Justine Jeanne-Marie Maëlie Manac'h

Relationship between dental caries and BMI among NGO-PSE's children in Phnom Penh, Cambodia

University Fernando Pessoa - Faculty of Health Sciences

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Pos-graduated project presented to the
University Fernando Pessoa
as part of the requirements for obtaining
a Master's Degree in Dental Medicine.

Resumo

Objetivos: O objetivo deste estudo foi investigar a prevalência da cárie dentária em crianças da organização não governamental (ONG) "Pour un sourire d'enfant" (PSE) em função da idade, sexo, peso corporal/estatura e avaliar uma possível correlação com o índice de massa corporal por idade (IMC-por-idade).

Material e métodos: Realizou-se um levantamento epidemiológico transversal que ocorreu em todo o mês de junho de 2017.Todos os participantes eram estudantes de PSE, 344 crianças e adolescentes de 6 a 18 anos foram examinados. O IMC-por-idade e o índice de dentes cariados, perdidos e obturados (CPO) foram gravados em softwares como AnthroPlus versão 1.0.4 da Organização Mundial da Saúde e SPSS (*Pacote Estatístico para Ciências Sociais)* versão 24. Os testes X^2 de Pearson, Kruskal-Wallis H e Mann-Whitney U foram utilizados para comparações univariadas. A associação multivariada entre os fatores independentes e CPO foi avaliada usando o coeficiente de Spearman, do tau de Kendall e de Pearson (o valor de p foi estabelecido em 0.05, o que foi estatisticamente significativo).

Resultados: O CPO médio foi de 5.83 (± 3.84), com experiência de cárie que afetou 94.8% de crianças e adolescentes, especialmente em idade de 6 anos e em grupos de 6-11 anos. A maioria (67%) apresentava IMC-por-idade normal, 25% apresentavam baixo peso e 8% acima do peso. Nenhuma associação significativa foi encontrada entre a cárie dentária e local, sexo, classes de IMC-por-idade, mas uma correlação negativa entre a cárie dentária em função da idade, e da distribuição do IMC-por-idade foi comprovada ($p < 0,05$).

Conclusão: O estudo mostrou uma associação estatisticamente significante entre caries dentárias e IMC para esta amostra. À medida que o IMC aumentou houve um declínio significativo no número de cáries dentárias entre os participantes, o excesso de peso mostrou dentes mais saudáveis do que outros.

Palavras-chave: cárie dentária, CPO, IMC, saúde bucal, Camboja, estado nutricional, crianças.

Abstract

Objectives: The purpose of this study was to investigate the prevalence of dental caries on children from the association « Pour un sourire d'enfant » (PSE) in accordance with age, sex, weight/height, and evaluate a possible correlation with body mass index for age (BMI-for-age).

Material and methods: This study was a cross-sectional epidemiological survey which took place on the entire month of June 2017. All participants were students from PSE, 344 children and adolescents from 6 to 18 years have been examined. BMI-for-age and index of teeth decayed, missed, filled (DMFT) were recorded on software: WHO AnthroPlus version 1.0.4 and SPSS *(Statistical Package for the Social Sciences)* version 24. The X^2 of Pearson test, Kruskal-Wallis H test and Mann-Whitney U Test were used for univariate comparisons. Multivariate association between independent factors and DMFT was assessed using Spearman's coefficient, Kendall's tau coefficient and Pearson's coefficient (p value was set up at 0.05 which was statistically significant).

Results: The mean DMFT was 5.83 (±3.84) with caries experience affecting 94.8% of children and adolescents, especially at 6 years old and in class of 6 to 11 years old. The majority (67%) had normal BMI-for-age, 25% were underweight and 8% overweight. No significant association were found between dental caries and locality, gender, classes of BMI-for-age, but a negative correlation between dental caries in function of age and distribution of BMI-for-age has been proved ($p<0.05$).

Conclusion: The study showed a statistically significant association between dental caries and BMI for this sample. As the BMI increased there was a significant decline in the number of dental caries among the participants, overweight showed healthier teeth than others did.

Keywords: dental caries, DMFT, BMI, oral health, Cambodia, nutritional status, children.

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List of abbreviations

DMFT: Decayed, Missing, Filled by permanent tooth

dmft: Decayed, Missing, Filled by primary tooth

FDI: Fédération Dentaire Internationale

GBD: Global Burden of Diseases

NGO: Non-Governmental Organisation

PPA: Association « Poids Plume Asie » [-Feather Weight Asia]

PSE: Association « Pour un sourire d'enfant » [-For a child's smile]

SPSS: Software « Statistical Package for the Social Sciences »

WHO: World Health Organisation

I. Introduction

Dental caries is a multifactorial disease caused by the interaction between the tooth surface, sugars from food and the bacterial biofilm, which metabolize sugars and produce acids, which over time break down the tooth enamel (International Dental Federation, 2015). It can cause difficulties in eating and sleeping, negatively impact the child growth, and is a leading cause of absence from school and work; it represents the most common childhood disease to maintain oral health, a key factor of quality of general health life (FDI, 2015). A systematic review by Kassebaum et al. in 2015 reported that oral health has not improved in the last 25 years due to the population growth and aging, still 48% of the world population suffered disability from oral conditions, and the conclusion of the review was that « untreated caries in permanent teeth remained the most prevalent health condition across the globe in 2010, affecting 2.4 billion people, and untreated caries in deciduous teeth was the 10th most prevalent condition, affecting 621 million children worldwide ».

Nutrition plays an important role in the incidence of caries by several factors: the presence in food of a high amount of carbohydrates and refined sugar that can be quickly fermented; the capacity to ensure a natural cleaning of the oral cavity; the increase in the number of meals; and the masticatory function which maintain the dental organ (Moynihan, 2017) (Kassebaum, 2015). Nutrition has a great influence also in body weight; therefore it was considered relevant to try to understand the possible relation of body weight with dental caries by the calculation of body mass index (BMI) according to gender and age. Many researchers have already investigated this, but results were inconsistent. A systematic review showed that 48% of studies reviewed didn't found any association between dental caries and BMI; 35% found a positive association, while 19% found an inverse association (Hooley, 2012).

Nowadays, general health and oral hygiene are influenced by various economic, social and cultural factors. The World Health Organization (WHO) in 2013 announced that prices of healthcare and medicines are an obstacle to health for more than a third of the world's populations. The poor are the most affected by unequal access to health, in addition to being exposed to food insecurity, outdated or non-existent sanitation systems, and lack of drinking water source. The study took place in Cambodia, one of the poorest countries in Asia touched by these inequalities. In fact the country has been left destroyed and in big instability because

of wars in the last century: World War II, Vietnam war, and the most recent (1975-1979), the genocide from communist Khmer Rouge forces under POL POT where at least 1.5 million Cambodians died from execution, forced hardships or starvation (World Fact Book, 2018). The World Bank in 2016 formally reclassified Cambodia as a lower middle-income country as a result of continued rapid economic growth over the past several years, because of tourism growth, but still 14% of the population in 2014 was living on less than $1.90 per day (poverty line in the world). In terms of health, Cambodia estimations from The World Factbook (Central Intelligence Agency) in July 2017 presents that from the 16.204.486 Cambodians, of which 50% are under 25 years old, the life expectancy at birth was 64.9 years old which was the lowest from Asia (except Laos); and the infant mortality rate was of 47.4 deaths/1.000 live births (35th country in the world). 75.5% had access to drinking water source, and only 42.4% had sanitation facility access; the prevalence of HIV/AIDS was of 0.6% which placed 47th country with an important excess mortality in HIV-positive patients. There is a big inequality of access to dental care, in fact a report of WHO show that 223 surgeons were in activity in 2012, far from the reference of 1/1000 people, and only one university of dentistry is based in the capital « University of Health Sciences ». To help Cambodian people recover from this situation more than thousands Non-Governmental Organisations (NGO) grew up, such as « Pour un sourire d'enfant » (PSE), one of the biggest, and « Poids Plume Asie» (PPA).

The purpose of this study was to investigate prevalence of dental caries on NGO PSE's children in accordance with age, sex, body weight/height, and evaluate a possible correlation with BMI. The study can help the NGOs to understand the causes of caries and improve response to health needs. Secondly, there were other purposes like:

- Providing measures of prevention of oral health like primary treatments (scaling, sealants, fillings…)
- Raising awareness about the importance of good oral hygiene and about alimentation, especially sugar consumption or present indicators: theoretical and practical courses of oral hygiene care have been done after each examination, with the help of macro model of mouth and big toothbrush: dental brushes and toothpaste have been offered to all participants evaluated.
- Finally, the last purpose was personal, as an opportunity for self-fulfilment through a humanitarian mission, personal enrichment through cultural exchanges and professional development by practicing dental care in different conditions.

II. Material and methods

II.1 Type of study

This study was a cross-sectional epidemiological survey, which took place on the entire month of June 2017. One *Informed Consent* form for PSE and PPA (Annex 1 and 2) has been signed at the beginning of the study. Patients have been informed and could decline to participate to the study. Confidentiality and anonymisation have been confirmed inserting only the number of identity from PSE on the clinical record.

II.2 Participants and criteria of inclusion/exclusion

All participants were students from PSE: 344 children and adolescents from 6 to 18 years. If children were out of the scale of age or not from PSE, they have been excluded from the study. To be part of the PSE's inclusion criteria, the recruitment was made through contacting the child's family context as follows: (Annex 3) main criteria are «poverty, widow/widower, orphan children, abused children, vulnerable children, family living in anarchy area, abandoned children, and scavenger family and priority to the girls». In case of being orphan or in big risk, the association can host in its own centre. Some children attended remedial classes in the PSE centre in Phnom Penh, while others were enrolled in 16 public rural schools in partnership with PSE (Annex 4).

II.3 Calibration

The oral examination and the measurement of body weight and height were made by a single examiner. A calibration has been realized based on models, and results were adequate.

II.4 Material and methodology

A revision of the literature has been done in English between 1990 to March 2018 on Pub med and scientific books. Keywords were: dental caries, DMFT, BMI, oral health, Cambodia, nutritional status and children.

Then in Cambodia, with the NGOs, the study has been divided in two times: one time to observe and evaluate oral health, and second time to measure body weight and height.
Patients were wearing all the same uniform, which was light weight. There were two types of observations: 33 patients have been observed in the dental clinic of the NGOs, and 311 in rural schools. Patients were lying on the dental chair.
In order to carry out the whole study, the following material was necessary:

- Dental mobile bus to travel to rural schools
- Dental material (as WHO criteria, 2013): set of dental mirror plane n°4 and dental probe (Arinstrumed 102-127), latex clinical gloves, LED light source for oral observation in PSE and front lamp in schools, camera, toothbrushes for supply and dental pastes for sample)
- Material to measure weight/height (as WHO Child Growth Standards, 2008): one stretch 2-meter measuring tape and electronic scale
- Copies of clinical records from patients (Annex 1)
- Prevention images during the oral prevention (Annex 5)

II.5 Indicators

II.5.1 Oral health status

In assessing oral health status, **DMFT** has been used to describe the prevalence of dental caries in an individual by teeth (T): Decayed (D), Missing (M), and Filled (F). It is used to get an estimation illustrating how much the dentition until the day of examination has become affected by dental caries. It is calculated for 32 (permanent) teeth, including "wisdom" teeth, as recommends WHO, 2013. If a tooth has both a caries lesion and a filling it is calculated as D only. For the primary dentition, consisting of maximum 20 teeth, the corresponding designations are «dmft». Patients have been analysed from 6-to-18-y-old and also divided in the followings ages and age groups as WHO recommendations (2013):

- 5- and 6-y-old: Between 5th and 6th birthdays of children, it can be possible to evaluate the caries levels in the primary dentition.
- 12-y-old: At this age, all the permanent teeth except the third molars will have erupted. For these reasons, it has been chosen as the global indicator age group for international comparisons and surveillance of disease trends.

- 15- to 19-y-old: By 15 years, the permanent teeth have been exposed to the oral environment for three to nine years. The assessment of caries prevalence in adolescents may therefore be relevant.

II.5.2 Anthropometric profile

Anthropometric measurements can be evaluating by BMI**,** it is a measure of body fat based on height and weight**:** BMI= Weight (kg) / Height² (m)

To monitor the growth of patients (BMI), values of height and weight of each child were transferred to the software WHO AnthroPlus version 1.0.4 for the global application of the WHO Reference 2007 for 5-19 years. It enables the calculation of z-scores BAZ (BMI for age), and cut-offs based on standard deviations (SD) from the median. The interpretation follows the scale below:

- Severe thinness: < -3SD
- Thinness: < -2SD
- Normal weight: -2SD < x < +1SD
- Overweight: > +1SD (equivalent to BMI 25-30 kg/m^2 at 19 years)
- Obesity: > +2SD (equivalent to BMI >30 kg/m^2 at 19 years)

II.6 Statistical analysis

Independent variables (locality, gender, height, weight, BMI, DMFT) were classified in descriptive statistics with the software SPSS *(Statistical Package for the Social Sciences)* version 24. This software permitted also to analyse univariate comparisons with the X^2 of Pearson test, Kruskal-Wallis H test and Mann-Whitney U test. Multivariate association between independent factors and DMFT was assessed using three tests of correlation: Spearman's coefficient, Kendall's tau coefficient and Pearson coefficient. The Spearman and Kendall's tau correlation are equal to the Pearson correlation between the rank values of those two variables; while Pearson's correlation assesses linear relationships, and others assesses monotonic relationships (whether linear or not). For all tests, p value was set up at 0.05 which was statistically significant.

III. Results

III.1 Evaluation of DMFT

In the 344 patients examined, the majority (64%) was 10 years old with an average of 10.5 ±2.5 years old. Females were 178 (51.7%) and males 166 (48.3%). The mean DMFT of the study was 5.83±3.84 (min=0 and max=19) with caries experience affecting 94.8% of children and adolescents. The biggest group (12.8%; n=44) was with a DMFT of 3 (Image 1). The mean DMFT of females and males were 5.85(±3.81) and 5.80(±3.87) respectively, without significant difference found by Mann Whitney U Test (p-value=0.870). DMFT has been also compared in two types of localities: children who have been observed in the PSE centre had a mean DMFT of 5.27(±3.13; n=33), and those observed in rural schools was of 5.88(±3.90; n=311), without also significant difference (p-value=0.462).

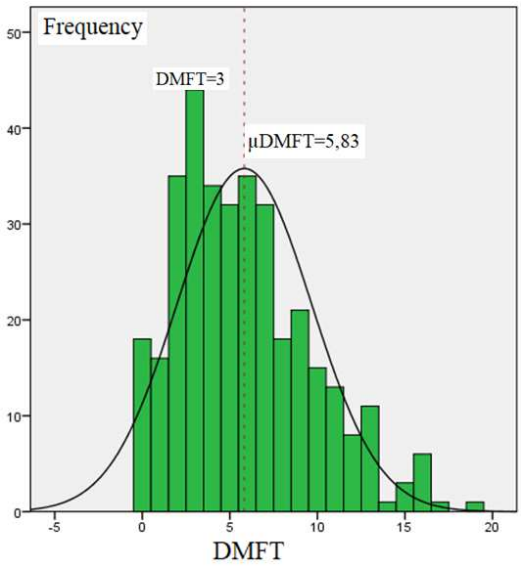

Image 1: Histogram of the frequency of number of patients in function of the DMFT.

		N	Min	Max	Mean	Std. Deviation	P Value
Age		344	6	18	10.47	2.51	P(X²)=0.027; r= -0.435 (X² and Pearson correlation)
DMFT		344	0	19	5.83	3.84	
DMFT of Gender	Females	178	0	19	5.85	3.81	P= 0.870 (Mann-Whitney U Test)
	Males	166	0	17	5.80	3.87	
DMFT of Locality	PSE centre	33	1	16	5.27	3.77	P=0.462 (Mann-Whitney U Test)
	Rural Schools	311	0	19	5.88	3.91	

Table 1: Sample characteristics of age, DMFT, gender, locality.

DMFT has been also analysed with X^2 and Pearson test by age and age groups (Annex 7), and there was significant differences: p(age)=0,027; p(age groups)=0,001; r(age)= - 0.435. At 6-y-old the mean dmft (primary dentition) was 9.75(±5.02 ; n=12) from 6-to-11-y-old the mean DMFT was 6.70(±3.98 ; n=233); at 12-y-old (global indicator age) the mean DMFT was 4.22 (±2.96 ; n=40) then between 12-to-14-y-old the mean DMFT was 3.98(±2.91 ; n=92) ; finally from 15-to-18-y-old it was 4.11 (±1.60 ; n=19). This distribution can be illustrated (Image 2), where the curve can show a decline from 6-y-old until 14-y-old then increase until 18-y-old.

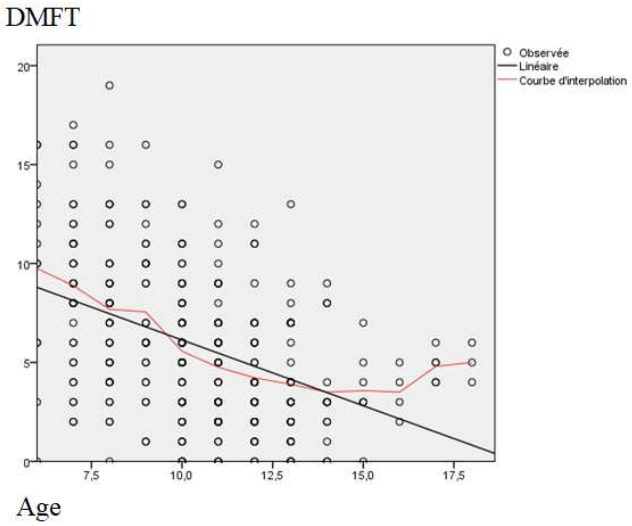

Image 2: Graph of the DMFT in function of the age.

III .2 Evaluation of BMI-for-age

In this evaluation, 290 children had been examined which 149(51.4%) were females and 141(49.6%) were males. The mean BMI-for-age of the study -1.17(±1.49) was under the WHO child growth standard 2007 (Image 3). Males and females had a mean BMI-for-age of -1.22(±1.60) and -1.12(±1.37) respectively. Both curves for males and females are under the BMI z-score WHO reference (Image 4). In function of the interpretation of the scale of growth reference (Table 2), it has been found that 25% were underweight (10% of severe thinness and 14.8% of thinness), 67.2% were normal weight, 7.6% were overweight, and 0.7% were obeses. According to age cohorts:

- For the 6-11-y-old: 21.8% were underweight, 70.6% were normal weight, and 7.6% were overweight.
- For the 12-14-y-old: 35% were underweight, 68% were normal weight, 7.7% were overweight, and 2% were obese.

- For the 15-18-y-old: 12,5% were underweight, 60% were normal weight, 26.8% were overweight.

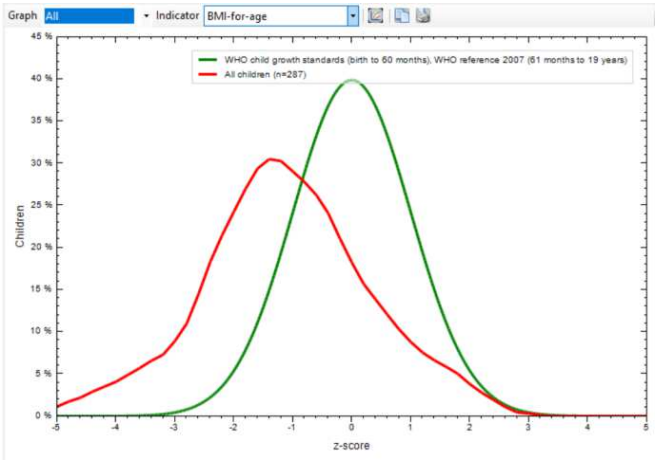

Image 3: Graph of the BMI-for-age in function of children. *In green:* Curve of the WHO child growth standards, WHO reference 2007 (61 months to 19 years). *In red:* Curve of children's study.

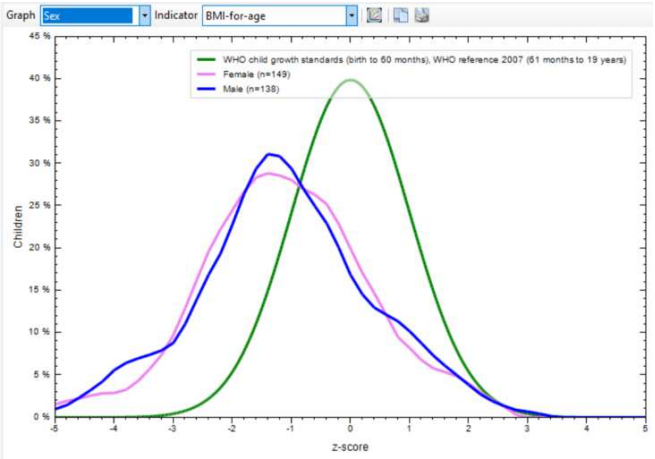

Image 4: Graph of the BMI-for-age in function of the gender. *In green:* Curve of WHO child growth standards, WHO reference 2007 (61 months to 19 years). *In blue:* Males curve. *In pink:* Females curve

Classes of BMI-for-age (5 to 3 classes)		Age Groups			Classes of BMI-for-age (n)
		6-11 y-old (n)	12-14 y-old (n)	15-18 y-old (n)	
1.Severe thinness 2.Thinness	Class 1	19 23 — 43 (21.8%)	9 18 — 27 (35%)	1 1 — 2 (12.5%)	29 (10%) 43 (14.8%) — 72 (25%)
3. Normal weight	Class 2	139 (70.6%)	43 (55.8%)	13 (81.2%)	195 (67.2%)
4. Overweight 5. Obese	Class 3	15 0 — 15 (7.6%)	5 2 — 7 (9.2%)	1 0 — 1 (6.3%)	21(7.3%) 2 (0.7%) — 23 (8%)
Total Children		197	77	16	290
X^2 of Pearson (For 3 classes of BMI-for-age*Age groups)		0.462	0.439	0.368	0.115

Table 2: Classes of BMI-for-age in function of age groups.

III.3 Evaluation of the correlation between DMFT and BMI-for-age

The mean DMFT in function of each BMI-for-age classes has been compared with the Kruskal–Wallis H test. No significant difference has been found between these variables p=0.098 (Table 3).

The distribution of DMFT and BMI-for-age has been compared with correlation tests and a significant ($p<0.05$) negative correlation has been found for the three tests (Table 4):

- Pearson coefficient : r(290)= - 0.126, p=0.032
- Kendall's tau coefficient : t(290)= -0.082, p= 0.046
- Spearman's coefficient : r(290)= -0.118, p=0.045

Classes of BMI-for-age	Mean DMFT	N	Standard Deviation	P value (Kruskal-Wallis H test)
Severe thinness	6.59	29	3.78	P value= 0,098
Thinness	5.56	41	3.30	
Normal weight	5.82	196	3.94	
Overweight	4.45	22	4.03	
Obesity	1.50	2	2.12	
Total	5.72	290	3.86	

Table 3: Classes of BMI-for-age in function of mean DMFT.

	BMI-for-age / DMFT	P value
Pearson coefficient	-0.126	0.032*
Kendall's tau coefficient	-0.082	0.046*
Spearman's coefficient	-0.0118	0.045*

*means that the correlation is significant at level of 0.05 (SPSS).

Table 4: Different tests of correlation of BMI-for-age in function of DMFT.

IV. Discussion

IV.1 Analysis of prevalence of dental caries

The results showed that the prevalence of dental caries was clearly high (94.8%), with only 16 on 344 children and adolescents being free of caries. The mean DMFT of the study was 5.83±3.84 with a range between 0 and 19 teeth affected. Significant differences were found between DMFT in function of age and age group, the negative correlation means that as the age increased, DMFT declined. The highest prevalence was at 6-y-old with a dmft of 9.75, then we can see that declined until 14-y-old, then increased slightly from 15-to18-y-old. No significant differences were found for DMFT according to gender, and locality of study. In a review of Kassebaum et al. (2015), a similar evolution has been found about DMFT in function of age. Sex differences were also not significant at the global level.

The results at 12-y-old (global indicator age) showed that, the mean DMFT was 4.22 (±2.96; n=40; min=0; max=12). This valour was higher than World statistics but less than Cambodian statistics. In fact, subsequent WHO findings suggested that prevalence of caries experience declined in many locations in the world with a DMFT for 12-y-old of 2.43 in 1980 to 1.86 in 2015 (Malmö University, 2015). The decline was especially in developed countries by the result of a number of public health measures, with changing living conditions, lifestyles and improved self-care practices. It was less obvious in low-income countries and moreover has increased these last 10 years (Lagerweij *et* van Loveren, 2015). This idea is following in Cambodia, a collection of studies (Annex 6) made possible to observe the evolution of DMFT where we see that in all age classes, from 1990 until 2012, the DMFT has risen sharply on average 3.5 more on the total. In 2012, it was the largest in the 5-6 age group with a dmft of 11.7, then at 12 years, with the arrival of permanent teeth, DMFT dropped with 5.5, then around 15 years decreased with 4.1.

The explication of this increase in low-income countries is supposed to correlate with an increasing sugar consumption and insufficient fluoride exposure (Petersen, 2016). In Cambodia, dietary habits have changed, the consumption of sugar by year increased from 0.6Kg in 1991 to 17Kg in 2012 (Sugar year Book, 2013). The enormous consumption of sugar is a recent trend.

Sugarcane production became a large industry in Cambodia during the continuing economic development (Rijk, 2015). In relation to the fluoride exposure, the problem in Cambodia is that some regions have too much fluoride and also arsenic in drinking water, and others regions have insufficient exposure of fluoride (Feldman et al, 2007). Small amounts of fluoride are good for teeth but high amounts can destroy teeth and accumulate in bones, leading to crippling skeletal damage. With their bodies still growing, children are most at risk (Psoter, 2005). World experts at a conference on *Oral Health through Fluoride for China and Southeast Asia* in 2007 have confirmed that: "fluoride toothpaste remains the most widespread and significant form of prevention and protection against tooth decay used worldwide." In fact it seems financially easier than changing all poor infrastructures. But a study enrolling Cambodia showed that prices of fluoride toothpastes increased as the country's per capita household expenditure decreased. Various measures to improve affordability of fluoride toothpastes were proposed like eliminate taxation for poorest countries and encourage generic and local production with cheaper ingredients (Goldman, 2008).

Other causes of high level of dental caries in this kind of country can be linked to hygiene habits which are still not yet in place in Cambodia; one in five 12 years old from rural children has never brushed their teeth (Chu et al, 2008). Also levels of salivary *Streptococci mutans* can be also causes of caries in infants (Maciel *et al*, 2008).

In low- and middle-income countries, the majority of dental caries is untreated and teeth are often extracted when they cause pain or mouth infection (WHO, 2017). It has been observed in the study, when the examination was in schools far away from the dental clinic of NGOs, it was not possible to treat deep dental caries, because of the high number of children, material and hygiene missing.

What are the kinds of care solutions for this type of country?

- Increase prevention as much as possible, like reducing acid attacks on tooth enamel by reducing the frequency of sugar consumption, and using techniques of oral hygiene: brushing teeth, passing floss, enhancing exposure to fluoride (via toothpaste or fluoridating water) (Bernabé, 2014).
- Raise minimal-intervention dentistry that may reduce the number of dental caries and lost teeth (Veugelers and Yip 2003).

The FDI and the WHO established the first *Global Oral Health Goals* in 1981, but even if in some countries they had been achieved none awareness had been developed in others. In 2003, new *Global Goals for Oral Health 2020* have been issued which "provided guidance for local, regional, and national planners and policy makers to improve the oral health status of their populations" (Hobdell et al., 2003). The new oral health goals were not numerically specific as the ancient goals. Instead, each country may specify targets according to the most current disease prevalence and severity, local priorities, and oral health systems. It is imperative to obtain baseline oral health information to plan for and to identify improvements in children's oral health status. Improve oral health won't necessary improve inequalities, but treating children as much as possible will improve health quality, because it has been proved that the burden of untreated caries seems to be shifting from children to adults (Kassebaum, 2015).

IV.2 Analysis of BMI-for-age

The mean BMI-for-age was -1.11±1.39 which was under the mean WHO growth child standard 2007, but stayed in the scale of normal weight between -2SD and +1SD excluded (image 5). The dispersion of children was more expanded than the reference (2SD more), it means that the distribution was less homogen but the curve still followed the Gaussian form. The form of this kind of curve suggests that the reference of WHO growth child standard is: 81.8% of normal weight, 15.9% of overweight and 2.3% of underweight. But in the study a considerable number of underweight of 25% (10% of severe thinness and 14.8% of thinness) was present compared to the reference. A majority of children had a normal weight (67%), and 8% were overweight (7.3% of overweight and 0.7% of obese). When BMI-for-age was compared in 5 classes, most severe thinness were found in 6-11-y-old group and the two unique obese of the study were in 12-14-y-old group. When it was in 3 classes, most underweight and overweight were 12-14-y-old group. But with the test X^2 of Pearson, no significant differences were found for the 3 classes of BMI-for-age in function of age groups ($p=0.115$), so comparisons by age groups are difficult. No significant differences were also found for gender. The results of high number of underweight is consistent with the double burden of malnutrition in Cambodia which is the 18th country in the world with the worst malnutrition rate, 23.9% of children under 5 years old are underweight. Malnutrition and diet are now the largest risk factors responsible for the global burden of disease by far

(Forouzanfar et al. 2015). An estimated 45% of deaths of children under age 5 are linked to malnutrition in the world (Black et al, 2013). In the *Global Nutrition Report* (IFPRI, 2016) «End all forms of malnutrition by 2030» is the goal which world leaders have agreed to reach.

IV.3 Analysis of the correlation between DMFT and BMI-for-age

No significant differences were found for mean DMFT in function of BMI-for-age classes with Kruskal-Wallis H test. But there was a significant negative correlation between DMFT and BMI-for-age for the three tests : Pearson coefficient : r(290)= - 0.126, p=0.032 ; Kendall's tau coefficient : t (290)= -0.082, p= 0.046 ; Spearman's coefficient : r(290)=-0.118, p=0.045). It can be interpreted that underweight children may have more dental caries than overweight children. The results could confirm some previous studies. A systematic review showed that primary dentition caries has been associated with underweight and early childhood malnutrition. In fact malnutrition may influence enamel hypoplasia, salivary glandular hypofunction and saliva compositional changes that can weaken teeth (Psoter et al, 2005). There are other studies where a positive correlation has been found like a recent systematic review of Chen *et* al. from 2018 which compared 14 studies published after March 2017 in different countries. Sensitivity analyses showed that the obese group had more caries than the normal-weight group in their primary teeth. Significantly more caries was found among the overweight and obese children in both primary and permanent teeth in high-income countries, but not in low- and middle-income countries. In this kind of positive correlation, caries have been associated to sugar consumption. Also, there were many studies with no statistically significant association like the systematic review of Merrilyn from 2012 which show that 48% of studies reviewed didn't found any association between dental caries and BMI.

The reason of this disagreement in studies results could be multi-factorial causes of dental caries and also from all factors which depends on the association between dental caries and BMI like age, gender, race, social factors, countries of studies, oral hygiene. Also the height and body weight in children change rapidly at this stage, so being underweight or overweight is apparent in a short period of time. In this study, children were all in a poor social situation, where the high level of dental caries has been associated with underweight. Malnutrition has been mentioned as one of the cause of this association, but during the collection of

informations, children were often eating sweets, and had easy access in front of the NGO by sellers of various types of sweet foods. Therefore high level of dental caries can also be linked to the recent trend of enormous consumption of sugar in Cambodia. There is also the impact of poor oral health on stated ability to eat certain foods which reduce the possibility to eat, cause of a weaker number of health teeth that can increase malnutrition, loose of weight and a higher level of caries (Sheiham, 2008).

In the sample of the study, the group of age most touched by dental caries and thinness was the group of low-age, where dental enamel is weaker, in contrary in the group of higher age, dental caries and thinness were the lower. It could explain also the correlation found between BMI-for-age and DMFT believing that children of higher age developed a stronger genetic which permitted struggle against dental caries.

The dentists can play an important role in promoting good nutrition and oral health. The NGOs PSE and PPA are doing an incredibly efficient intervention there to help these children to grow as well as possible by giving food, health and education skills. Hygiene oral wasn't respected by the majority of children even if the NGO was giving an important regard to it. Even if the number of overweight were small, prevention should be engaged to impede the growth of obesity.

IV.4 Limitations of the study and futures studies

About the validity of this study, there was first an inequality in the number of adolescents from the group 15-to-18-y-old (16 patients) to others groups of comparison; the biggest group were children 6-to-11-y-old (233 patients). Secondly, it was a cross-sectional study, which limits the ability to identify the cause-effect relationship. Regarding the causes of dental caries mentioned before, no one has been monitored in this study to confirm any influencing factor (malnutrition, consumption of sugar, hygiene habits).

Future research should focus on studying early childhood caries experience because of the high level of caries on children of low age and the interactions between risk and protective factors in their developments, in particular the effects of infant feeding practices. Longitudinal studies are needed to determine causes and effects of BMI on dental caries.

V. Conclusion

The study demonstrated a high prevalence of dental caries (94.8%) in the 344 participants from the NGO PSE. The majority has been found in low ages, especially at 6-y-old and in class of 6-11-y-old.

No significant association were found between dental caries and locality, gender, classes of BMI-for-age. But the study showed a statistically significant association between dental caries in function of age and BMI-for-age for this sample. As the BMI-for-age increased there was a significant decline in the number of dental caries among the participants, overweight showed healthier teeth than others did.

Possible causes of the high level of dental caries have been mentioned like the recent trend of enormous consumption of sugar in Cambodia, the double burden of malnutrition and the lack of oral hygiene habits. But to understand the relationship between dental caries and poor growth, only future longitudinal studies will help to determine the exact cause-effect by monitoring nutrition and oral hygiene habits at the same time with DMFT and BMI.

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Annex 1: Informed Consent form for PSE and PPA

Informed Consent form for PSE and PPA **1 June 2017**

Name of Investigator: Justine Manac'h

Name of the project: « Study of investigation on the oral health of children from the organization PSE »

Introduction:

I am Justine Manac'h, student of University of Fernando Pessoa, Porto, Portugal. I am doing a study of investigation on the oral health of children from the organization PSE to obtain my graduation of master in dentistry. I am coming as volunteer from PPA, working in collaboration with PSE.

I am going to invite you information and asking permission to collect informations on patients of PSE to complete this study. To make patients feel comfortable, the study will be anonymous. Please ask me to stop as we go through the information and I will take time to explain.

Purpose of the study:

- To evaluate the prevalence of caries on children, and compare in function of sex, BMI, and age
- To evaluate the organization of oral health cares, and improve as possible weaker sides
- To provide measures of prevention of oral health

Participant Selection:

I will make two groups of children as the association PPA is working:

- From 6 to 12 years and from 12 to 18 years

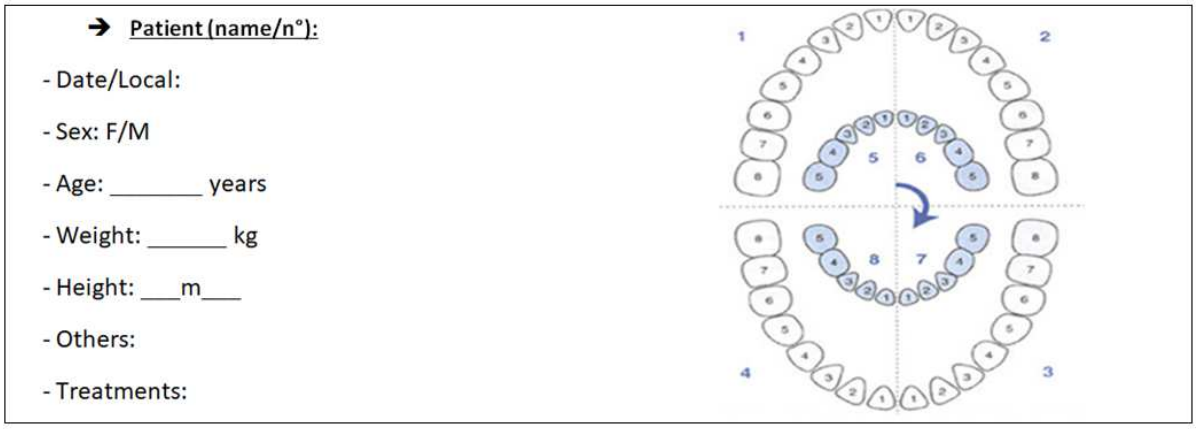
I will also differentiate:

- children studying in PSE, treated in the dental clinic of PSE
- children studying in schools sponsored by PSE, treated by the dental mobile team, which can also come to PSE dental clinic

Type of Study intervention: Study observational of prevalence:

For each child, I will complete the clinical record below, making one check-ups, annotating caries (C), lost teeth (X), obdurate teeth (O). Patients will be informed and can decline to participate to the study. Confidentiality will be confirmed.

Duration:



The study will take place during June 2017. Results will be given to the association.

Certificate of consent:

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent to authorize as responsible of associations the study.

Investigator of the study: _____

(Name/Date/Signature)

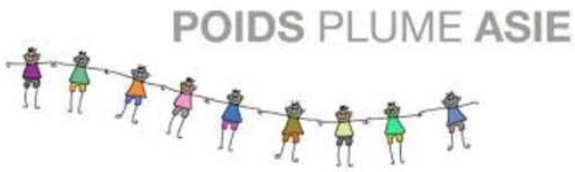
Titular dentist PSE: _____

(Name/Date/Signature)

Director of health department PSE: _____

(Name/Date/Signature)

Annex 2: Certificate of mission



28 June 2017

To Whom It May Concern:

This is to certify that Ms.**Justine Manac'h** was a full-time Dentist volunteer under Health Department, Human Education and Extra-curricular Activities Programs Department at Pour un Sourire d'Enfant (PSE). She joined the internship from 31 May 2017 to 28 June 2017.

This Certificate is issued at the request of Ms. Justine Manac'h for any lawful purposes in may serve.

Yours faithfully,

Hout VIBOL
PPA's Manager Cambodia

Annex 3: Criteria of Family recruitment of PSE

According to the recent line of poverty in Cambodia (GDP:$1.90),the committee of Pour un Sourire d'Enfant (PSE) decided to identify new criteria of family recruitment by the main components such as widow/widower, orphan children, abused children, vulnerable children, family living in anarchy area, abandoned children, and scavenger family and priority to the girls, attached with the gap of income as following:

I- Level 1 (40 programs will be supported as the benefit**)**

1- Income: **0 riel to 7600 riel (1.9$)** per person, per day.
2- One bicycle/old motorbike
3- Rental house/room.
4- Polluted or anarchy zone.
5- Serious debt.
6- Mother or father's chronic illness.

II- Level 2 (Only 35 programs will be supported as the benefit; excepted 5 programs such as: **Weekend work, Social work, Financial support, Financial support participation, rehousing)**

1- Income: **7700 riel (1.92$) to 10460 riel (2.61$)** per person, per day.
2- Rental room/own house.
3- One medium motorbike.
4- Debt.

III- Level 3 (Only 9 programs will be supported as the benefit: **CRPSE, CREE, CP, FP, SEA, Class special, Participation(30$), Flip, and Superiors studies)**

1- Income: **10500 riel (2.62$) to 13320 riel (3.33$)** per person, per day.
2- High price of rental room/own house.
3- One modern motorbike.
4- Debt.
5- Modern utilities (TV and refrigerator).
6- Good environment.

- **Note:** The students are absent for 1 week without information. He/she won't be followed up by social officer and he/she will be proposed to stop from school in CD session. All the problems of family are not responsible by social officer, but they will be visited by social officer to analyze their level of family.

IV- Level 4 (Only 4 programs will be supported as the benefit: **SB, CP, FP, and Participation(35$))**

1- Income: **13400 riel (3.35$) to 16180 riel (4.04$)** per person, per day.
2- Two or more modern motorbikes.
3- Debt.
4- Modern utilities (TV and refrigerator).
5- Good environment.

Note: The students are absent for 1 week without information. He/she won't be followed up by social officer and he/she will be proposed to stop from school in CD session. All the problems of family are not responsible by social officer, but they will be visited by social officer to analyze their level of family.

Supplementary Criteria of Candidate Recruitment

1- For PSE-I and SB candidates, only, we won't use the limit that we normally have, i.e. having been living at least 1 year in Phnom-Penh.
2- No supporting forsiblings' candidates in Vocational Training and SB.
3- Education and age must respect the recruitment criteria of each school.
4- The candidates must present official documents such as: poverty letter, certificate of education, certificate of birth, residence book.
5- Accommodation program will be provided to candidates if they have no solution (Social officer's last solution).
6- The candidates will be provided with social service by social officer.
7- The candidates will be not provided with yearly visit of social officer at the province.
8- All social officers must visit the families one time per year.

Methodology of Candidate Recruitment

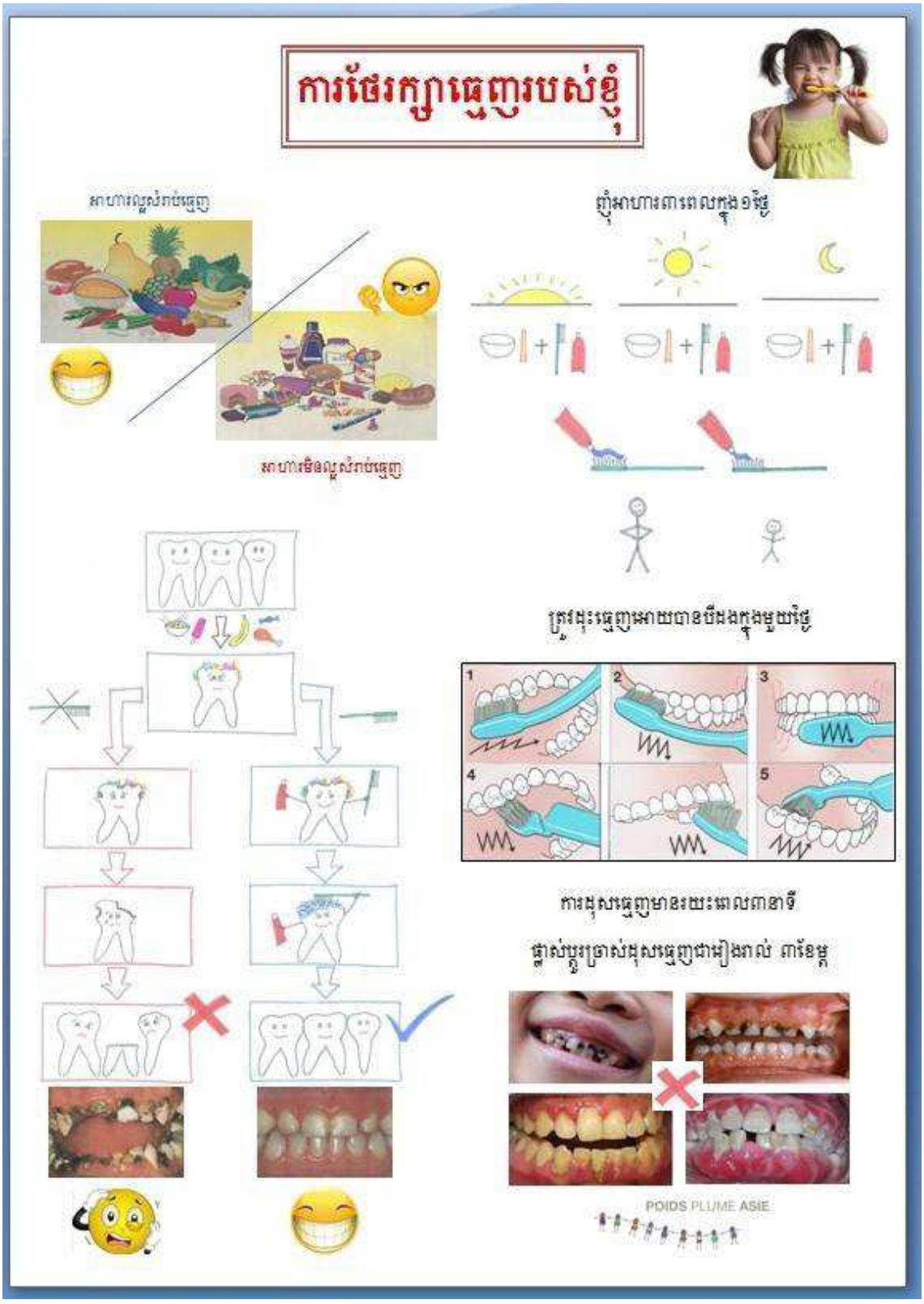
1- Making campaign towards grade 12^{th} students after they finish national exam and orientation towards students in Phnom-Penh high schools, conducted by external school staff and social staff.
2- Making orientation towards students studying in CRPSE, conducted by orientation staff of PSE-I.
3- Cooperating with authorities to promote our vocational training to villagers in Phnom-Penh communities.
4- Conducting meetings with all NGOs and churches to promote our vocational training.
5- Making orientation towards students studying in high schools at the province.
6- Broadcasting by TV and Radio.

Making the registration form of new candidates.

Annex 4: List of the 16 schools, paillotes and communities of the Dental Mobile missions

Name in English	Name in Khmer	Time to go there
B.S.L (BoeungSalang)	បឹងសាឡាង	15'
ChamroeunPhal	ចំរើនផល	20'
D.B.K (Dom Bok Kpous)	ដំបូកខ្ពស់	20'
D.K (Dong Kor)	ដងកោរ	15'
O.B.K (ObèkKaorm)	អូរបែកក្អម	5'
Oudong	ឧដុង	1h45
PrekTual	ព្រែកទាល់	20'
P.R.S (PhumRussey)	ភូមិឬស្សី	15'
SenSok	សែនសុខ	45'
S.M.C (Steong Mean Chey)	ស្ទឹងមានជ័យ	5'
Smile Village	ភូមិញញឹម	35'
Sorla	សរឡា	5'
Tror Pang AnhChanh	ត្រពាំងអញ្ចាញ	1h
Tror Pang Sala	ត្រពាំងសាលា	45'
Tuol Sam Bou	ទូលសំបូរ	35'
Veal Sbov	វាលស្បូវ	45'

Annex 5: Prevention Paper in the dental clinic



Advices to give to patients after oral examination:

- Brush teeth after each meal and at least twice a day (morning and evening) after eating.
- Brush during 2 minutes.
- Use a flexible toothbrush
- Toothpaste must be fluoridated:
    - < 1 year : No toothpaste
    - 1 to 3 : Just dip the hairs of the toothbrush in the toothpaste
    - > 3 : Put a pea-size quantity of toothpaste
- The toothbrush is personal!
- Change your toothbrush every 3 months
- Before 6 years old, an adult must help the kid to brush his teeth
- Do not eat and do not drink sugar food/drink between meals
- Always prefer to drink water

Annex 6: Evolution of DMFT for different age groups in Cambodia

Caries trends for different age groups		
dmft 5-6 years	Year	Source
7.4***	2003-07	3)
9.0	2011	4)
11.7+	2010-12	5)
DMFT 12 years	Year	Source
1.6	1990-91	1)
3.2*	1991	2)
2.3*	2002	2)
1.1**	2003-07	3)
3.5	2011	4)
5.5++	2010-12	5)
DMFT 15 years	Years	Source
1.7	1990-91	1)
4.1°	2011	4)
DMFT 35-44 Years	Years	Source
6.4	1990-91	1)
5.6	2011	4)

* Phnom Penh.
** rural areas.
*** 6 years
° 14-15 years
+5 year olds, Phnom Pehn and Siem Reep provinces
++ Phnom Pehn and Siem Reep provinces

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Annex 7: Statistical analysis with various variables (age, sex, DMFT, BMI) with the software SPPS

IdadeClasses3		N	Mínimo	Máximo	Média	Erro Desvio
1,00	Carie	233	0	19	6,52	4,016
	Perdido	233	0	1	,02	,145
	Obturado	233	0	3	,15	,481
	CPO	233	0	19	6,70	3,981
	Selante	233	0	10	,28	1,053
	Idade	233	6	11	9,11	1,562
	Peso (kg)	197	10	40	23,09	5,215
	Altura (cm)	197	102	147	124,21	8,534
	IMC	197	7,8	23,0	14,829	2,2129
	N válido (de lista)	197				
2,00	Carie	92	0	13	3,51	2,911
	Perdido	92	0	4	,18	,725
	Obturado	92	0	4	,28	,716
	CPO	92	0	13	3,98	2,916
	Selante	92	0	4	,04	,417
	Idade	92	12	14	12,72	,716
	Peso (kg)	77	18	64	33,47	9,228
	Altura (cm)	77	123	165	141,86	8,760
	IMC	77	11,2	27,6	16,411	3,1536
	N válido (de lista)	77				
3,00	Carie	19	0	7	3,05	1,840
	Perdido	19	0	2	,32	,582
	Obturado	19	0	4	,74	1,284
	CPO	19	0	7	4,11	1,595
	Selante	19	0	0	,00	,000
	Idade	19	15	18	16,21	1,134
	Peso (kg)	16	33	72	46,94	8,805
	Altura (cm)	16	140	172	158,94	8,012
	IMC	16	15,2	26,4	18,580	3,2053
	N válido (de lista)	16				

3 groups of age : 1,00= 6-to-11-y-old ; 2,00=12-to14-y-old ; 3,00=15-to-18-y-old