.001) than in children who had normal weight. The APR of ECC in children with underweight was nil (APR: 0; 95% CI: 0-0; p<0.001) when compared with children who had normal weight. Among the studied children with ECC, none had poor oral hygiene (APR: 0; 95% CI: 0-0; p<0.001, Tables 2 and 3). Non-significant risk indicators for ECC included, consuming sugar between meals three times a day or more (APR: 2.18), having low socioeconomic status (APR: 2.4) and being female (APR: 2.9). This model explained 18% of differences in the prevalence of ECC observed. The pseudo R2 of the model for ECC increased with the addition of each block, indicating the validity of the choice of confounders for caries in the study population.

Discussion

For this study population, our hypothesis was sustained - there was an association between ECC and nutritional status of pre-school children: children who were stunted or underweight had lower prevalence of ECC and children who were overweight had higher prevalence of ECC. ECC was also associated with oral hygiene status ECC in the study population: children with fair oral hygiene had higher prevalence of ECC than those with good oral hygiene. There were no child with ECC who had poor oral hygiene and so the full extent of the oral hygiene/ECC relationship cannot be assessed. Prior significant factors associated with ECC in the study population – consumption of sugar between meals three times a day or more, being female and having mothers with poor knowledge of oral health – lost their significance in this study, as explanatory factors for ECC.

One of the strengths of the study was that its theoretical model for the study was built on evidence generated from the latest study conducted to identify risk indicators for ECC in Ile-Ife. Also, the study sample is representative of the study population and therefore, the results can be generalized to the study population and to Southwestern Nigeria, a region where the culture and diet – social factors associated with ECC - are similar to that of Ile-Ife [73]. The z score used to determine the nutritional status of the study population is more appropriate for children 2-year-old and younger [74], thereby increasing the validity of the study results [75]. Also, the robust estimation of variance analysis enhanced the validity of the inferential analysis conducted for the subgroups with small sample size.

This study contributes to the sparse literature on the relationship between malnutrition and ECC in sub-Saharan Africa. Although the continent has one a high prevalence of malnutrition [76] and a rising caries prevalence [77] the publications on ECC and malnutrition are only from Kenya [78, 79] and South Africa [80]. The only other study conducted in Africa on ECC and nutrition is from Egypt [81]. These previous studies found no significant relationship between ECC and nutritional status. Unlike those studies, we found that being stunted, underweight and overweight are associated with ECC.

First, the low prevalence of ECC in children who are stunted is likely a reflection of the high-starch, low-sugar diet found in communities where being stunted, wasted and underweight are prevalent [82]. We however, found no significant association between ECC and high sugar consumption in the study population when the analytical model included nutrition variables. Arantes et al [83] suggested a more comprehensive assessment of dietary risks related to caries beyond that addressing sugar intake alone. We feel that our study finding – the absence of a relationship between ECC and frequency of sugar consumption in an analysis model that included nutritional status – supports the suggestion of Arantes et al. We therefore postulate that our observed association between ECC, being stunted, underweight and overweight may reflect a complex impact of the household socioeconomic status on dietary choices – consumption of oil, salt, fat, vegetable, carbohydrate, sugar and micronutrients; and the relationship between ECC, being stunted, underweight and overweight is not limited exclusively to a sugar-caries pathway. Future studies are needed to explore this issue.

Second, fair and poor oral hygiene was the only risk indicator associated with ECC in a past study [63] that was found in this analysis to be a risk factor association with ECC. A prior study conducted in Nigeria, had also identified that fair oral hygiene was associated with higher prevalence of ECC [84], whereas another study highlighted an increase in ECC prevalence as oral hygiene worsened [85]. The calculated estimate for the association between poor hygiene and ECC should be interpreted with caution bearing in mind that there were no children with poor oral hygiene among those with ECC, and that the overall prevalence of poor oral hygiene was 2.2%. It is important to explore this finding since a study conducted in Nigeria in a different location from this study site(84) had also observed a similar phenomenon.

This is a cross-sectional study and therefore liable to the limitations associated with that design such as our inability to establish that malnutrition is a cause of ECC or otherwise. Although we controlled for some confounders by using multivariable analysis techniques [86,87], we were unable to control for all possible confounders in the absence of suggestive data. An example is that seasonality reportedly affects access to food, with impact on the prevalence of malnutrition [88]. The proportion of study participants with ECC was very low leading to estimates with wide confidence intervals of some associations. Similarly, the low prevalence of poor oral hygiene may be the reason for the observed lower prevalence of ECC association with it. We addressed the issues of low ECC and poor oral hygiene prevalence using robust estimation of variance so that the observed associations are based on sound statistical techniques. Thus, our study findings provide new information on the relationship between ECC and malnutrition in a country where malnutrition is endemic [75]. These findings are important because they produce evidence that is difficult to obtain in other countries where malnutrition prevalence may be lower. The study findings however raises a few questions that require further exploration to help improve our understanding about the relationship between ECC and malnutrition.

In conclusion, we found a significant association between ECC and being stunted, underweight and overweight in a suburban population with low prevalence of ECC, and no association between frequency of sugar consumption and ECC. Further studies that examine diet and ECC comprehensively are required. Also, for this study population, further studies are required to help build a stronger predictive model for ECC.

Declarations

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Availability of data and material

All study related data and materials are included in this publication.

Authors' contributions

The idea of the manuscript was conceived by EOO. The study was designed and data collection process managed by EOO, MOF, KAK. The data analysis was conducted by OA and MET. The first draft of the manuscript was developed by MOF. All the authors made intellectual inputs to the development of and finalization of the manuscript. All authors agreed to the final version of the manuscript to its submission.

Ethics approval and consent to participate

Not applicable

Consent for publication

Approval was obtained from participants to publish their statements.

Competing interests

The authors declare that they have no conflict of interest

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Tables

Table 1: Socio-demographic profile of study participants in the primary study and the current study

Variables	Total study participants		χ^2
	Current study N=370 (%)	Primary study N=497 (%)_	p-value
Sex			
Male	203 (54.9)	266 (53.5)	0.15
Female	167 (45.1)	231 (46.5)	0.69
Age Group			
6-23 months	46 (12.4)	72 (14.5)	
24-25 months	74 (20.0)	95 (19.1)	
36-47 months	88 (23.8)	122 (24.5)	
48-59 months	76 (20.5)	102 (20.5)	1.15
60-71 months	86 (23.3)	106 (21.4)	0.89
Socioeconomic Status			
High	83 (22.4)	129 (25.9)	
Middle	161 (43.5)	226 (45.5)	3.32
Low	126 (34.1)	142 (28.6)	0.19
Caries			
Present	18 (4.9)	33 (6.6)	1.75
Absent	352 (95.1)	434 (93.4)	0.19

Table 2: Association between ECC and sex, age, socioeconomic status, maternal knowledge of caries prevention, frequency of consumption of sugar, oral hygiene status and malnutrition (N=370)

Variables	ECC status				Test of Association	
	Absent (N=352)		Present (N=18)			
	N	%	N	%		
Sex						
Male	196	96.6	7	3.4	χ^2	1.95
Female	156	93.4	11	6.6	p-value	0.16
Age Group						
6-23 months	46	100	0	0.0	χ^2	11.69
24-25 months	74	100	0	0.0	p-value	0.02*
36-47 months	83	94.3	5	5.7		
48-59 months	68	89.5	8	10.5		
60-71 months	81	94.1	5	5.9		
Socioeconomic Status						
High	77	92.8	6	7.2	χ^2	3.36
Middle	157	97.5	4	2.5	p-value	0.19
Low	118	93.7	8	6.3		
Mother's Knowledge of Oral Health						
Poor	109	94.8	6	5.2	χ^2	0.05
Good	243	95.2	12	4.8	p-value	0.83
Frequency of Sugar Consumption in Between Meals						
<3 times daily	297	95.8	13	4.2	χ^2	1.86
≥3 times daily	55	91.7	5	8.3	p-value	0.17
Oral Hygiene Status						
Good	248	96.3	10	3.7	χ^2	2.24
Fair	96	92.3	8	7.7	p-value	0.29
Poor	8	100.0	0	0.0		
WAZ						

Normal	287	94.7	16	5.3	Exact test	-
Wasted	65	97.0	2	3.0	p-value	0.75
HAZ						
Normal	234	93.6	16	6.4	Exact test	-
Stunted	118	98.3	2	1.7	p-value	0.07
WHZ						
Normal	316	95.7	14	4.3	χ^2	3.14
Underweight	18	90.0	2	10.0	p-value	0.16
Overweight	18	90.0	2	10.0		

*: Statistically significant at P <0.05

Table 3: Poisson regression model for risk indicators of early childhood caries using robust variance estimation (N=370)

bles	Model 1 APR (95% CI)	p-value	Model 2 APR (95% CI)	p-value	Model 3 APR (95% CI)	p-value
			WAZ			
al	1	-	1	-	1	-
ed - PR (CI)	0.9 (0.24-3.28)	0.87	0.98 (0.27-3.6)	0.98	1.08 (0.19-6.26)	0.93
			HAZ			
al	1	-	1	-	1	-
ed - PR (CI)	0.26 (0.07-1.05)	0.06	0.25 (0.06-1.04)	0.06	0.14 (0.03-0.69)	0.02*
			WHZ			
al	1	-	1	-	1	-
rweight- PR	1.05 (0.17-6.5)	0.96	1.26 (0.2-8.06)	0.81	0 (0-0)	<0.001*
veight- PR	2.06 (0.51-8.32)	0.31	2.33 (0.55-9.89)	0.25	6.88 (1.83-25.85)	<0.001*
			SEX			
			1	-	1	-
le- PR (CI)			2.31 (0.89-6)	0.09	2.9 (0.91-9.29)	0.07
			SOCIOECONOMIC STATUS			
			1	-	1	-
e - PR (CI)			0.39 (0.11-1.39)	0.15	0.41 (0.08-2.02)	0.27
PR (CI)			1.1 (0.37-3.26)	0.86	2.4 (0.62-9.34)	0.21
			ORAL HYGIENE STATUS			
					1	-

PR (CI)					2.81 (1.02-7.74)	0.05*
- PR (CI)					0 (0-0)	<0.001*
FREQUENCY OF DAILY CONSUMPTION OF SUGAR						
nes daily					1	-
mes daily - I)					2.18 (0.5-9.53)	0.30
MATERNAL KNOWLEDGE OF CARIES PREVENTION						
					1	-
- PR (CI)					1.24 (0.31-4.93)	0.76
lo R^2	**0.04**		**0.08**		**0.18**	

APR: adjusted prevalence ratio, CI: confidence interval

¶Model 1 includes four malnutrition factors: wasted, stunted, overweight and underweight. Model 2: includes Model 1 variables plus demographic variables (gender and socioeconomic status). Model 3: includes Model 2 variables plus oral hygiene status, frequency of sugar consumption and maternal knowledge of caries prevention.

*: Statistically significant at $P \leq 0.05$