Clin Oral Invest (2013) 17:1515–1523
DOI 10.1007/s00784-012-0849-3

ORIGINAL ARTICLE

Association of dental caries and weight status in 6- to 7-year-old Filipino children

Roswitha Heinrich-Weltzien · Bella Monse · Habib Benzian · Joachim Heinrich · Katrin Kromeyer-Hauschild

Received: 16 November 2011 / Accepted: 18 September 2012 / Published online: 28 September 2012

Abstract
Objectives The aims of the study were (1) to assess in 6- to 7-year-old Filipino children caries prevalence and experience and the weight status and (2) to investigate the association between dental caries and weight status.
Materials and methods Dental and anthropometric examinations were conducted on 1,962 6- to 7-year-old children during the National Oral Health Survey in 2005–2006. Dental caries assessments were carried out using World Health Organisation (WHO) criteria (1997). Weight status was assessed with body mass index according to WHO growth reference. A multivariable logistic regression model was applied to investigate the effect of dental caries and sociodemographic variables on the children's weight status.
Results Caries prevalence was 96.8 % in primary and 39.7 % in permanent teeth, and caries experience was 8.4 dmft and 0.6 DMFT. Of the children, 17.8 % were underweight, 73.0 % had normalweight, 6.0 % were overweight and 3.2 % were obese. Girls had a lower risk of being underweight than boys odds ratios (OR) 0.70, confidence interval (CI) 0.55–0.88. Children living in rural areas and with no television at home were more likely to be underweight (OR 1.36, CI 1.07–1.72; OR 1.37, CI 1.07–1.76, respectively). Fewer primary and permanent teeth were risk factors for being underweight (OR 0.93, CI 0.92–0.95; OR 0.90, CI 0.89–0.94, respectively).
Conclusions Underweight was associated stronger with demographic and socioeconomic conditions than with dental variables. However, underweight and dental caries are public health issues of high priority affecting children at an important phase of their development.
Clinical relevance Definite conclusions upon an association between dental caries and weight status in high caries risk schoolchildren cannot be drawn.

Keywords Dental caries · Weight status · Body mass index · Anthropometry · Philippines · Schoolchildren

R. Heinrich-Weltzien (✉)
WHO Collaborating Centre for Prevention of Oral Diseases,
Department of Preventive and Paediatric Dentistry,
Jena University Hospital,
Bachstr. 18,
07743 Jena, Germany
e-mail: roswitha.heinrich-weltzien@med.uni-jena.de

B. Monse
Department of Education, Health and Nutrition Centre,
P. O. Box 119, City of Division,
9000 Cagayan de Oro, Philippines

H. Benzian
Fit for School International,
London, UK

J. Heinrich
Helmholtz Zentrum München, Institute of Epidemiology,
Ingolstaedter Landstrasse 1,
85764 Neuherberg, Germany

K. Kromeyer-Hauschild
Institute of Human Genetics, Jena University Hospital,
Kollegiengasse 10,
07743 Jena, Germany

Introduction

Assessment of children's weight and height is internationally accepted as a valid clinical indicator of general health and well-being [1]. Childhood obesity and underweight have both devastating effects on growth, health, well-being and quality of life and are important public health problems in children [1, 2]. Recent research on malnutrition revealed an association with poor general health, inadequate diet, sanitation services and inadequate care for children [3], and mild underweight was larger and more robust correlated with child mortality than extreme underweight in children over time [4]. Furthermore, underweight, stunting (chronic malnutrition) and wasting (acute malnutrition) are associated with synergistic increases in mortality from diarrhoea, respiratory diseases and infections [5] and may be responsible for over half of the death associated with such infections worldwide [6].

Recently, there has been a growing interest in dental research to assess the relationship between dental caries, one of the most prevalent chronic diseases worldwide [7], and obesity as well as underweight in children. A systematic review indicated a limited body of literature and provided no evidence for an association between dental caries and obesity in subjects aged 3 to ≥65 years [8]. The association between malnutrition, dental caries and tooth eruption examined in a another review showed that primary dentition caries is associated with early malnutrition while an effect on caries in the permanent dentition could not be established because of the small number of studies [9]. Most evidence is based on cross-sectional studies and one longitudinal survey undertaken in Peruvian children [10–14]. The authors concluded that malnutrition delayed tooth development and eruption, affected the age distribution of dental caries and resulted in increased caries experience in the primary dentition. In a large population of 4- to 5-year-old South African children, a significant association was noted between wasting and caries experience but not between stunting and caries experience [15].

If the weight status in children is adversely influenced by dental caries, problems can be expected especially in countries where children are suffering from a high caries burden due to nutritional deficiencies, inadequate fluoride exposure and limited access to oral care services [16]. One of these countries is the Philippines. The seventh National Nutrition Survey (NNS) in 2008 revealed a 25.6 % prevalence of underweight in 6- to 10-year-old Filipino children [17]. At the same time, caries levels are among the highest in the Southeast Asian region, with a prevalence of 97 % among 6-year olds in 2006 [18, 19]. 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 caries: diarrhoea and respiratory tract infections. Two thirds of school children are infected with chronic soil-transmitted helminths [20]. These poor health conditions have a significant impact on children's development [21], by affecting their cognitive, motor and social-emotional development as well as their school performance [22].

In order to explore the link between oral and general health in more detail, the recent National Oral Health Survey (NOHS, 2006) in the Philippines gathered demographic, socioeconomic and anthropometric data among 6- and 12-year-old Filipino children in addition to traditional tooth-related data [19].

The aims of the present study were (1) to assess the caries prevalence and experience as well as the weight status and (2) to investigate the association between dental caries and the weight status in 6- to 7-year-old Filipino children using data collected in the NOHS [19].

Material and methods

Study design and sampling

The NOHS was conducted from November 2005 to February 2006 using a stratified cluster sampling design. Schools served as clusters and were classified according to region (n=17) and urban–rural classification of the National Statistics Office. In total, 68 public elementary schools were selected for the survey, two 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 children attending grade I. In each selected school, the enrolment lists of grade I was taken and all children who were not within the selected age group (6–7 years) were excluded from the list. Sampling of students was done either by systematic sampling in big schools or by simple random sampling in small schools. The sample size calculation was 2,030 students based on the estimated caries prevalence of 80 % and a desired precision of 2 % with a confidence level at 95 %.

Ethical approval

Ethical approval was obtained from the Department of Education (DepEd) under whose authority the NOHS was undertaken [19]. Participation was voluntary, and no student refused the participation in the study. Written parental/legal guardian consent was obtained prior to the examinations.

Oral examination

The examination was performed outside in the schoolyard with sunlight as a direct light source. The children were placed in a supine position on a long classroom bench, with their heads on a pillow on the lap of the examiner, who sat behind them. The World Health Organisation (WHO) (1997) diagnostic criteria were used for caries scoring [23]. Dental caries prevalence and severity were measured by decayed, missing and filled primary and permanent teeth (dmft and DMFT index, respectively). Furthermore, the caries status was characterised as dmft ratio (dmft/number of primary teeth × 100) and DMFT ratio (DMFT/number of permanent teeth × 100).

The PUFA/pufa index was used according to standard procedure and was recorded separately from the DMFT/dmft scores [24]. The presence of either a visible pulp (P/p), ulceration of the oral soft tissues due to root fragments (U/u), a fistula (F/f) or an abscess (A/a) was recorded. The PUFA/pufa index per child was calculated in the same cumulative way as the DMFT/dmft index and represented the number of teeth meeting the PUFA/pufa diagnostic criteria. The assessment was made visually without the use of an instrument.

To ensure consistent clinical judgements, all ten dental examiners and ten recorders underwent 3 days of training by a WHO consultant epidemiologist, who was seen as the gold standard. Re-examination of every 15th subject throughout the study was performed. The inter-examiner kappa values were in a range of 0.78 and 0.92 and the intra-examiner reproducibility ranged between 0.80 and 0.97, which can be classified as good.

Anthropometric measures

The height of the children erected and without shoes was measured with a portable stadiometer (Seca 216 Height Rod; Seca GmbH & Co. KG, Hamburg, Germany) to the nearest 0.5 cm. Weight was measured with children wearing minimal light clothing using a portable electronic digital scale (Soehnle Gala XL; LEIFHEIT AG, Nassau, Germany) to the nearest 0.5 kg. No adjustments were made for clothing. The measuring equipment was re-calibrated daily. All measurements were carried out by well-trained nurses following standardised guidelines [25]. Body mass index (BMI) was calculated as body weight in kilograms divided by height in meter squared [weight (in kilogram)/height (meter square)] for each child. The weight status of the children was defined according the BMI-for-age data of the 2007 World Health Organisation (WHO) growth reference for school-aged children and adolescents [26]. Children with a BMI-for-age above 1 SD and 2 SDs from the age- and sex-specific WHO growth reference median were defined as overweight and obese, respectively, and with values below 2 SDs as underweight. Collection of data about the children's medical health status was not possible as no information on general health could be included in the school-based setting design of the NOHS.

Demographic and socioeconomic parameters

In order to assess demographic parameters, the area (urban/rural) of living was included in the analyses. In addition, all children were asked (in local dialect) whether they had a television (TV) at home and about the number of siblings living at home. Both variables were used as proxy variables for the assessment of poverty as no other indicators (occupation, income and the educational level of the parents) for the socioeconomic status or poverty were available.

Statistical methods

Data were analysed using SPSS, version 18.0. Anthropometric and dental characteristics were presented as means (and standard deviations or confidence intervals); sociodemographic parameters were categorised and presented as percentages. t tests and χ^2 analyses were used to compare these variables between sexes and weight status categories. Weight status categories resulted from dichotomising BMI (in underweight and non-underweight) according to the definition of underweight described above. As the low number of overweight (n=117) and obese children (n=63) did not influence the findings if considered separately (data not shown), they were summarised together with "normalweight children" in the group "non-underweight children". Correlations among dental variables were determined using Spearman's rank correlations coefficient. A logistic regression model was performed to obtain adjusted odds ratios (OR) and 95 % confidence intervals (95 % CI) to assess the age- and sex-adjusted effects of dental and sociodemographic variables on weight status simultaneously. By means of a backward stepwise procedure, variables not significantly contributing to the fit of the model, as indicated by changes in the log-likelihood of successive hierarchical models, were eliminated. The level of significance was set at $p \leq 0.05$.

Results

A total of 1,962 children (945 boys and 1,017 girls) with complete data were included in the analysis (Table 1). The distribution of students living in urban (50.1 %) or in rural (49.9 %) areas was well-balanced. About one third of the children had no TV at home and about 40 % had three or more siblings with no sex-related differences. Weight, height and BMI were similar in boys and girls. The children had, on average, 15 primary and 8 permanent teeth. Boys had significantly more primary teeth than girls but significantly fewer permanent teeth. The caries prevalence was 96.8 % in primary dentition and 39.7 % in permanent dentition. The mean caries experience was 8.4 dmft and 0.6 DMFT, mainly concentrated on the dt and DT components (8.0 dt, 0.4 mt/0.6 DT). Girls had a significantly higher caries prevalence and experience in permanent dentition than boys. The pufa index for the primary dentition was 3.4, and the PUFA index for the permanent dentition

Table 1 Anthropometric, dental and demographic and socioeconomic characteristics among 6-7-year-old Filipino children

Variable	Boys (n=945)	Girls (n=1,017)	p value
Age	n (%)	n (%)	0.186[b]
6 years	347 (36.7)	403 (39.6)	
7 years	598 (63.3)	614 (60.4)	
Anthropometric data	Mean (SD)	Mean (SD)	
Height (cm)	114.5 (5.3)	114.2 (5.7)	0.149[a]
Weight (kg)	19.3 (3.5)	19.1 (3.6)	0.174[a]
BMI (kg/m^2)	14.7 (2.1)	14.6 (2.3)	0.534[a]
Dentition status			
Number of primary teeth (n)	15.4 (3.0)	14.8 (3.0)	<0.001[a]
Number of permanent teeth (n)	7.4 (3.3)	8.3 (3.2)	<0.001[a]
Caries prevalence (%)			
Primary dentition	914 (96.7)	986 (97.0)	0.769[a]
Permanent dentition	308 (32.6)	394 (38.7)	0.005[a]
Caries experience			
Mean dmft (SD)	8.6 (4.2)	8.3 (4.1)	0.067[a]
Mean pufa (SD)	3.4 (2.6)	3.4 (2.5)	0.934[a]
Mean DMFT (SD)	0.6 (1.1)	0.7 (1.1)	0.036[a]
Mean PUFA (SD)	0.1 (0.5)	0.1 (0.5)	0.696[a]
dmft ratio (%)	Mean (95 % CI) 57.3 (55.5–59.0)	Mean (95 % CI) 57.3 (55.6–59.0)	0.815[a]
DMFT ratio (%)	Mean (95 % CI) 8.9 (7.9–9.9)	Mean (95 % CI) 9.3 (8.5–10.1)	0.547[a]
Demographic and socioeconomic parameter			
Area	n (%)	n (%)	0.736[b]
Urban	469 (49.6)	497 (48.9)	
Rural	476 (50.4)	520 (51.1)	
TV at home			
Yes	651 (68.9)	716 (70.4)	0.466[b]
No	294 (31.1)	301 (29.6)	
Number of siblings			
0–3	545 (57.7)	603 (59.5)	0.420[b]
>3	400 (42.3)	414 (40.5)	

[a]Unpaired Student's t test

[b]χ^2 test

was 0.1. The pufa/PUFA index and the dmft/DMFT ratio were not different between both sexes.

Of the children, 17.8 % were underweight, 73.0 % had normalweight, 6.0 % were overweight and 3.2 % were obese with significant more underweight, overweight and obese boys than girls (Table 2). The comparison of dental and demographic as well as socioeconomic characteristics between underweight and non-underweight children revealed that children with underweight had significantly less permanent teeth, lived more frequently in rural regions and had less frequently a TV at home (Table 3).

Because the dmft and DMFT values were highly correlated with the dmft and DMFT ratios, these variables were not included in the multiple logistic regression model to predict underweight (yes/no) (Table 4). The following variables were included in the model: sex, age, number of

Table 2 Weight status categories among 6- to 7-year-old Filipino children according to the WHO growth reference of 2007 [26]

	Boys			Girls		
	n	%	(95 % CI)	n	%	(95 % CI)
Underweight	194	20.5*	(18.0–23.3)	156	15.3	(13.2–17.7)
Normalweight	648	68.6	(65.5–71.5)	784	77.1	(74.4–79.6)
Overweight	71	7.5*	(6.0–9.4)	46	4.5	(3.4–6.0)
Obesity	32	3.4*	(2.4–4.8)	31	3.0	(2.1–4.4)

95 % CI=95 % confidence intervals. *Significant χ^2 test for sex differences (p<0.001)

Table 3 Distribution of dental, demographic and socioeconomic characteristics in weight status categories

Variable	Level	Non-underweight (n=1,612)	Underweight (n=350)	p value
Sex				0.003[a]
	Male	46.6 %	55.4 %	
	Female	53.4 %	44.6 %	
Number of primary teeth				
	Mean (SD)	15.0 (3.0)	15.3 (2.9)	0.151[b]
Number of permanent teeth				
	Mean (SD)	8.0 (3.3)	7.5 (3.3)	0.025[b]
dmft				
	Mean (SD)	8.4 (4.2)	8.7 (4.1)	0.172[b]
pufa				
	Mean (SD)	3.4 (2.6)	3.4 (2.6)	0.971[b]
dmft ratio (%)				
	Mean (SD)	56.7 (27.0)	58.9 (27.7)	0.171[b]
	<25 %	14.0 %	14.3 %	0.258[a]
	25–49 %	28.2 %	25.7 %	
	50–74 %	30.8 %	28.0 %	
	>75 %	27.0 %	32.0 %	
DMFT				
Mean (SD)	0.6 (1.1)	0.7 (1.0)	0.317[b]	
PUFA				
Mean (SD)	0.1 (0.5)	0.1 (0.5)	0.692[b]	
DMFT ratio (%)				
	Mean (SD)	8.8 (14.0)	10.4 (15.9)	0.09[b]
Area				0.017[a]
	Urban	50.5 %	43.4 %	
	Rural	49.5 %	56.6 %	
TV at home				0.001[a]
	Yes	71.3 %	62.0 %	
	No	28.7 %	38.0 %	
Number of siblings				0.059[b]
	0–3	59.5 %	54.0 %	
	>3	40.5 %	46.0 %	

[a]Unpaired Student's t test

[b]χ^2 test

primary and permanent teeth, dmft and DMFT ratio, pufa and PUFA, living area, TV ownership and number of siblings. Table 5 demonstrates the effects of those variables which contribute independently to the prediction of underweight. An OR of 1 denotes the respective reference category. Variables remaining in the model were sex, number of

Table 4 Spearman's correlations matrix of dental parameters in the study population

	Dental parameters	1	2	3	4	5	6	7	8
1	Number of primary teeth	–	−0.927*	0.181*	−0.320*	−0.225*	−0.182*	−0.03	−0.196*
2	Number of permanent teeth		–	0.165*	0.327*	0.207*	0.177*	0.038	0.195*
3	dmft			–	0.197*	0.886*	0.240*	0.628*	0.085*
4	DMFT				–	0.357*	0.874*	0.165*	0.446*
5	dmft ratio					–	0.335*	0.615*	0.200*
6	DMFT ratio						–	0.194*	0.367*
7	pufa							–	0.011
8	PUFA								–

* p<0.01 (significant correlations)

Table 5 Odds ratios (OR) and 95 % confidence intervals (CI) for underweight among 6–7-year-old Filipino children according to dental and demographic and socioeconomic characteristics adjusted for age

Variable[a]	Level	OR	(95 % CI)	*p* value
Sex				
	Male	1		
	Female	0.70	(0.55–0.88)	0.003
Number of primary teeth		0.93	(0.92–0.95)	<0.001
Number of permanent teeth		0.90	(0.89–0.94)	<0.001
dmft ratio		1.96	(0.91–4.21)	0.087
Area				
	Urban	1		
	Rural	1.36	(1.07–1.72)	0.012
TV at home				
	Yes	1		
	No	1.37	(1.07–1.76)	0.013
Number of siblings				
	0–3	1		0.099
	>3	1.22	(0.96–1.56)	

[a] Variables excluded from the multivariate logistic regression model: age, DMFT ratio, pufa and PUFA (R^2 =50.3)

primary teeth, number of permanent teeth, living area and TV at home. Although statistically not significant, the variables dmft ratio and siblings contribute to the fit of the statistical model.

The final model showed that girls had a lower risk of being underweight than boys. Children living in rural regions and with no TV at home were more likely to be underweight compared with children living in urban regions and having a TV at home. Also, there was a tendency that children with more than three siblings had a higher risk to be underweight. With regard to the dental variables, the findings indicate that both less primary and permanent teeth were independent risk factors for being underweight. A trend can be seen for the dmft ratio. Children with a high caries experience in relation to the number of primary teeth (dmft ratio) were more likely to be underweight.

Discussion

The findings of this study are based on data collected in the recent NOHS 2006 from the Philippines [19]. The survey included a representative random sample of 6- to 7-year-old Filipino public elementary schoolchildren. In addition to tooth-related data, anthropometric, demographic and socioeconomic parameters of the children were gathered in this cross-sectional study. Knowing that growth and the nutrition status are influenced by genetic, constitutional and environmental factors, including malnutrition and infectious diseases [21], the authors had to accept that in the school-based setting design of this NOHS [19] no data about the general health status of the children could be recorded. Although the study population of public elementary schoolchildren revealed homogeneous demographic and socioeconomic characteristics, the question of a causal relationship between weight status and their oral status cannot be answered by a cross-sectional study design. Possible variables and confounding factors in this complicated interplay between physical processes are very difficult to cover [16].

Caries prevalence and experience

The study documented that nearly all children suffered from dental caries in their primary dentition and more than one third had already carious permanent teeth (Table 1). Untreated decayed primary and permanent teeth dominated the high dmft and DMFT index, 93 % of the carious teeth were untreated. This high proportion of untreated teeth is consistent with findings from other low-income countries [16, 27–29]. Furthermore, the findings confirm data of a previous regional study [30] on the national level and indicate the widespread neglect of oral health presenting a serious public health problem for Filipino children.

The higher caries prevalence and experience in the permanent dentition among girls compared to boys might be attributed to more erupted permanent teeth. Thus, the teeth are earlier exposed to cariogenic risk factors in the oral cavity which might be associated with an earlier caries onset and increased caries experience (DMFT index). Considering this aspect, caries experience was related to the number of present teeth by calculation of the dmft and DMFT ratio. As seen in Table 1, no significant difference between girls and boys was apparent for the DMFT ratio. The difference found for erupted permanent teeth in boys and girls, among boys fewer teeth were erupted than among girls, could be associated with differences in pre-pubertal growth rates between the sexes [31]. In addition, the lower proportion of underweight girls (Tables 2 and 3) in the children studied could be accounted to the higher number of permanent teeth too. This assumption is based on two studies reporting a delay in eruption of permanent teeth and in primary teeth exfoliation among children with early childhood malnutrition and nutritional insufficiency (stunting) throughout childhood [31, 32].

Weight status

The assessment of the weight status in 6- to 7-year-old Filipino children revealed that underweight is also highly prevalent among this age group (17.8 %) with boys being more at risk than girls. This finding is in line with data of the NNS that reported an increased underweight rate from

22.3 % in 2005 to 25.6 % in 2008 for 6-10-year-old children [17]. That survey reported only sex-related underweight rates for 11-19-year olds to the disadvantage of boys (21.7 % boys vs. 11.7 % for girls) but not for younger children. As nearly 2 to 3 out of 10 children are affected by underweight, malnutrition is like dental caries a serious public health problem in the Philippines. In contrast to other developing countries, overweight and obesity are no public health issues [17].

Looking at underweight more broadly besides the immediate determinants of dietary intake and health status, underlying determinants such as income, household food security, quality of care, healthy environment and access to health services are important additionally influencing factors [3, 33, 34]. Especially poverty influences the level of impact from these determinants [22]. The higher risk of underweight among children with no TV at home (OR 1.39, Table 5) might be explained by poverty aspects. Given the high proportion of TV ownership in the population studied (70 %), children with no TV at home could belong to the poorest families with less food resources and intake compared to less poor families.

The general observation that the burden of undernutrition is particularly high among rural and indigenous populations in South and Southeast Asia [34] seems to be confirmed by this study. Children living in rural areas revealed a higher risk to be underweight (OR 1.34) than those from urban areas. It is assumed that people from rural areas are more disadvantaged by insufficient hygiene conditions, lack of clean water and sewage disposal systems and therefore at a higher health risk and infection rates associated with underweight than people from urban areas. Recently reported differences of up to 11 % of the mean underweight rate in this age group among the 17 regions in the Philippines could contribute to this finding [17]. Explanations for the lower risk for underweight among girls compared to boys also observed in this NOHS among 12-year olds [19, 35] are speculative as the recent report of the NNS 2008 [17] left the sex difference out of consideration. An influence of infectious diseases, particularly of soil-transmitted helminthiasis, with an average national prevalence of 82.3 % [20] is unlikely since no differences in the prevalence and severity between boys and girls were reported [20, 36]. For practical and resource reasons, it was not possible to collect stool samples for testing of worm infections.

Concerning the outcome of the dental variables in the model, a significant association between underweight and number of primary and permanent teeth was found. Although not significant, the dmft ratio was an explanatory variable in the model like the number of siblings. Thus, children with a high dmft ratio were more likely underweight than children with a lower ratio. This finding should be considered in the context of previous data of Alvarez et al. [10, 12, 14] who found that stunted children developed deciduous caries 15 months later than the well-nourished children of the same age because of the delayed tooth eruption. This would be explaining the absence of a significant association between dmft ratio and underweight in the examined 6- to 7-year olds in this study since the underweight children could reach their caries peak just at 8 years of age.

The finding that less permanent teeth were associated with underweight supports those of others who found an association between childhood malnutrition and delayed eruption of permanent teeth as well as delayed exfoliation of primary teeth with the mentioned consequences on caries experience in both dentitions [31, 32]. Our multivariable analysis showed that underweight is related not only to less teeth in permanent dentition but also in primary dentition. This different finding concerning the primary dentition could be due to the earlier exfoliation of carious-attacked primary incisors in our high caries risk population. This assumption is supported by tooth-related caries attack rates among 2-6-year-old Filipino children [37]. Fifty-six percent of 2-year olds had maxillary incisor caries and 18 % had carious mandibular incisors. Among the 3-5-year olds, 75 % had carious maxillary incisors and 26 % had carious mandibular incisors. However, a cause-effect relationship between caries experience and tooth exfoliation in the primary dentition of virtually untreated children can be deduced only by a longitudinal study design.

The positive attribute and strengths of this cross-sectional study was the representative sample of the population studied, the large sample size, trained and calibrated examiners and the robustness of the results. Due to the cross-sectional study design, the identification of cause-effect relationships between weight status and dental caries experience requires a longitudinal design. This is a major limitation of the present study. Furthermore, this study did not include children from private schools representing higher socioeconomic classes. However, the findings are representative for children visiting public elementary schools (92 % of Filipino school-aged children). Due to limited resources and the difficulties of interviewing children under field conditions, the indicators related to socioeconomic status are simple proxy indicators. This choice seems justified and appropriate in the light of the findings of the study.

In a recent paper based on data of the same study, the authors included untreated dental decay in a modified model of hypothesized factors influencing child development [35]. The results of our analysis are in line with the model of child development proposed, although we do not find the strong associations for the 6- to7-year-old age group compared to the 12-year-old age group analysed in the before-mentioned paper. It seems possible that the impact of tooth decay on child BMI changes over time. Further research will be required before a comprehensive view of the extent of cause-and-effect relationship between tooth decay and physical child development can be established.

This study revealed the high prevalence and experience of dental caries as well as underweight in 6-to 7-year-old Filipino children. Underweight showed associations with demographic and socioeconomic conditions and caries experience, though the latter association was weaker. However, underweight and dental caries are public health issues of high priority affecting children at an important phase of their development and need to be addressed with effective programmes, preferably in the school context where children can be easily reached and cost-effective interventions are possible.

Acknowledgments Data collection was part of the National Oral Health Survey, which was financed by the German Federal Ministry for Economic Cooperation and Development (Title 685.01, through InWent Capacity Building, Bonn, Germany). The funding entity had no involvement in (1) study design; (2) the collection, analysis and interpretation of data; (3) the writing of the report and (4) the decision to submit the manuscript for publication. None of the authors received any funding for writing the paper.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. de Onis M, Blössner M (2003) The World Health Organization global database on child growth and malnutrition: methodology and applications. Int J Epidemiol 4:518–526
2. de Onis M (2004) The use of anthropometry in the prevention of childhood overweight and obesity. Int J Obes 28:S81–S85
3. Alderman H, Hoogeveen H, Rossi A (2006) Reducing child malnutrition in Tanzania – combined effects of income growth and program interventions. Econ Hum Biol 4:1–23
4. Bhagowalis P, Chen SE, Masters WA (2011) Effects and determinants of mild underweight among preschool children across countries over time. Econ Hum Biol 9:66–77
5. Black RE, Allen LH, Bhutta ZA (2008) Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 371:243–260
6. Caufield LE, de Onis M, Blossner M, Black RE (2004) Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria and measles. Am J Clin Nutr 80:193–198
7. Petersen PE, Bourgeois D, Ogawa H et al (2005) The global burden of oral diseases and risks to oral health. Bull World Health Organ 83:661–669
8. Kantovitz KR, Pascon FM, Rontani RM et al (2006) Obesity and dental caries. A systematic review. Oral Health Prev Dent 4:137–144
9. Psoter WJ, Reid BC, Katz RV (2005) Malnutrition and dental caries: a review of the literature. Caries Res 39:441–447
10. Alvarez JO, Lewis CA, Saman C et al (1988) Chronic malnutrition, dental caries and tooth exfoliation in Peruvian children aged 3–9 years. Am J Clin Nutr 48:368–372
11. Alvarez JO, Navia JM (1989) Nutritional status, tooth eruption, and dental caries: a review. Am J Clin Nutr 49:417–426
12. Alvarez JO, Eguren JC, Caceda J et al (1990) The effect of nutritional status on the age distribution of dental caries in the primary dentition. J Dent Res 69:1564–1566
13. Alvarez JO, Caceda J, Woolley TW et al (1993) A longitudinal study of dental caries in the primary teeth of children who suffered from infant malnutrition. J Dent Res 72:1573–1576
14. Alvarez JO (1995) Nutrition, tooth development, and dental caries. Am J Clin Nutr 61(suppl):410S–416S
15. Cleaton-Jones P, Richardson BD, Granath L et al (2000) Nutritional status and dental caries in a large sample of 4- and 5-year-old South African children. S Afr Med J 6:631–635
16. van Gemert-Schriks MCM, van Amerongen EW, Aartman IHA et al (2011) The influence of dental caries on body growth in prepubertal children. Clin Oral Invest 15:141–149
17. Food and Nutrition Research Institute. The state of nation's nutrition: 7th National Nutrition Survey 2008. Manila: Department of Science and Technology (2008); available at: http://www.fnri.dost.gov.ph/images/stories/7thNNS/nns_result.pdf. Accessed July 2011
18. Beaglehole R, Benzian H, Crail J et al (2009) The Oral Health Atlas: mapping a neglected global health issue. FDI World Dental Education Ltd & Myriad Editions, Geneva
19. Department of Education (2008) National oral health survey among the public school population in the Philippines 2006. Department of Education, Manila
20. Belizario V, de Leon WU, Lumampao YF et al (2009) Sentinel surveillance of soil-transmitted helminthiasis in selected local government units in the Philippines. Asia-Pacific J Publ Health 21:26–42
21. Bhutta ZA (2006) Effect of infections and environmental factors on growth and nutritional status in developing countries. J Pediatr Gastroenterol Nutr 43(suppl):513–521
22. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, International Child Development Steering Group (2007) Developmental potential in the first 5 years for children in developing countries. Lancet 369:60–70
23. World Health Organization (1997) Oral health surveys: basic methods, 4th edn. World Health Organization, Geneva
24. Monse B, Heinrich-Weltzien R, Benzian H, Holmgren C, van Palenstein HW (2010) PUFA—an index of clinical consequences of untreated dental caries. Community Dent Oral Epidemiol 38:77–82
25. Lohman TG, Roche AF, Martorell R (1988) Anthropometric standardization reference manual. Human Kinetics, Champaign
26. de Onis M, Onyango AW, Borghi E et al (2007) Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 85:660–667
27. Koirala S, David J, Khadka R et al (2003) Dental caries prevalence, experience and treatment needs of 5–6-year-old, 12–13-year-old and 15-year-old schoolchildren in Sunsari district, Nepal. J Nepal Dent Assoc 5:12–24
28. David J, Wang NJ, Åstrøm AN et al (2005) Dental caries and associated factors in 12-year-old schoolchildren in Thiruvananthapuram, Kerala, India. Int J Paediatric Dent 15:420–428
29. Ngoenwiwatkul Y, Leela-Adisorn N (2009) Effects of dental caries on nutritional status among first-grade primary school children. Asia-Pacific J Publ Health 21:177–183
30. Yabao RN, Duante CA, Velandria FV et al (2005) Prevalence of dental caries and sugar consumption among 6–12yr-old schoolchildren in La Trinidad, Benguet, Philippines. Eur J Clin Nutr 59:1429–1438
31. Psoter W, Gebrian B, Prophete S et al (2008) Effect of early childhood malnutrition on tooth eruption in Haitian adolescents. Community Dent Oral Epidemiol 36:179–189
32. Toverud G (1956) The influence of war and post-war conditions on the teeth of Norwegian school children. Eruption of permanent

teeth and status of deciduous dentition. Milbank Mem Fund Q 34:355–430
33. UNICEF (1990) Strategies of improving nutrition of children and women in developing countries. UNICEF, New York
34. Pasricha S-R, Biggs B-A (2010) Undernutrition among children in South and South-East Asia. J Paediatr Child Health 46:497–503
35. Benzian H, Monse B, Heinrich-Weltzien R et al (2011) Untreated severe dental decay: a neglected determinant of low body mass index in 12-year-old Filipino children. BMC Publ Health 11:558. doi:10.1186/1471-2458-11-558
36. Baldo E, Belizario V, de Leon W et al (2004) Infection status of intestinal parasites in children living in residential institutions in Metro Manila, the Philippines. Korean J Parasitol 2:67–70
37. Cariño KMG, Shinada K, Kawaguchi Y (2003) Early childhood caries in northern Philippines. Community Dent Oral Epidemiol 31:81–89