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Protein-energy malnutrition during early childhood and periodontal disease in the permanent dentition of Haitian adolescents aged 12–19 years: a retrospective cohort study

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Abstract

Objectives—The aim of this retrospective cohort study was to examine whether exposure to early childhood protein-energy malnutrition (ECPEM) is related to worsened periodontal status in the permanent dentition during adolescence.

Design—A trained clinician/researcher examined the periodontal status of 96 persons aged 12–19 living in rural Haiti using WHO diagnostic criteria (Community Periodontal Index, WHO 1997). Malnutrition data of the study participants had been collected during the years 1988–1993 by a nongovernmental organization. We compared those who had been malnourished in early childhood, based on *z*-scores for anthropomorphic data collected during the first 5 years of life, with those who had not been malnourished, regarding mean Community Periodontal Index (CPI) score, controlling for age, sex, socioeconomic status, and smoking.

Results—Overall, 57.3% of the participants demonstrated a CPI score of 3 or greater in at least one sextant. ECPEM was independently and positively related to mean CPI score, when controlling for sex and smoking.

Conclusions—More than half of these young Haitians demonstrated CPI scores of 3 or greater, and ECPEM was related to poorer periodontal status, as measured by CPI, in the permanent dentition.

Introduction

Data on the relationship between malnutrition and oral outcomes are scarce. The few epidemiologic studies conducted over the past four decades have tended to focus malnutrition effects on the dentition, including effects on tooth eruption patterns[1], enamel hypoplasia[2], and

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on dental caries prevalence[2–4]. Although epidemiologic studies of acute periodontal conditions in malnourished populations have shown that malnutrition is related to noma (cancrum oris) [5,6], and acute necrotizing ulcerative gingivitis[7], and that various nutritional deficiencies, including those of calcium[8], vitamin D[9], ascorbic acid[10], and protein[11] may be related to various forms of periodontal disease or manifest oral symptoms which mirror periodontal disease (e.g., scurvy), these investigations have all been cross-sectional in nature, have tended to evaluate only the degree of gingivitis but not periodontitis, or have examined the effects of malnutrition on the tooth supporting structures in only the primary dentition.

Protein-energy malnutrition (PEM) occurs when there are deficiencies in protein, energy foods or both, relative to a body's needs[11]. PEM during early childhood is thought to have profound effects on the developing immune system[12], most likely due to the concomitant occurrence of micronutrient deficiency, and therefore may have effects on susceptibility to infectious disease that last long past early childhood[13].

This is a retrospective cohort study designed to evaluate the effects of early childhood protein-energy malnutrition (ECPEM) measured during the first 5 years of life on the periodontal status of the permanent dentition in Haitian adolescents 7–12 years later, when aged 12–19, as measured with the Community Periodontal Index (CPI)[14]. Data relating to the malnutrition status of the participants during the first 5 years of life were obtained in these participants from the Haitian Health Foundation (HHF); a US-based nonprofit oral re-hydration and nutrition health programme operating in Jeremie, the third largest city of Haiti located in the southern region, and the surrounding rural areas. Since 1988, the HHF has provided a primary health care outreach program for over 120,000 residents of the Jeremie region of Haiti. As part of this health programme, the HHF established, and has continued to maintain, a computerized database on persons served; this database includes monthly weightings for the first 6 months of life and quarterly through 5 years of age for all children born since 1988. The presence of this unique database has allowed us the opportunity to answer important and intriguing scientific questions on the physiology and pathology of oral disease, including caries, tooth eruption patterns, and periodontal disease as they relate to PEM as experienced during early childhood.

The purpose of this retrospective cohort study was to examine whether those adolescents who had been exposed to ECPEM during their first 5 years of life were more likely to subsequently develop periodontal disease by age 12–19, compared to those who were not malnourished.

Materials and methods

Study sample

The sample of participants in this study was drawn from the population of a larger, ongoing investigation that investigated the effects of ECPEM during the first 5 years of life on the permanent dentition of rural Haitian children and adolescents. This larger core investigation included over 1000 Haitians who were enrolled from a total of 19 local villages. Details about the sampling and recruitment methodology for the core study have been previously published[1]. In order to be eligible for this and for the larger, ongoing study, participants had to have two recorded weighing per year for at least 3 of first 5 years of life in the HHF database and to reside in one of targeted villages in the Jeremie region during the study field period (May–August 2004). This time period was chosen as it guaranteed access to the greatest number of children, as the small per cent of children from Jeremie who are sent to Port-au-Prince for their education return for the summer months as schools close from June to October. Additionally, these months predate the rainy season and its associated travel difficulties.

For this sub-study, a study recruiter invited all eligible children of three villages to participate, and the study staff obtained informed consent, in Creole, from the parent and assent from the corresponding child. The protocol for this study was reviewed and approved by the Institutional Review Board of the New York University School of Medicine.

Measurements

Early childhood protein-energy malnutrition was based upon height and weight measurements made during the first 5 years of each participant's life, which were extracted from the database maintained by the HHF. The weighing scales were UNICEF-issued and calibrated at the beginning and during the weighing process. Monthly weightings for the first 6 months of life and quarterly through 5 years of age were the targets for the 1988–1996 period.

All definitions used a *z*-score based upon the weight-for-age for each child on a given visit, normalized with National Center for Health Statistics (NCHS) data. The NCHS database was selected for normalization to allow international comparisons as recommended by the WHO. A *z*-score of 0.00 indicates a weight-for-age equal to that of an average child of the same gender in the NCHS database, whereas a score less than 0.00 indicates a weight-for-age that is the indicated number of standard deviations below the average child of the same gender and age in the NCHS database. For this sub-study, ECPEM was defined as a child having any recorded weight-for-age *z*-score of less than or equal to ≤ -2.0.

Periodontal status was recorded by a single, trained dentist (G.J.C.). All children examined had a cardiac auscultation prior to periodontal probing; no children were found to have cardiac murmurs. The examinations were conducted in local villages and consisted of a visual dental periodontal examination following World Health Organization Criteria (WHO 1997) for periodontal disease measures. The examiner was standardized to WHO criteria for the Community Periodontal Index Treatment Needs by an experienced examiner prior to the initiation of the data collection phase (field operation), and in the field the examiner was assisted by a trained recorder. As recommended by the WHO, examinations of these children were limited to six index teeth: 16, 11, 26, 36, 31, and 46. We used a colour-coded pressure-sensitive probe (Vivacare; Vivadent, Schaan, Liechtenstein), which was specially designed to meet international standards for the screening of periodontal disease. Periodontal probing measurements were taken at two sites (mesiobuccal and mesiolingual) on each first molar and at two sites (mesiofacial and distofacial) on each of the selected incisor teeth for all participants. A total number of 12 sites per participant (two sites per tooth) received CPI scores ranging from 0, which signified healthy tissue, to a score of 4, which indicated a pathologic pocket. The WHO recommends that, in order to avoid scoring the deepened sulci associated with eruption (specifically of the premolar teeth) as periodontal pockets, scores of 3 and or 4, which indicate pocketing of 4–5 mm and 6+ mm, respectively, not be recorded in children under the age of 15[14]. Because (i) a substantial proportion (47%) of those examined were aged 12–14 and (ii) periodontal disease is known to occur in children as young as 10–12 years[15], we chose to include measurements made on the mesial aspects of the first molars of those younger than age 15. But, in order to examine whether deepened probings in those aged 12–14 (that might be associated with tooth eruption and not with periodontitis *per se*) accounted for differences found in our primary analysis of the ECPEM–CPI relationship, we conducted additional analyses which included alternative measurements taken from the first molars which would not likely be affected by adjacent erupting premolar teeth (i.e., the direct buccal and direct lingual measurements). The level of periodontal disease was based upon the highest score recorded per tooth; scores were then averaged to produce a mean CPI score per individual.

Other measures

Socioeconomic status (SES) at baseline was taken from the original HHF data set and represents SES status of the participant's family at birth. The SES questionnaire was developed to define rural Haitian SES status and is based upon the standard Haitian government census form. It has been translated and used in research in rural Haiti[16]. The goal of the SES questionnaire was to ascertain the children's household SES for rural Haiti and therefore questions includes items including number of rooms of the house, presence of a working radio, type of roof (e.g., tin, thatch), type of floor, water source, and presence of a latrine. Data may be considered as defining a relative socioeconomic measure. As part of this study, participants were also asked whether or not they presently smoked cigarettes, and were classified as either smokers or nonsmokers. Sex and age were also recorded.

Data management/analysis

All data were double-entered into a computerized database, confirmed against the original datasheets and then converted to an SPSS data set. Frequency cleaning was carried out to correct any possible range or distribution errors. Descriptive and exploratory analyses were conducted regarding the relationship between demographic variables (age, sex, SES, and smoking status) and both periodontal status (as measured by mean CPI score) and ECPEM (malnutrition *versus* no malnutrition). In addition, we examined the two groups of participants based on ECPEM regarding mean CPI, and tested for an independent association between the periodontal disease severity (as measured by mean CPI score), and the primary exposure of interest ECPEM, controlling for differences in age, sex, SES, and smoking using least squares multivariate linear regression.

Results

The distribution of the 96 study participants by age group, sex, and baseline SES level is shown in Table 1. The mean age of the group was 14.8 years (SD = 1.7 years), and males constituted slightly more than half (56.3%) of the sample. In bivariate analyses of the interrelationship of these demographic factors, we found that smoking was related to increased age; in fact, by the age of 16–19, half of the children reported smoking ($\chi^2 = 15.4$, d.f. = 4, $P = 0.004$). No other important relationships were found between any other of the demographic variables.

Demographic characteristics of the study participants by ECPEM are shown in Table 2. Overall, 49.5% of those in our sample were malnourished, which did not differ substantially from the proportion of children who were malnourished in the core study, where ECPEM was recorded in approximately 45.0% of the participants. ECPEM did not vary by sex or age. There was an inverse relationship between SES and ECPEM – those in the lowest SES category ('poorest') were more than four times more likely as those who were merely categorized as 'poor' to have had ECPEM (OR = 4.2; 95% CI 1.2, 14.3); those in the middle ('poorer') category were twice as likely to have had ECPEM; however, the difference between the 'poorer' adolescents and those classified as merely 'poor' did not reach statistical significance (OR 2.0; 95% CI 0.4, 10.9).

In bivariate analysis (Table 2), we found that although participants who were malnourished during the first 5 years of life had a higher mean CPI than those who were not malnourished, the difference in mean CPI was not statistically significant (1.63 *vs* 1.42, Student's *t*-test $P = 0.10$). Although mean CPI scores were reduced when we substituted the alternate CPI score which substituted buccal and lingual surfaces for the mesial surfaces that might have been subject to deepening because of erupting premolar teeth, we found no statistical difference by ECPEM status (1.26 *vs* 1.09, Student's *t*-test $P = 0.13$).

Results from multiple linear regression analysis, controlling for the potential confounding variables of age, sex, SES, and smoking, however, showed that children who were malnourished in early childhood had worse periodontal status, as measured by CPI, than those who were not malnourished (Table 3). In our final model, which was adjusted for sex and smoking, we found that ECPEM was significantly and directly related to mean CPI. Based on our model, in a non-smoking female without ECPEM exposure, the predicted mean CPI was 0.44, whereas for a smoking male with ECPEM exposure, the predicted mean CPI was 0.87. Calculating mean CPI based on buccal and lingual scores for first molars in those participants under the age of 15 did not meaningfully affect the findings.

Discussion

Over a third of the world's children are affected by PEM[17], a syndrome of inadequate intakes of protein, energy, and micronutrients. The relationship between ECPEM and acute infections is a complex one, as ECPEM adversely affects the immune system leading to an increased risk of infection[5,13,18], while, conversely, infection may cause nutritional imbalances leading to PEM[5,13,19]. The appreciation of this complex relationship has led to the contemporary view of ECPEM being a syndrome, which includes protein, energy and micronutrient intake deficiencies as well as frequent infectious disease episodes[17].

It has been hypothesized that ECPEM can have effects that reach beyond early childhood, for those who survive malnutrition. Specifically, ECPEM is thought to affect the developing immune system and therefore may alter an individual's ability to respond to infection long after the PEM has itself subsided[12]. This retrospective cohort study of the effects of PEM during the first 5 years of life on periodontal status is unique as reliable anthropomorphic assessments were reliably recorded in a cohort highly exposed ECPEM. Haiti, the poorest country in the western hemisphere, has one of the highest rates of childhood malnutrition in the world: between 40% and 75% of children are reported to have some level of malnutrition[20]. In our study sample, half of the children had experienced malnutrition, either regularly or intermittently, during their first 5 years of life.

We found that those children who had been malnourished during the first 5 years of life had higher CPI scores than those who had not been malnourished. The effect of EC-PEM on mean CPI score in our model was roughly as great as the effect of smoking, an established risk factor for periodontitis. It is important to note that, in the light of the delayed eruption of the permanent teeth that has been identified in these Haitian children who were exposed to ECPEM, the effect of ECPEM on the periodontal condition of the permanent dentition may, in fact, be underestimated, as the time these teeth were at risk for developing periodontal disease was reduced[1].

It is also notable that although determination of the prevalence of periodontal disease level was not the primary purpose of this study, we found that roughly half of all examined children exhibited CPI scores of 3 or greater in at least one sextant. Although we chose to record CPI scores of 3 or greater in those under the age of 15, the mean CPI score did not change appreciably when we substituted sites that would be less likely to be subject to deepening due to erupting teeth. Indeed, CPI scores of 3, which indicate pocketing of 4–5 mm, have not been previously reported in such a young population. Of the two previous studies which investigated dental disease levels in Haitian children, one did not include measures of periodontal destruction[21], whereas the other[22], conducted over 20 years prior to the present investigation, measured periodontal disease levels using the Ramfjord's Periodontal Disease Index, which makes comparing the two studies difficult. Nevertheless, this prior investigation identified low levels of disease in Haitian children aged 12–15, with a mean PDI of only 0.59 on a scale of 0, which represents no disease, to a score of 6, which represents a pocket measuring >6.0 mm.

Periodontal surveys conducted on children elsewhere in the Caribbean (see Table 4) also show lower levels of periodontal disease than what was found in this investigation[23–28]. Because the purpose of our study was to investigate the relationship of ECPEM and the subsequent development of periodontal disease, and not to quantify levels of periodontal disease, our sampling measures varied from the other studies that have been conducted. In addition, although the CPI is often used to quantify periodontal disease levels, its properties do not make it an ideal periodontal index to establish the presence of periodontitis. But, given the high proportion of adolescents in our study with periodontal pocketing, clearly, further investigation regarding levels of periodontal disease in these Haitian children is warranted.

Although we found that SES was related to ECPEM, we did not find that SES was related to CPI score, and in fact in our multivariate analysis which investigated the relationship between ECPEM and CPI score, SES was dropped from the final reduced model, while smoking status and sex remained significant predictors of CPI score. We hypothesize that ECPEM is a likely a good reflection of SES in this population, and that ECPEM is a stronger predictor of CPI than SES. It is perhaps more likely that malnutrition would biologically affect the periodontium via effects on the developing immune system than would SES factors, which may or may not be related to oral habits and oral care in this population.

To our knowledge, this is the first study to investigate the relationship between ECPEM and the subsequent deterioration of periodontal status in the permanent dentition. Although effects of specific nutritional deficiencies on the periodontium have been reported previously[8–10], the mechanism by which PEM in early childhood is likely to be quite different than that hypothesized to exist when the two conditions, nutrient deficiency, and periodontal disease or gingivitis occur simultaneously. Because ECPEM is likely to affect the developing immune system, a person's ability to respond to colonization with periodontal pathogens may be adversely affected permanently.

What this paper adds

- In this study sample, a substantial proportion of rural Haitian children aged 12–18 had manifestations of periodontal disease, as measured by CPI. Roughly half of all examined children exhibited CPI scores of 3 or greater in at least one sextant.
- Early childhood protein-energy malnutrition was related to increased CPI score in this cohort of children.

Why this paper is important to paediatric dentists

- Results of this study indicate that early childhood protein-energy malnutrition may predispose to periodontitis in the permanent dentition.

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Table 1

Demographic characteristics of the study participants.

	Age		
	12–13	**14–15**	**16–19**
Sex			
Male	17 (56.7)	22 (52.4)	15 (62.5)
Female	13 (43.3)	20 (47.6)	9 (37.5)
Socioeconomic position			
Poor	3 (10.0)	7 (16.7)	7 (29.2)
Poorer	13 (43.3)	15 (35.7)	7 (29.2)
Poorest	14 (46.7)	17 (40.6)	9 (37.6)
Smoking status*			
Nonsmoker	28 (93.3)	29 (69.0)	12 (50.0)
Present smoker	2 (6.7)	13 (31.0)	12 (50.0)
Total	30 (100)	42 (100)	24 (100)

Values within parenthesis are expressed in percentage.

*$P \leq 0.01$, $\chi^2 = 12.7$, d.f. = 2.

Table 2

Early childhood protein-energy malnutrition (ECPEM) Haitian adolescents.

	ECPEM	
	Malnutrition (50.5%)	**No malnutrition (49.5%)**
Age		
12–13 (*n* = 30)	15 (51.7)	14 (48.3)
14–15 (*n* = 42)	27 (67.5)	13 (32.5)
16–19 (*n* = 24)	16 (66.7)	8 (33.3)
Sex		
Male	32 (60.4)	21 (39.6)
Female	26 (65.0)	14 (35.0)
SES*		
Poor	6 (37.5)	10 (62.5)
Poorer	20 (58.8)	14 (41.2)
Poorest	32 (80.0)	8 (20.0)
Village		
1	33 (67.3)	16 (32.7)
2	14 (60.9)	9 (39.1)
3	11 (52.4)	10 (47.6)
CPI score, mean (SD)	1.63 (0.57)	1.42 (0.62)

Values within parenthesis are expressed in percentage. SES, socioeconomic status; CPI, Community Periodontal Index.

*$P \leq 0.05$, $\chi^2 = 6.2$, d.f. = 2.

Table 3

Linear regression modelling results, ECPEM (independent variable) on mean CPI score (dependent variable).

	Full model CPI score definition #1* (r^2 =0 .15)				Final reduced model CPI score definition #1* (r^2 = 0.15)				Final reduced model CPI score definition #2** (r^2 = 0.21)			
	***β* (SE)**	$\beta_{standardized}$	***t***	***P***	***β* (SE)**	$\beta_{standardized}$	***t***	***P***	***β* (SE)**	$\beta_{standardized}$	***t***	***P***
Constant	0.69 (0.66)		1.0	0.30	0.44 (0.21)		2.1	0.04	0.47 (0.19)		2.5	0.01
ECPEM	0.26 (0.13)	0.22	2.1	0.04	0.25 (0.12)	0.21	2.1	0.04	0.39 (0.12)	0.21	2.2	0.02
Sex	0.34 (0.12)	0.28	2.8	0.01	0.34 (0.12)	0.28	2.8	0.01	0.31 (0.11)	0.29	3.0	0.004
Age	−0.02 (0.04)	−0.07	−0.6	0.55								
SES	0.01 (0.04)	0.01	0.2	0.86								
Smoking	0.31 (0.15)	0.23	2.1	0.05	0.27 (0.13)	0.20	2.0	0.05	0.23 (0.11)	0.31	3.2	0.03

ECPEM, early childhood protein-energy malnutrition; CPI, Community Periodontal Index; SE, standard error.

*Dependent variable: mean CPI score calculated using mesial sites of all teeth scored, for all children.

**Dependent variable: mean CPI score calculated using mesial sites of all teeth scored, for children ≥15 years, and using b and l sites of molars for children 12–14 years, and mesial sites of incisors, to prevent possible overestimation of pocket depth due to erupting premolar teeth.

ECPEM, two levels; reference level = no malnutrition.

Sex: reference level = female.

Smoking, two levels; reference level = no smoking.

Table 4

Periodontal status of Caribbean children.

Country	Year	Authors	Study sample	Measurements	Findings
Dominican Republic	2005	Collins *et al*.	School-based sample of 2007 adolescents aged 12–21 years	PPD, recession and CAL at six sites per tooth	CAL ≥2 mm at one site or more seen in 15% of participants CAL ≥3 mm at one site or more seen in less than 4% of participants
St. Vincent/Grenadines	1991	Alonge *et al*.	School-based sample of 1646 children aged 7–19 years	CPI (WHO)	12 years old: 21% scored 0 6% scored 1 (bleeding) 74% scored 2 (calculus present) 15–19 years old: 12% scored 0 5% scored 1 (bleeding) 83% scored 2 (calculus present)
Dominica	1990	Leake *et al*.	School-based sample of 442 adolescents aged 11–13 years	CPI (WHO)	31% scored 0 62% scored 1 or 2 (calculus present)
Antigua	1990	Vignarajah *et al*.	School-based sample of 246 children aged 12 years and 456 adolescents 15–19 years	CPI (WHO)	12 years old: 26% scored 0 28% scored 1 (bleeding) 46% scored 2 (calculus present) 15–19 years old: 14% scored 0 13% scored 1 (bleeding) 56% scored 2 (calculus present) 14% scored 3 (pockets 3.5–5.5 mm) 3% scored 4 (pockets ≥6 mm)
Dominican Republic	1986	Garcia-Godoy *et al.*	School-based sample of 1080 adolescents aged 12–16 years	CPI (WHO)	13% scored 0 6% scored 1 (bleeding) 69% scored 2 (calculus present) 12% scored 3 (pockets 3.5–5.5 mm) 0% scored 4 (pockets ≥6 mm)
Trinidad	1961	Wertheimer *et al.*	Census-based sample of 2000 persons, including adolescents aged 15–19 years	PI (Russell, 1956*)	PI score of 0.43 seen in those aged 15–19, on a scale of 0–8

PPD, pocket probing depth; CAL, clinical attachment loss; CPI, Community Periodontal Index.

*Source: Russell AL. A system for classification and scoring for prevalence surveys of periodontal disease. J Dent Res 1956; **35**: 350–359.