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Untreated severe dental decay: a neglected determinant of low Body Mass Index in 12-year-old Filipino children

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Abstract

Background: Dental decay is the most common childhood disease worldwide and most of the decay remains untreated. In the Philippines caries levels are among the highest in the South East Asian region. Elementary school children suffer from high prevalence of stunting and underweight.

The present study aimed to investigate the association between untreated dental decay and Body Mass Index (BMI) among 12-year-old Filipino children.

Methods: Data collection was part of the National Oral Health Survey, a representative cross-sectional study of 1951 11-13-year-old school children using a modified, stratified cluster sampling design based on population classifications of the Philippine National Statistics Office. Caries was scored according to WHO criteria (1997) and odontogenic infections using the PUFA index. Anthropometric measures were performed by trained nurses. Some socio-economic determinants were included as potential confounding factors.

Results: The overall prevalence of caries (DMFT + dmft > 0) was 82.3% (95%CI; 80.6%-84.0%). The overall prevalence of odontogenic infections due to caries (PUFA + pufa > 0) was 55.7% (95% CI; 53.5%-57.9%) The BMI of 27.1% (95%CI; 25.1%-29.1%) of children was below normal, 1% (95%CI; 0.5%-1.4%) had a BMI above normal. The regression coefficient between BMI and caries was highly significant ($p < 0.001$). Children with odontogenic infections (PUFA + pufa > 0) as compared to those without odontogenic infections had an increased risk of a below normal BMI (OR: 1.47; 95% CI: 1.19-1.80).

Conclusions: This is the first-ever representative survey showing a significant association between caries and BMI and particularly between odontogenic infections and below normal BMI. An expanded model of hypothesised associations is presented that includes progressed forms of dental decay as a significant, yet largely neglected determinant of poor child development.

Background

Dental decay (caries) is the most common childhood disease and the most frequent non-communicable disease worldwide [1,2]. Most of the dental decay remains untreated with significant impacts on general health, quality of life, productivity, development and educational performance [3-6]. In the Philippines caries levels are among the highest in the South East Asian region, with

a prevalence of 82% and a Decayed, Missing and Filled permanent Tooth index (DMFT) of 2.9 among 12-year-olds in 2006 [7,8].

Besides, children in the Philippines as in many other low- and middle-income countries, suffer from a high burden of preventable diseases other than dental decay: diarrhoea and respiratory tract infections, the top killer diseases among children. Two-thirds of school children are infected with chronic soil-transmitted helminths (STH) [9]. Because of these poor health conditions children suffer from significant impacts on their development, growth, well-being, as well as their social and

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educational performance. With regard to growth development, low Body Mass Index (BMI) is very prevalent in the Philippines, like in many other low- and middle-income countries [10].

Despite the pandemic character of dental decay, particularly in children, there are only a few studies that have examined the relationship between the severity of dental decay and child weight. Previous research concluded that children with early childhood caries (ECC) who needed treatment for tooth extraction had lower mean weights than those without treatment need [11-13]. In larger surveys among 1-6-year-old non-hospital visitors, the relationship between caries and underweight remained inconclusive [14-19]. A recent large population-based prospective cohort study in the United Kingdom (UK) among 5-year olds reported that children with tooth decay had slightly smaller increases in weight and height in the previous years than children without tooth decay [20]. Virtually nothing is known about this association in older age groups.

The present study aimed to investigate the association between dental decay and low BMI, 2 highly prevalent conditions among 12-year-old Filipino children. The hypothesis was tested that an association between dental decay and low BMI in 12-year-old Filipino children did not exist. Weight, height, caries prevalence and caries experience as well as some demographic and socio-economic variables were included in a National Oral Health Survey (NOHS) undertaken in 2006.

Methods

Sample

The NOHS was conducted from November 2005 to February 2006 using a stratified cluster sampling design. All 17 regions of the country were included, in each region a rural and urban area were identified according to the criteria of the National Statistics Office. In total, 68 public elementary schools were selected for the survey, 2 in each stratum ($n = 34$). Inclusion criteria for schools were: a location in a secure area; access within an hour from the main road; and schools having more than 60 grade VI children. In each school 30 grade VI children aged 11-13 years were systematically sampled from a list of enrolled schoolchildren. This sample size was estimated on the presumption of a caries prevalence of 80%, a desired precision of $\pm 2\%$ with a confidence level at 95%. Ethical approval was obtained from the Department of Education under whose authority this survey was undertaken.

Oral examination

All children brushed their teeth prior to examination. Oral examinations were performed outside in the schoolyard with children lying in a supine position on a school bench or table with their heads on a pillow on

the lap of the examiner who sat behind them. Cotton pellets were used for drying. A CPI ball-ended probe and a lighted mouth mirror (MIRRORLIGHT™, Kudos, Hong Kong) were used as examination tools to score caries according to standard procedures described by WHO (1997) [21]. Initial caries lesions and early stages of cavitation where the ball-ended probe could not enter were not scored as caries, unless a greyish appearance of enamel as a sign of an underlying dentine involvement with caries was noted.

In addition to data collection for DMFT/dmft (permanent and primary dentition) the PUFA/pufa index was used according to the standard procedure [22]. PUFA/pufa is an index used to assess the presence of oral conditions and infections resulting from untreated caries in the primary (pufa) and permanent (PUFA) dentition. The index is recorded separately from the DMFT/dmft and scores the presence of either a visible pulp (P/p), ulceration of the oral mucosa due to root fragments (U/u), a fistula (F/f) or an abscess (A/a). The PUFA/pufa index per child is calculated in the same cumulative way as the DMFT/dmft index and represents the number of teeth meeting the PUFA/pufa diagnostic criteria.

5 survey teams, each consisting of 2 dentists and 2 recorders underwent 2 days of theoretical and 3 days of clinical training in caries (DMFT/dmft) and PUFA/pufa diagnosis and calibration. During the entire survey, each examiner re-examined 7.5% of the children and reproducibility was assessed with Kappa values.

Anthropometric measures

All measurements were performed by trained school nurses according to standard guidelines [23]. The height of children, standing upright without shoes, was measured with a portable stadiometer (Seca®) to the nearest 0.5 cm. Weight was assessed with a portable electronic digital scales to the nearest 0.5 kg (Soehnle®). No adjustments were made for clothing, but children were only lightly dressed. The measuring equipment was re-calibrated daily. Height and weight were used to compute BMI (weight in kilograms divided by height in metres squared - weight (kg)/height (m²)) for age. The children were grouped in 3 categories of BMI with age and sex related cut-off points according to the criteria of WHO (Thinnes [24]), CDC (Thinnes [25]), Philippine NHANS I [26] and Cole (Thinnes grade 2 [27]). For further analyses, the 3 BMI categories according to the Philippine NHANS I criteria were used (Table 1).

Demographic and socio-economic parameters

Teachers provided information on place of residence, gender and age of the child. The child was asked about the number of siblings and whether there was a television set at home.

Table 1 Cut-off points for the 3 classes of Body Mass Index (BMI) of 11-, 12- and 13-year-old boys and girls

Boys			
Age	BMI < normal	BMI normal	BMI > normal
11	14.82	14.83 - 23.73	23.74
12	15.23	15.24 - 24.89	24.90
13	15.72	15.73 - 25.93	25.94
Girls			
Age	BMI < normal	BMI normal	BMI > normal
11	14.59	14.60 - 24.59	24.60
12	14.97	14.98 - 25.95	25.96
13	15.35	15.36 - 27.07	27.08

Statistical methods

The data were analysed with SAS 9.1 software. Examiner’s reproducibility of oral conditions at tooth level was measured by Kappa statistics. The caries status (including odontogenic infections), caries prevalence and caries experience, were combined for the primary and permanent dentition. A regression equation between BMI and caries and between BMI and odontogenic infections (PUFA) was calculated and presented in a scatter plot. For further analysis, the variable caries status was dichotomised into caries free children versus children with caries. Children with odontogenic infections were dichotomised into those with odontogenic infections versus those without and into children with one odontogenic infection versus children with more than one odontogenic infection. BMI was the dependent variable in all analyses. Chi-square and Student-*t*-tests were used for comparison between groups. Since the number of children with a BMI above normal was small, the BMI was dichotomised into below normal BMI versus normal together with above normal BMI. In the logistic regression model only those explanatory variables were introduced that showed statistical significance ($P < 0.05$) in bi-variate analysis with low BMI as dependent variable.

Results

From a total of 2022 11-13-year-old children, 1951 (949 boys and 1002 girls) with a mean age 11.8 years were included in the analysis. Of the 71 excluded children due to incomplete data, 33 were boys and 38 were girls.

Inter-examiner Kappa values for caries detection assessed after the calibration session were in the range from 0.78 to 0.92, which can be judged as good. Throughout the NOHS, 7.5% of children were re-examined in order to assess intra-examiner consistency. Intra-examiner reproducibility varied between Kappa values of 0.80 to 0.98 for scoring DMFT/dmft and 0.80 to 0.97 for PUFA/pufa.

Caries

The frequency distributions of children with caries and odontogenic infections (PUFA) are presented (Figure 1). The mean prevalence of caries (DMFT + dmft > 0) is 82.3% (95%CI; 80.6%-84.0%) and the mean prevalence of odontogenic infections (PUFA + pufa > 0) is 55.7% (95% CI; 53.5%-57.9%). The prevalence data are summarised in Table 2 for gender, demography, and socio-economic determinants. There are no significant differences in the caries prevalence between the variables. The mean experience of caries (DMFT + dmft) is 3.12 and the mean experience of odontogenic infections (PUFA + pufa) is 1.15. The caries experience data are summarised in Table 3 for the same variables and no significant differences were found. The filled (F/f) component was close to zero and the missing (M) component (due to caries) was 7% of the total caries experience.

BMI

The frequency distributions of the 3 categories of BMI with sex and age related cut-off point according to WHO, CDC, Philippine NHANS I and Cole are presented in Figure 2. Figure 3 depicts the distribution of the 3 BMI categories, obtained with the Philippine NHANS I criteria, according to the number of DMFT and the number of odontogenic infections (PUFA). A scatter plot depicting each child for BMI and number of DMFT and a scatter plot showing each child for BMI and number of odontogenic infections (PUFA) are presented in Figure 4. The regression equation for the relation between BMI versus DMFT and BMI versus PUFA, are statistically significant ($p < 0.001$). The regression coefficient for BMI versus PUFA is larger than the one for BMI versus DMFT, indicating a stronger effect for PUFA on BMI. Table 4 gives the numbers and percentages of the 3 categories of BMI according to dichotomised explanatory variables. Of the child sample, 50% were children from rural areas, 38% of children lived in large families with more than 4 siblings and 74% had a TV set at home. The BMI of 27.1% (95%CI; 25.1%-29.1%) of children was

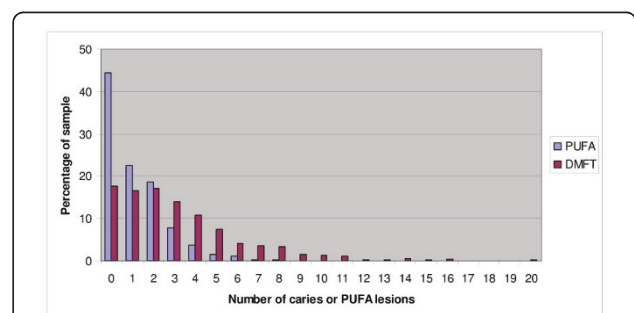


Figure 1 Distribution of caries lesions and caries lesion that progressed into the pulp (PUFA) of 11-13-year olds.

Table 2 Prevalence (95% CI) of caries and prevalence of dental infections due to caries in 11-13-year-old schoolchildren

Variables	N	DMFT + dmft >0	Chi-square P-value	PUFA + pufa >0	Chi-square P-value
Girls	1002	82.9% (80.6-85.3)	P = 0.46	56.6% (53.5-59.7)	P = 0.43
Boys	949	81.6% (79.1-84.0)	P = 0.46	54.7% (51.5-57.7)	P = 0.43
Rural	978	80.6% (78.1-83.1)	P = 0.057	54.5% (51.4-57.6)	P = 0.32
Urban	973	84.0% (81.6-86.3)	P = 0.057	56.8% (53.7-60.0)	P = 0.32
TV at home - yes	1443	83.1% (81.1-85.0)	P = 0.12	55.9% (53.3-58.4)	P = 0.81
TV at home - no	508	79.9% (76.4-83.4)	P = 0.12	55.1% (50.8-59.5)	P = 0.81
Siblings 0-4*	1201	82.8% (80.7-85.0)	P = 0.37	55.0% (52.2-57.9)	P = 0.49
Siblings >4*	742	81.1% (78.3-84.0)	P = 0.37	56.7% (53.2-60.3)	P = 0.49

* 8 children not included in this variable due to incomplete data.

below normal and 1% (95%CI; 0.5%-1.4%) had a BMI above normal. The prevalence of low BMI was similar for caries free children and children with caries, but the prevalence of low BMI was significantly higher in children with odontogenic infections (PUFA/pufa > 0) as compared with children without odontogenic infections. Associations were found between low BMI and gender, TV set at home, large families and odontogenic infections. The associated explanatory variables were introduced into a logistic regression model with low BMI as dependent variable. Table 5 depicts the results. Boys, children in large families (>4 siblings) and children with odontogenic infections (PUFA + pufa) were more likely to have a low BMI with an odds ratio (OR) of 1.52, 1.39 and 1.47, respectively.

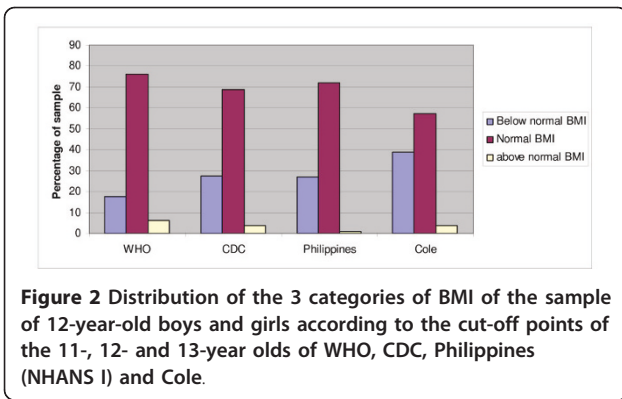
Discussion

The data presented in this paper were collected using a systematic representative random sample from the Philippine National Oral Health Survey in 2006, which is one of a new generation of oral health surveys that, in addition to the traditional tooth-related indicators, take socio-economic and anthropometric parameters into account [8]. The survey was also the first to use the new PUFA index to assess the amount of odontogenic infection resulting from advanced untreated decay. The introduction of the PUFA index in this study examining possible associations between dental decay and low BMI appeared to be relevant, since it created a clear differentiation in the findings. Although a significant association existed between BMI and caries, only children with

Table 3 Mean (sd) experience of caries and mean (sd) experience of odontogenic infections due to caries in 11-13-year-old schoolchildren

Variables	N	DMFT + dmft	Student T P-value	PUFA + pufa	Student T P-value
Girls	1002	3.16 (2.94)	P = 0.54	1.19 (1.39)	P = 0.30
Boys	949	3.08 (3.03)	P = 0.54	1.12 (1.42)	P = 0.30
Rural	978	3.06 (3.00)	P = 0.35	1.11 (1.40)	P = 0.19
Urban	973	3.18 (3.00)	P = 0.35	1.19 (1.41)	P = 0.19
TV at home - yes	1443	3.14 (3.02)	P = 0.52	1.17 (1.44)	P = 0.40
TV at home - no	508	3.05 (2.86)	P = 0.52	1.11 (1.31)	P = 0.40
Siblings 0-4*	1201	3.05 (2.83)	P = 0.18	1.13 (1.39)	P = 0.34
Siblings >4*	742	3.23 (3.21)	P = 0.18	1.19 (1.44)	P = 0.34

* 8 children not included in this variable due to incomplete data.

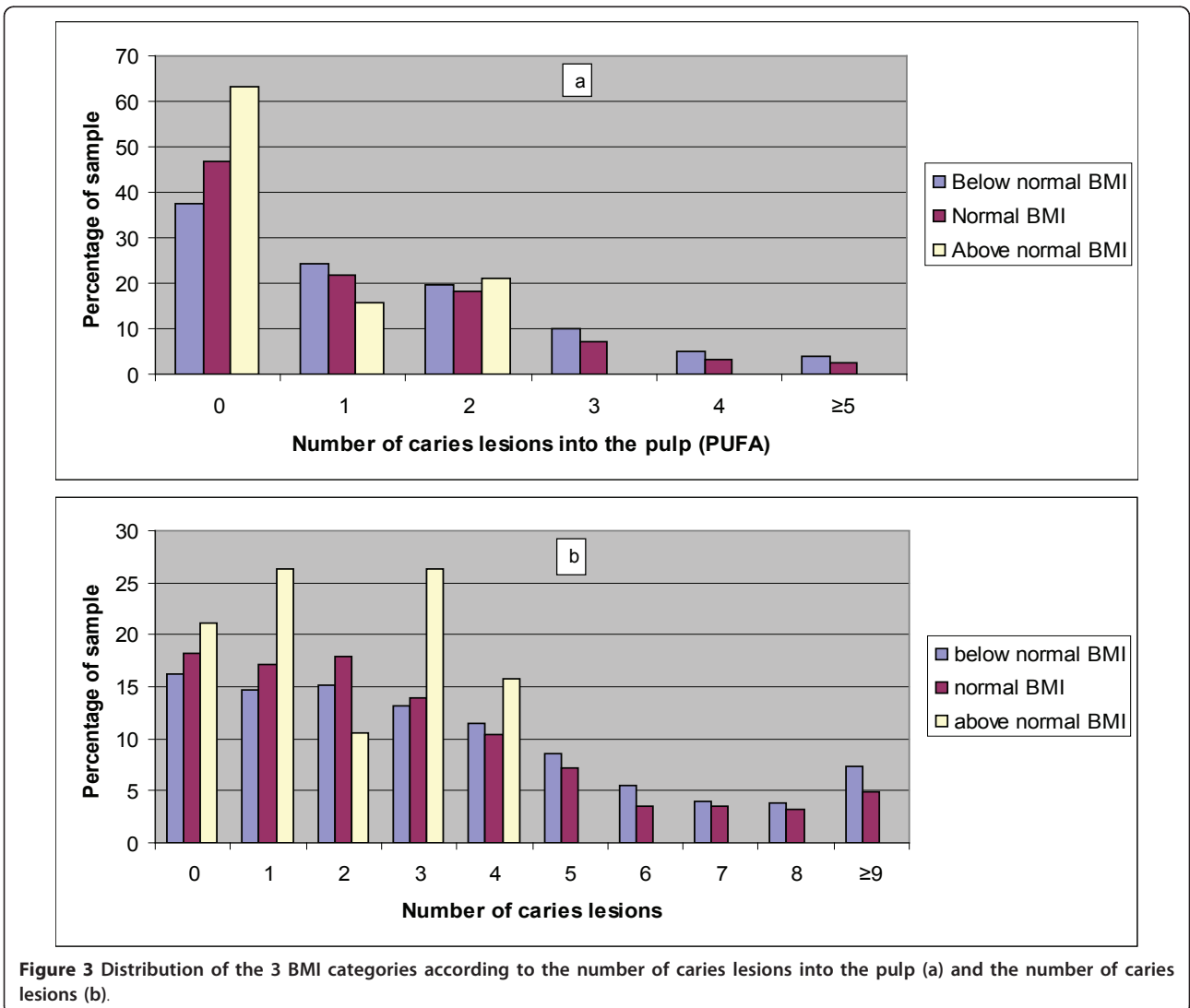


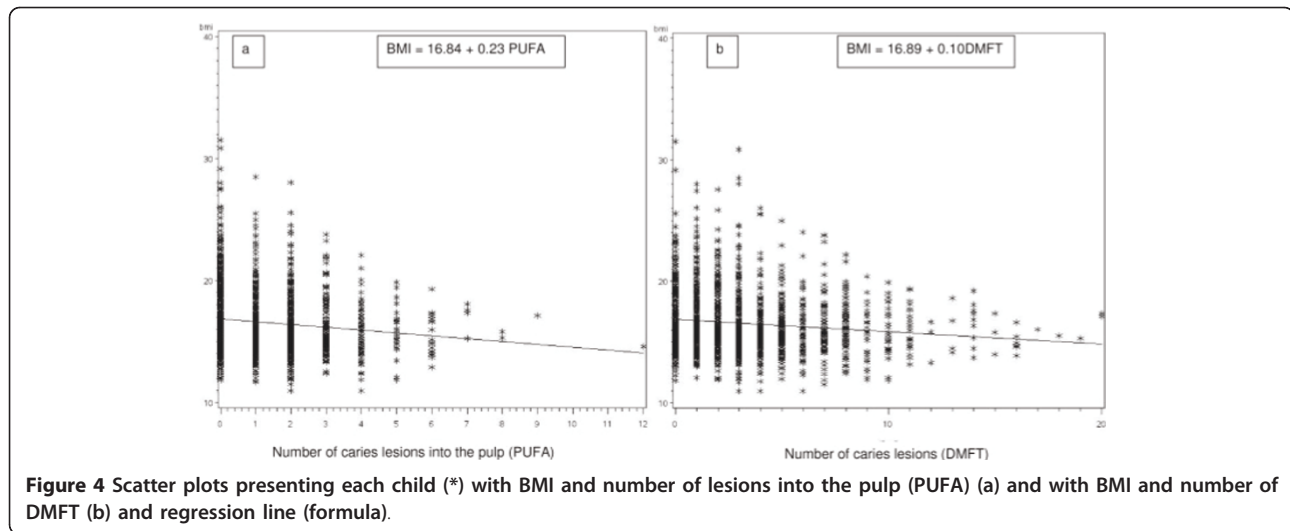
caries progression into the pulp (odontogenic infections) appeared to have an increased risk of a below normal BMI as compared to those without odontogenic

infections. These findings imply that the null hypothesis was rejected with an added nuance that:

- Children with caries had no increased risk of a below normal BMI as compared to caries free children; whereas
- Children with caries into the pulp (odontogenic infections) had an increased risk of below normal BMI as compared to children without odontogenic infections.

Our study design is a cross-sectional study, which limits the ability to identify causative factors. A longitudinal design would be more adequate to reveal cause and effect relationships. There are indications from several longitudinal studies that treatment of severe caries resulted in weight gain [28-30]. If untreated caries





progresses into the dental pulp there are possibly 3 main pathways for this association: 1) pain and discomfort result in reduced food intake; 2) reduced quality of life affects children's growth and development through restricted activity, reduced sleep, concentration deficits etc; and 3) odontogenic infections may result in cytokine release which might impact on growth. One study on inflammatory periodontal diseases reported an association with cytokine release [31], but this issue is yet highly speculative. Future research will hopefully provide a more complete picture of the causal relationships, of the nature of the relation over time from early childhood to adolescence, and of the impact of different oral care options on child development.

In contrast to reports from other countries with similar socio-economic status this survey did not find any significant differences between 12-yr-old children from rural and urban areas in terms of caries prevalence, caries experience (DMFT + dmft), odontogenic infections (PUFA + pufa) and BMI [32-36]. A possible explanation for a lack of stratification effects on the studied variables could be the absence of higher socio-economical classes in the present study, since private schools that are mainly located in urban areas were not included in the sample.

This study indicated a higher risk of low BMI for boys compared to girls and for children in large families as compared to children in smaller families, which cannot be attributed to the caries status (Table 2 and 3). The percentage of 31% for low BMI of boys being higher than the 23% for girls is in accordance with the last national update on nutritional status of children in 2005 [10]. Low BMI is a result of several complex factors. Lack of hygiene, lack of nutritious food, as well as respiratory and other infections could account for

differences in BMI between boys and girls. Additional factors that may also be considered include for instance that males are more active in sports. For practical and resource reasons it was not possible to obtain stool samples to test for worm infestation. However, STH infections are highly prevalent in Filipino children with an average national prevalence of 82.3% [9]. The summarised results from studies on STH infections do not indicate a difference in the prevalence and severity between boys and girls [9,37]. Given the high prevalence and the sample size of the survey it is not expected that a differing STH infection status affected the associations between dental decay and BMI found.

An expanded model of hypothesised relations

The contemporary scientific discourse among paediatricians, nutritionists and even international organisations and NGOs related to child health and development, has so far completely ignored the impact of untreated dental decay. Virtually all dental decay remains untreated and contributes to poor child development and educational performance. This may be a result of the still new and growing evidence about the relation between dental decay and child development, but it is also a result of a disconnection between dental researchers and the "mainstream" of child development research.

A recent model visualises the possible complex relationships between the many factors ranging from nutritional deficits to maternal depression, from infectious diseases to intrauterine factors [38]. In order to bridge the gap between the "scientific niche" of oral-health-related research and child development we present a modified model for the hypothesised causal relationships leading to poor education performance of children (Figure 5). It builds on the research already published and adds the

Table 4 Prevalence of normal, below-normal (low) and above-normal (high) Body Mass Index (BMI) of 11-13-year-old schoolchildren according to various variables

Variables	N	Dependent variable			Chi-square P value*
		BMI < normal N = 529 N (%)	BMI normal N = 1403 n (%)	BMI > normal N = 19 n (%)	
Gender					
Girls	1002	234 (23.4)	762 (76.1)	6 (0.6)	P < 0.001
Boys	949	295 (31.1)	641 (67.5)	13 (1.4)	P < 0.001
Socio-economic					
Rural	973	277 (28.5)	688 (70.7)	8 (0.8)	P = 0.18
Urban	978	252 (25.8)	715 (73.1)	11 (1.1)	P = 0.18
TV at home - yes	1443	373 (25.9)	1053 (73.0)	17 (1.2)	P = 0.04
TV at home - no	508	156 (30.7)	350 (68.9)	2 (0.4)	P = 0.04
Siblings 0-4*	1201	291 (24.2)	892 (74.3)	18 (1.5)	P < 0.001
Siblings >4*	742	234 (31.5)	507 (68.3)	1 (0.1)	P < 0.001
Caries status					
DMFT + dmft = 0	346	86 (24.9)	256 (74.0)	4 (1.2)	P = 0.30
DMFT + dmft >0	1605	443 (27.6)	1147 (71.5)	15 (0.9)	P = 0.30
PUFA + pufa = 0	865	198 (22.9)	655 (75.7)	12 (1.4)	P < 0.001
PUFA + pufa >0	1086	331 (30.5)	748 (68.9)	7 (0.6)	P < 0.001
PUFA + pufa = 1	439	129 (29.4)	307 (69.9)	3 (0.7)	P = 0.52
PUFA + pufa >1	647	202 (31.2)	441 (68.2)	4 (0.6)	P = 0.52

* 8 children not included in this variable due to incomplete data

Due to small numbers in the high BMI cell, P-values were calculated on dichotomised BMI classes (low versus normal + high).

dimension of a specific and highly prevalent chronic disease, dental decay, particularly dental decay that has progressed into the pulp and highlights pathways of interaction with all of the established factors contributing to poor child development. By placing dental decay in the centre of the diagram we do not imply that untreated caries and the resulting chronic infections are the most important factor for suboptimal child development; we rather wanted to highlight the complexity of interrelations among the various factors.

Although the extent of the negative effect of odontogenic infections compared to other determinants in this context still needs to be quantified by further research, early results from ongoing studies and previous research indicate that removing odontogenic infection has a

significant positive effect on subsequent child growth and development. In addition, simple and cost-effective measures for preventing dental decay exist, which could easily be applied comprehensively and on a mass scale in school health programmes [39]. We suggest that the absence of odontogenic infections (PUFA + pufa = 0) can be considered as an important outcome indicator for (oral) health programme planning, monitoring and evaluation.

In the context of increased efforts to achieve the United Nation's Millennium Development Goals (MDG), and more specifically Goals 1 and 2 related to hunger and education, it would seem to be important to address the determinants of child development, nutrition status and educational performance comprehensively and from

Table 5 Odds ratio (adjusted) obtained from a logistic model

Variables	Dependent variable		P-value
	Odds ratio	Confidence limits	
Boys versus girls	1.52	1.24-1.87	<0.001
Large families versus small families	1.39	1.13-1.72	0.002
No TV at home versus TV at home	1.21	0.96-1.53	0.10
PUFA versus no PUFA	1.47	1.19-1.80	<0.001

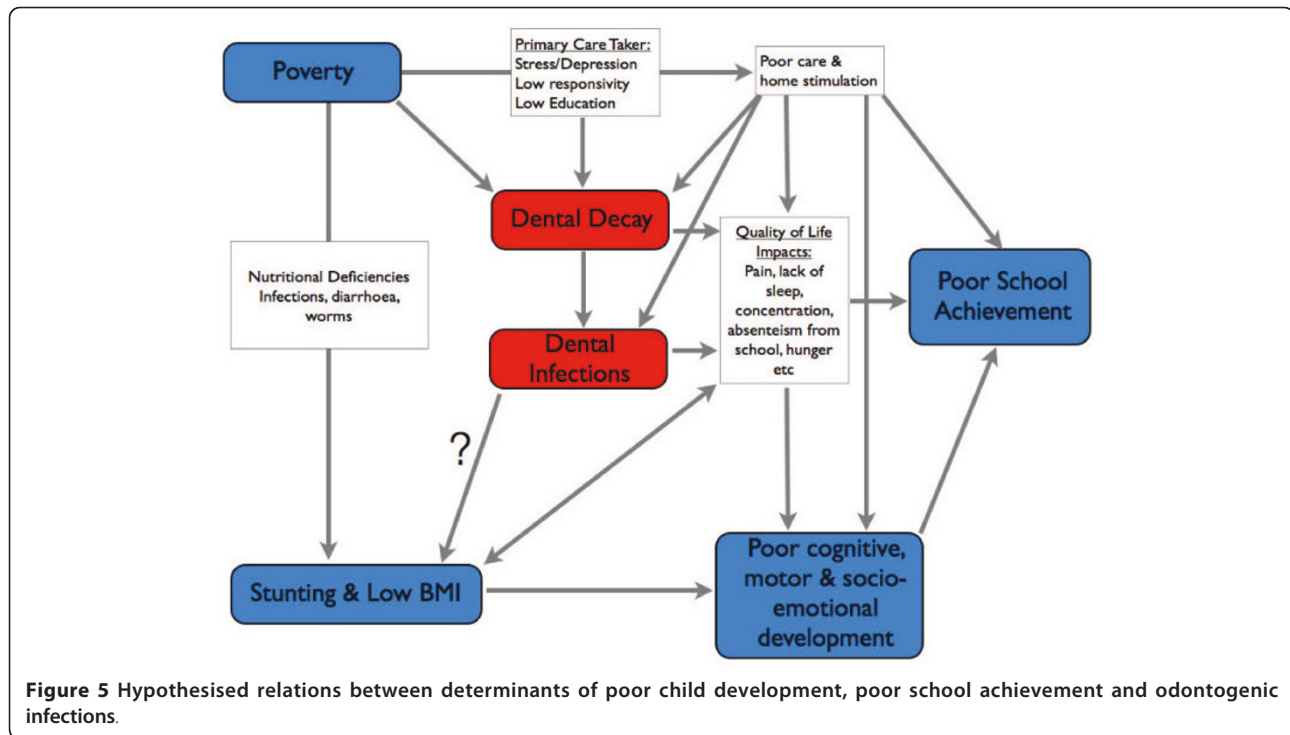


Figure 5 Hypothesised relations between determinants of poor child development, poor school achievement and odontogenic infections.

different perspectives. Good oral health is closely related to all MDG goals [40]. Poor oral health is the result of neglect of oral hygiene as respiratory and intestinal infections are the result of lack of general hygiene (of hands). Given that most other determinants of poor child development are rather complex, the relatively simple interventions for improving oral and general hygiene health of the world's disadvantaged children should be among the priority choices for health planners. Looking for quick, comparatively easy and cost-effective measures to contribute to the timely achievement of the MDGs, the 'Fit for School' programme in the Philippines, that addresses hygiene-related diseases, worm diseases and dental decay in a simple and cost-effective package, is a good and realistic example [39].

Conclusions

This is the first-ever representative survey showing a significant association between caries and BMI and particularly between odontogenic infections and below-normal BMI. The data of this cross-sectional study indicate that children with odontogenic infection have an increased risk of below normal BMI as compared to children without odontogenic infections.

List of abbreviations

STH: Soil-transmitted helminths; DMFT/dmft: Decayed, Missing and Filled Tooth (Permanent/primary dentition); PUFA/pufa: Presence of oral conditions and infections resulting from untreated caries (Permanent/primary dentition);

BMI: Body Mass Index; ECC: Early Childhood Caries; NOHS: National Oral Health Survey; OR: Odds ratio; P/p: Visible pulp; U/u: Ulceration of the oral mucosa due to root fragments; A/a: Abscess; F/f: Fistula; M/m: Missing; MDGs: Millennium Development Goals.

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Authors' contributions

BM and RH supported the data collection in the field, JM performed the statistical data analysis, WvP and MH contributed to the critical interpretation of the data. HB drafted the first version of the paper, and was involved in the data collection and its interpretation. All authors contributed equally to the final version of the paper and have read as well as approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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