Aspects of Dental Caries in Sudanese Schoolchildren

Nazik Mostafa Nurelhuda

Thesis submitted in partial fulfilment of the requirements of the PhD degree
Department of Clinical Dentistry
Centre for International Health
Faculty of Medicine and Dentistry
University of Bergen
Bergen, Norway

2011

Dedication

To my parents, my sisters, my brother and my teachers.

‘Seeking knowledge is an obligation upon every muslim, be it a man or a woman’
Prophet Mohamed (pbuh)

Abbreviations

ART	Atraumatic Restorative Treatment
ATCC	American Type Culture Collection
BMI	Body Mass Index
CBS	Central Bureau of Statistics
CCUG	Culture Collection, University of Göteborg
CI	Confidence Interval
C_T	threshold cycle
DMFT	Number of Decayed, Missing and Filled permanent teeth
dmft	Number of decayed, missing, and filled primary teeth
def	decayed extracted filled
FFQ	Food Frequency Questionnaire
FBC	Food Behaviour checklist
GI	Gingival Index
HCEG	Higher Caries Experience Group
OIDP	Oral Impact on Daily Performance
OR	Odds Ratio
PI	Plaque Index
PCR	Polymerase chain reaction
Q-PCR	Quantitative Polymerase Chain Reaction
SES	Socio-economic status
SiC	Significant Caries Index
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organisation

ACKNOWLEDGEMENTS

During the preparation of this thesis, many people have contributed valuable guidance, support and feedback and I have been looking forward to publicly acknowledging their contributions.

First and foremost, I thank Allah the Almighty for everything and specially for giving me the strength to complete this work.

I am greatly indebted to my supervisors: Associate Professor Tordis Trovik for valuable advice, cheerful support and trust throughout my study period. I am grateful to my mentor and friend Dr. Mutaz Ahmed, for his faith in my ability and for his continuous efforts and immense encouragement. I thank Professor Vidar Bakken for his endless support and for accepting every challenge with an encouraging smile. I thank Senior Researcher Marian Malde for valuable advice and feedback, which considerably improved this work. I thank you all for your constructive input and accept sole responsibility for any remaining inadequacies.

Thanks to the Department of Clinical Dentistry, the Centre for International Health, the Gade Institute and the National Institute for Nutrition and Seafood Research (NIFES) for providing an inspiring and creative working environment. I am grateful to Statens Lånekassen and Colgate for generous support. I would also like to thank the staff in these departments particularly Borgny Lavik, Linda Foreshaw, June Indrevik, Kari Nordvik, Erik Sandquist, Sissel Stokes, Sigrun Ask, Marit Stubdal, Knut Buanes, Øyunn Nielsen and Brita Lofthus for their endless patience and kind assistance.

I thank Associate Professor Salah Osman for exploring avenues for me to the University of Bergen. I thank Professor Raouf Ali for his valuable advice, assistance in dealing with the Sudanese bureaucracy and immense support during the fieldwork. I am grateful to Associate Professor Olav Bøe and Ms. Khalida AbdulGhaffar for statistical advice and Dr. Karl Brokstad for his assistance with laboratory procedures. I am grateful to Professor Yahia

Ibrahim for his valuable feedback. I thank Professor Anne Åstrøm and Dr Mohamed El-Haroni for their valuable contribution and Dr. Joan Carrick for English language revision of the thesis.

I am grateful to my teachers for their priceless guidance and advice. Special thanks go to Professors Rune Neilsen, Magne Raadal and Kristian Heggenhaugen for being an inspiration and enlightenment.

Thanks to the following field assistants who transformed a tedious task into a delightful, learning experience: Osama Sayed Ahmed, Mohamed Elsheikh Ali, Sulafa Yahia, Salwa Mustafa, Mohamed Osman and Osama Taifour.

Thanks to the schoolchildren who participated in this study, the teachers who assisted with the data collection and administrative officials in the Ministry of Health and Education who welcomed me, helped me and provided me with the information I needed.

I wish to also thank my colleagues for stimulating discussions and all wonderful friends who made a positive impact on my life as a PhD student in Bergen, specially; Alem, Hager, Sally, Nada, Vilhjalmur, Nazareth, Lars, Jarle, Shiva, Maria, Ingvild, Mathilda, Margaret, Amani, Bass, Nouman, Lumbwe, Manal, Shaza, Elwalid, Mohamed, Hisham, Waad & Eltayeb.

Some people I have known in Bergen have deeply touched and inspired me along the way, and have indirectly contributed to my research work: Professor Kamal Mustafa, Dr. Fadwa Taha, Mr/Uncle Mahmoud Salih, Professor Abdelsalam Saleh: I thank you all.

I owe my deepest gratitude to my parents Awatif and Mustafa, my sisters Nasreen and Salwa, and my brother Mohamed, for their immeasurable support, endless encouragement and prayers and for gracefully enduring the long years of preparation. I am blessed to have you.

The above list is by no means exhaustive of all those who contributed to this work which gives me room to seek forgiveness should I have unmindfully left out some names.

ABSTRACT

Background: Effective delivery of dental services must be based on reliable information about the level of disease and treatment need in the target population. Evaluation of the relative impact of various factors known to influence disease severity and progression is fundamental to identification of those whose quality of life is most likely to be impacted by the disease. Little is known about the current oral health status of Sudanese schoolchildren. Recent changes in socioeconomic status and dietary habits, particularly with respect to availability of sugary snacks, may have influenced trends in disease prevalence and severity.

Aim: The overall aim of the present study was to assess oral health status and oral health related quality of life in 12-year-old schoolchildren in Khartoum State, Sudan, and to investigate factors of importance for predicting caries experience and promoting good oral health related quality of life, including the impact of non-biological determinants such as intake of sugary snacks, socio-demographic factors and biological determinants such as salivary microbiology.

Methodology: A school-based survey was conducted on 1109 schoolchildren, selected by stratified random cluster sampling from 58 private and public schools. Data were collected by clinical examination, saliva sampling and structured and pretested questionnaires administered by face to face interview. The questionnaires covered socio-demographics, Child-OIDP, Food Frequency Questionnaire (FFQ) and Food Behaviour Checklist (FBC). Saliva samples were obtained from 140 of the subjects, including 30 from individuals with caries experience. The saliva samples were analysed by quantitative real time polymerase chain reaction (qRT-PCR) with specific oligonucleotide primers. DMFT was measured

according to WHO criteria. Gingival index (GI) of Loe & Silness, Plaque index (PI) of Silness & Loe and Dean's Index of fluorosis were recorded.

Results and conclusions: The mean DMFT for 12-year-olds was 0.42. Private school attendees had significantly higher DMFT (0.57) than public school attendees (0.40). The untreated caries prevalence in the sample (deciduous and permanent teeth) was 30.5%. Furthermore, the SiC was 1.4 when adjusted to the population and 1.6 and 1.4 for private and public school attendees respectively. The DMFT disclosed that 24% of the children had caries in permanent teeth. The mean GI for the six index teeth was 1.05 (95% CI 1.03 – 1.07) and the mean PI was 1.30 (95% CI 1.22 – 1.38). . In a multivariate model, higher socioeconomic status (SES) was found to be a risk indicator of caries experience in all the children (IRR 1.23 (95% CI 1.02-1.47)), and an indicator of poor oral health related quality of life in public school attendees (OR 1.4 (95% CI 1.1-1.8). The seven sugary snacks and beverages were run in a multiple variable logistic regression model (Nagelkerke 0.026) alongside socio-demographic variables, with the Higher Caries Experience Group (DMFT > 1) as the dependent variable. For this group, the results supported the hypothesis that frequency of intake of sugary snacks or beverages is associated with caries experience and socio-demographics in 12-year-old schoolchildren in Khartoum, suggesting that frequent consumption of soft drinks (OR 1.5 95% CI 1.0 – 2.4) might be a risk indicator for disease. The mean ratio of fold differences of *Streptococcus mutans* to *Streptococcus sobrinus* was 0.77 (sd 5.4) and 2.29 (sd 6.0) for samples obtained from caries-free and caries-active individuals respectively, suggesting a higher proportion of *S. sobrinus* than *S. mutans* in the caries-active group than in the caries-free group. The Arabic Child-OIDP showed acceptable psychometric properties and is considered a valid, reliable and practical inventory for use in this population. Almost half the sample perceived a moderate impact of oral status on quality

of life, mostly with respect to eating. The most commonly cited impacting factors were erupting teeth and toothache. The results of this study may be used to assess the need for health promotion and dental care among schoolchildren in Khartoum State. It may be useful for purposes of evaluation, setting priorities, planning and allocation of resources for oral health promotion and treatment programmes.

List of original publications:

This thesis is based on the following publications and manuscripts referred to in the text by their Roman numerals:

Paper I

Nurelhuda NM, Trovik TA, Ali RW, Ahmed MF. Oral health status of 12-year-old school children in Khartoum State, The Sudan; a school-based survey. *BMC Oral Health* 2009, **9:**15 (DOI:10.1186/1472-6831-9-15)

Paper II

Nurelhuda NM, Malde MK, Ahmed MF, Trovik TA. Correlation between caries experience in Sudanese schoolchildren and dietary habits according to a food frequency questionnaire and a modified 24-hr recall method. *Submitted for publication*

Paper III

Nurelhuda NM, Al-Haroni M, Trovik TA, Bakken V. Caries Experience and Quantification of Streptococcus mutans and Streptococcus sobrinus in Saliva of Sudanese Schoolchildren. Caries Research 2010;44:402-407 (DOI: 10.1159/ 000316664)

Paper IV

Nurelhuda NM, Ahmed MF, Trovik TA, Åstrøm AN. Evaluation of oral health-related quality of life among Sudanese schoolchildren using Child-OIDP inventory. *Health and Quality of Life Outcomes* 2010, **8**:152 DOI:10.1186/1477-7525-8-152

Table of Content

1 INTRODUCTION

1.1 Dental caries as an oral health problem

The World Health Organization (WHO) defines oral health as the standard of oral and related tissues which enables an individual to eat, speak and socialise without active disease, discomfort or embarrassment and which contributes to general well-being (Larson, 2006). This comprehensive definition of oral health emphasizes the impact of disease on the quality of life of the individual.

Oral diseases such as dental caries are a major global health problem, although there are considerable variations in occurrence between countries, between regions within countries, areas within regions and within social and ethnic groups (Edelstein, 2005). Dental caries affects 60-90% of school-aged children and the majority of adults. The WHO reported that if treatment was available in low income countries, the costs of treating dental caries alone in children would exceed the total health care budget for children (Petersen, 2003). Disease prevention is clearly the way forward; through designing comprehensive oral health prevention programmes (Lancet Editorial, 2009).

1.2 Global caries trend

1.2.1 WHO global epidemiology

As shown in Figure 1, Africa has the lowest prevalence of dental caries (DMFT 1.7); the highest values are in the Americas (DMFT 3) and in Europe (DMFT 2.6). In industrialized countries, the reported trend is a decline in caries experience, attributed to improved public health measures, including effective use of fluorides, changed living conditions and lifestyles and improved self-care practices. Figure 2 shows that the opposite trend is often reported in

developing countries, attributed to increasing sugar consumption and inadequate exposure to fluoride (Petersen et al., 2005).

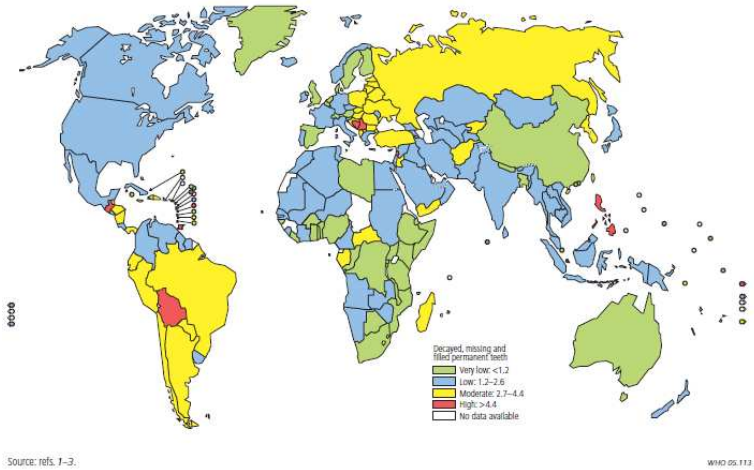

Figure 1. Dental caries levels (DMFT) among 12-year-olds world-wide. World Health Organisation (Petersen et al., 2005).

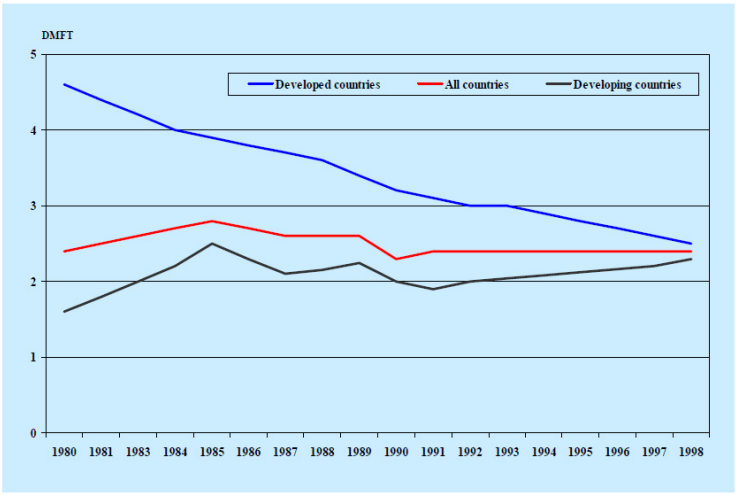

Figure 2. Changing levels of dental caries experience (DMFT) among 12-year-olds in developed and developing countries (WHO, 2002) (WHO Oral Health Country/Area Profile Programme 2007).

1.2.2 Scientific publications

The reported trend towards increasing caries prevalence in developing countries is supported by epidemiological studies. A recent systematic review by Cleaton-Jones et al. (2006) covered 130 caries epidemiological studies published between 1970 and 2004. WHO caries diagnostic criteria were used in all the studies; the subjects comprised 5 to 6-year-old and 11 to 13-year-old children. Both mean prevalence and mean DMFT were lowest in Sub-Saharan Africa and highest in Latin America and the Caribbean. Thus this review did not support the widely-held assumption that dental caries rates are increasing in developing countries (Cleaton-Jones et al., 2006).

Data from national oral health surveys in China were unable to show increasing or decreasing trends in caries experience (Zhang et al., 2008). Furthermore, a more recent study in Hubei Province, China, reported a dramatically decreasing trend among all sex-age subgroups in the rural population between 1990 and 2005, more pronounced in deciduous than in permanent teeth. However, this trend was not steadily decreasing throughout the years (Tang et al., 2005).

In a study from 2002, dental caries trends over a 16-year period were recorded in Chandigarh schoolchildren in India, by the same research group, consistently using WHO recording criteria: the data disclosed a continuous decline in caries in 12- and 15-year-old children but a slight increase among 5-6 year-olds (Chawla et al., 2000). In Brazil, a pronounced decline in DMFT, observed between 1980 and 2003, was attributed to improved availability of fluoridated water and toothpaste and changes in the goals of public oral health programs (Narvai et al., 2006).

A review of the literature in 1999 disclosed a general decline in dental caries across eleven Sub-Saharan countries (Cleaton-Jones and Fatti, 1999). However, the reasons for this decline were unclear: water fluoride levels in the region are low and sugar consumption is also low (Ismail et al., 1997). Most importantly, a decline observed by chance due to changing diagnostic standards was justifiably excluded in the review.

The assumption that there is a general trend towards increasing caries experience in developing countries should thus be challenged. Public health policy in individual countries should be based on data from the local population.

1.2.3 Caries trend in The Sudan

There is little available data on dental caries in The Sudan. Few studies include information about socio-economic and behavioural factors. The following description of caries trends in The Sudan is based on published studies conducted over the past five decades. It should be noted that comparison of the studies is complicated owing to lack of conformity: the reported studies were conducted on different populations and different clinical criteria were applied.

In 1966, Emslie reported a mean DMFT of 0.7 in 12-year-old Sudanese children (Emslie, 1966). It was stated in a publication by Ibrahim et al. that Barmes reported an increase in caries among 12-year-olds from a DMFT of 1.0 in 1977 to 2.6 in 1979 (personal communication, Ibrahim et al.) (Ibrahim et al., 1986). In 1982, Dowty, using WHO criteria, examined a sample of 426 12- and 15-year-olds from the town of Juba in southern Sudan, and reported higher caries prevalence in Juba (36% in both age groups) than in Jonglei Province (4% in both age groups) (Dowty, 1982). In 1986, the prevalence of dental caries was reported in a sample of 625 schoolchildren from three different communities in Khartoum province

(Ibrahim et al., 1986). In the 7-year-olds, the def value in the urban children was 3.4, compared with 4.7 in the rural and 3.9 in the semi-rural groups. The highest DMFT values were found in 12-year-olds in urban and rural communities, and in 11-year-olds in semi-urban communities: 2.9, 3.2 and 2.3 respectively. The DMFT values reported for all age groups in the urban, rural and semi-urban samples were 1.35, 1.41 and 1.56 respectively. The overall mean DMFT for the whole sample was 1.46. It was reported in this study that caries situation in Sudanese children was deteriorating.

In 1988, caries status was reported in 600 12-year-old schoolchildren living in Omdurman. The average DMFT was 3.7 for girls and 2.8 for boys, with an overall mean of 3.2 (Aziz Ghandour et al., 1988).

In 1993 Raadal et al. recorded dental caries in a total of 544 children in Khartoum, Sudan: 275 pre-school children (aged 4-5 years) and 269 schoolchildren (aged 7-8 years) (Raadal et al., 1993). Modified WHO criteria were applied, recording only caries grade 3 or more, according to Moller (Moller, 1966). The mean dmft was 1.68 in the 4-5-year-old group; 58% were caries-free. In the 7-8-year-old group, the mean dmft (molars and canines) was 2.77; 33% of the children were caries-free. Most of the caries in both groups was untreated. In decayed teeth which were not beyond repair, the sites most commonly affected were the occlusal surfaces in the pre-school group and the approximal surfaces in the school-age group. The mean DMFT in the 7-8-year olds was 0.15: only the occlusal surfaces of the first molars were affected. The permanent dentition was caries free in 94% of the 7-year group and 88% in the 8-year group. Stratification according to socio-economic level disclosed no statistically significant differences in caries prevalence between the groups. Because of the difficulty of

comparing the data with those of earlier studies, no conclusions could be drawn with respect to dental caries trends in The Sudan.

In summary, the above studies might indicate a trend towards increasing caries experience in the Sudanese child population.

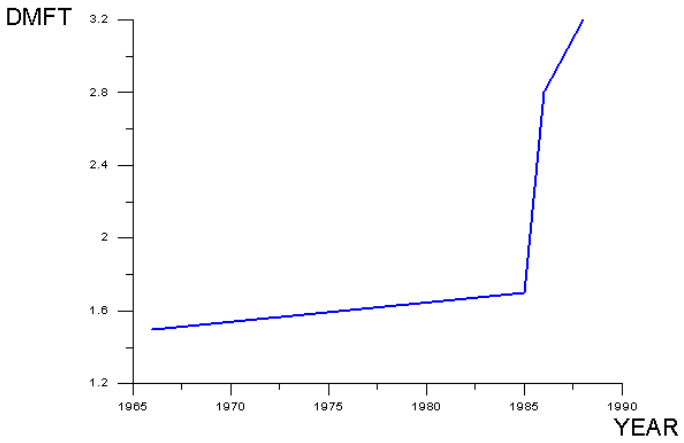

Figure 3. Scientific publications showing caries trend in The Sudan.

Until the second half of 2008, Sudan's economy boomed as a result of rising oil production, high oil prices, and large inflows of direct foreign investment. In socioeconomically developing countries, globalization and economic growth imply a risk for future increases in dental caries. The studies on which the present thesis is based were designed to document present conditions and to study the associations and possible determinants of dental caries in the Sudanese population of schoolchildren.

1.3 Dental Health system in Sudan

Health services are provided through the Federal and State Ministries of Health, Armed Forces, police, the universities and the private sector. There is little co-ordination among the

different delivery systems and most systems are treatment- rather than preventive in orientation (WHO, 2006).

Services in the remote areas are usually provided by dental assistants recruited by the State Ministry of Health and include fillings, uncomplicated extractions, removable dentures and even, under certain circumstances, removal of impacted teeth if the necessary equipment is available.

The ratio of dentists to population in The Sudan is 1:100,000, 3 times lower than for example in India. However, there are wide regional variations: high in urban areas (1:30,000), but as low as 1:130,000 in rural areas (Yousif and Miskeen, 2009). Most dentists are based in Khartoum and major cities such as Madani, Port Sudan and Al Obeyid. A recent study in Gezira State reported inadequate dental health services, especially in rural areas, with respect to instruments, equipment and personnel (Yousif and Miskeen, 2009). Although the situation in other regions has not been documented, it is likely that similar conditions apply.

Today the State Ministry of Health runs a school health programme targeting Classes 2 and 6 in most public schools and in some private schools. The programme includes oral health screening, oral health education at morning assembly and provision of free treatment in terms of fissure sealants, ART and fluoride application and referral of more complex cases. This programme comprises the only screening and recording of the oral health of children and adolescents. The Sudanese National Health Insurance system covers expenses for specific basic dental procedures, but out-of-pocket payments are common.

1.4 Determinants of dental caries

Dental decay is the outcome of a disease process, which includes pathological factors (acidogenic bacteria, sugar), triggered by initiating factors, such as social factors including

attitudes and behaviour (Eriksen and Dimitrov, 2003). These factors, however, do not fully explain the distribution of the disease (Harris et al., 2004). There are two key risk periods during which children are most susceptible to initiation of dental caries: during the eruption of the permanent molars and the period during which the enamel is undergoing secondary maturation (Axelsson, 2006). In recent years, public health research has focused on exploring social determinants of oral health.

1.4.1 Diet and disease

Sucrose has been described as 'the arch criminal of dental caries' (Marsh P, 1999). In research into caries aetiology, sucrose has probably received more attention than any other factor, with convincing evidence from animal experiments and human and experimental studies on the cariogenic potential of carbohydrates, especially sugars (Harris, 1963; Moynihan and Petersen, 2004).

Global epidemiological studies have found associations between the intake of sugary snacks and dental caries in developing countries, but not in developed countries (Sreebny, 1982; Woodward and Walker, 1994). Studies investigating individual frequency of intake have presented different levels of association (Anderson et al., 2009; Rugg-Gunn and Hackett, 1993). With good oral hygiene habits and a regular supply of fluoride, teeth are not particularly susceptible to caries, even under conditions of frequent sugar consumption (Loveren, 2000). Oral health promotion programmes have generally targeted a reduction in frequency of sugar intake between meals (Rugg-Gunn and Hackett, 1993).

1.4.2 Microorganisms

The ecological plaque hypothesis proposes that dental caries is a consequence of changes in the natural balance of the resident microflora, brought about by an alteration in the local

environment. Intraoral stresses such as consumption of sucrose may generate environmental changes in the dental biofilm, which may subsequently stimulate a shift in the composition of the biofilm bacteria in favor of more acidogenic and aciduric species (Kleinberg, 2002; Marsh, 2003).

A correlation has been shown between levels of *S. mutans* in the oral cavity, caries experience and possible future caries susceptibility (Blay et al., 2000). A Kenyan study reported a significant correlation between caries experience and *S. mutans* alone, a weaker association when combined with *S. sobrinus* and no association with *S. sobrinus* alone (Beighton et al., 1989). Other studies have reported that the mere presence of *S. mutans* is not sufficient to predict the occurrence of dental caries in children (Acevedo et al., 2009; Loesche, 1986). Furthermore, some epidemiological studies have shown that the prevalence of *S. sobrinus* is more closely associated with high caries activity (Fujiwara et al., 1991; Hirose et al., 1993).

1.4.3 Host factors

Saliva is the major host defence system against dental caries. Its main functions are clearing food debris from the oral cavity and buffering acids (Mandel, 1987). It also acts on microorganisms: antimicrobial agents in saliva reduce the production of harmful products and prevent adherence of microorganisms to the tooth surfaces. Therefore, the quantity, quality and flow rate of saliva are a major determinants of dental caries (Lagerlof and Oliveby, 1994). Tooth structure and growth stage are also influential. The tooth is most susceptible to caries during the post-eruptive stage (Carlos and Gittelsohn, 1965). Morphological features such as deep fissures and structural tooth defects harbour dental plaque and microorganisms and anomalies of the dental arch such as crowding makes removal of biofilm difficult. All these factors increase susceptibility to dental caries (Burt and Eklund, 1992).

1.4.4 Social determinants

Age, sex, ethnicity and genetics influence the prevalence of dental caries (Antunes et al., 2006). It has been reported that variations in caries prevalence are attributable partly to diversity of dietary habits, culture and oral hygiene in different communities and are associated with socio-economic and biological risk factors (Nicolau et al., 2003). In a literature review on social class and dental caries, higher caries experience was associated with lower social classes, 5 studies found no difference and 2 reported lower caries levels in lower social classes (Carmichael et al., 1980).

1.5 Risk prediction in caries research

The development of dental caries is described as an interaction among determinant factors: etiologic risk factors (microflora), external modifying risk factors (diet), internal modifying risk factors (host) and duration of exposure (Keyes, 1962). This basic model has been modified several times to incorporate more variables.

Factors that have been proved in cross sectional studies to be significantly associated with increased prevalence of a specific disease are termed risk indicators.

Factors that have been proved, in well-controlled prospective studies, to increase significantly the risk of onset or progression of a specific disease are termed risk factors and prognostic risk factors, respectively. Among these factors are fermentable carbohydrates, poor socioeconomic status, systemic disease, medication that impairs salivary function and irregular dental attendance habits (Cinar, 2009).

Risk prediction through epidemiological studies has two main approaches. One approach involves the prediction of high-risk individuals in studies which try to identify the characteristics of high- and low-risk individuals. The search for acceptable, accurate and cost-

effective strategies for identifying high-risk individuals has been intensified and multiple risk factors and indicators have been proposed. Past caries experience has been shown to be the single best predictor of future caries development (Harris et al., 2004). However, this is not satisfactory, as the primary purpose of prediction is to prevent the occurrence of caries in the first place. In management of individual patients in private dental practice, a cariogram model has been used as a risk assessment strategy. It is a computer program showing a graphical picture that illustrates to what extent different etiological factors of caries affect caries risk (Bratthall and Hansel Petersson, 2005). However, this approach is expensive. It also requires good data collection scheme to conduct the longitudinal observation. In order to reduce the costs, candidates were also screened without salivary tests, but the positive predictive value was fairly low and the negative predictive value remained the same (Petersson et al.). Another approach is the multi-risk approach, whereby in order to study the combined effect of the factors, multiple risk factors are assessed simultaneously. This approach has enabled researchers to detect the effects of single risk factors nestling among multiple risk factors (Schwartz et al., 1999). Such studies usually report the results of regression models, and the findings from different studies with respect to the relative effect of the predictors are usually inconsistent. These inconsistencies may be attributed to individual differences, to differences inherent in different populations or to statistical analysis. Thus extrapolation of the findings is difficult (Aleksejuniene et al., 2009).

Because of the limitations of current approaches to caries risk epidemiology (Aleksejuniene et al., 2009), an alternative causal approach has been proposed (Eriksen and Dimitrov, 2003). This encourages considering the causes at multiple levels of organization and at both societal and individual level. The proposed approach does not contradict current oral epidemiology, but is intended to preserve and expand previous contributions. The series of studies in this

thesis were designed in the context of the multiple levels, causal approach to dental caries risk.

1.6 Conceptual model for Papers 1-4

A risk factor model was designed by Petersen (Petersen, 2005) to analyse dental caries in populations (Figure 4).

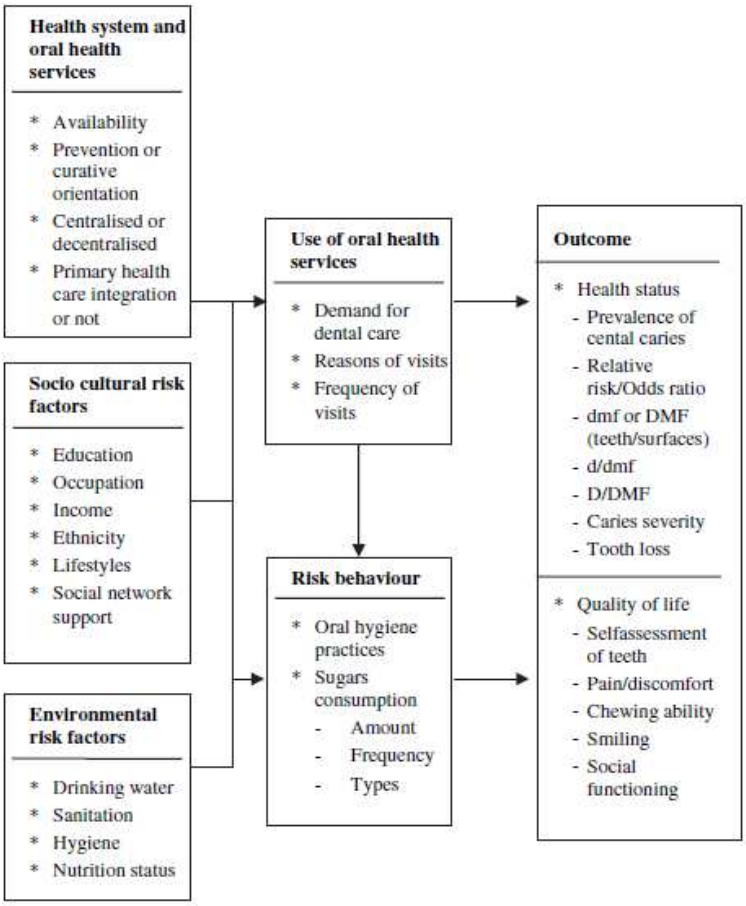

Figure 4. Risk factor model including distal and proximal factors for analysis of dental caries, applied from the WHO (Petersen, 2005).

Figure 5 illustrates how the four papers of this thesis are related based on the depicted model (Petersen, 2005). They assess some of the commonly known caries-associated risk factors which in turn have an impact on clinically assessed oral health status and subjective evaluation and self reported OIDP.

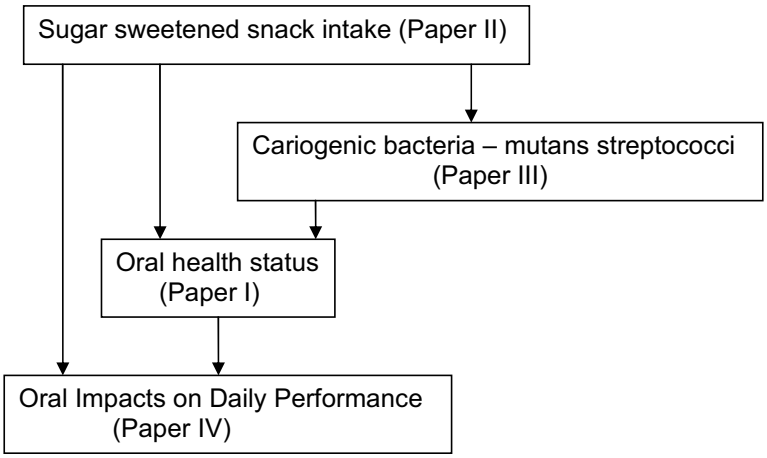

Figure 5. Conceptual model guiding all 4 papers.

Effective delivery of dental services must be based on reliable information about the level of disease and treatment need in the target population. Evaluation of the relative impact of various factors known to influence disease severity and progression is fundamental to identification of those whose quality of life is most likely to be impacted by the disease. Little is known about the current oral health status of Sudanese schoolchildren. Recent changes in socioeconomic status and dietary habits, particularly with respect to availability of sugary snacks, may influence trends in disease prevalence and severity. The studies in this thesis involve the collection and analysis of data related to key caries risk factors in a representative population of Sudanese schoolchildren.

2 AIMS OF THE STUDY

2.1 General aim

The overall aim of the present study was to assess oral health status and oral impact on daily performance (OIDP) in 12-year-old Sudanese schoolchildren, and its association with specific non-biologic and biologic determinants.

2.2 Specific objectives

The specific aims were:

1. To assess the oral health status of 12-year-old schoolchildren in Khartoum State, expressed in terms of prevalence and severity of selected clinical parameters (DMFT, GI, PI, Dean's Index) and oral health related quality of life (Child-OIDP) (Papers I, IV).

2. To study the inter-relationship between non-biological (socio-demographic factors, frequency of intake of sugary snacks and beverages) and clinical parameters of oral health status and oral health related quality of life as assessed by the Child-OIDP inventory (Papers I, II, IV).

3. To study the presence and relative amounts of *S. mutans* and *S. sobrinus* in saliva samples from 12-year-old Sudanese schoolchildren and their association with dental caries (Paper III).

4. To examine the psychometric properties of the Arabic version of Child-OIDP (Paper IV

2.3 Working Hypothesis

The oral health of Sudanese 12-year-old schoolchildren, in terms of clinical parameters and OIDP, is associated with non-biological determinants such as socio-demographic

characteristics, oral hygiene habits, intake of sugary snacks and beverages and biological determinants such as salivary levels of mutans streptococci; these factors are all interrelated.

3 MATERIALS AND METHODS

3.1 Study area

Sudan has twenty-six states, 134 provinces and 600 localities, with a total area of 2,505,810 km^2. The State of Khartoum has an area of only 22,122 km^2 (0.88% of the total area of Sudan) but is inhabited by approximately 21% of the population. The city of Khartoum, the national capital of Sudan, is the capital of Khartoum State. As shown in Figure 6, the State comprises 7 main localities (*Khartoum, Jabal awaliya, Omdurman, Ombada, Karary, Bahry and Sharq Elnil).*

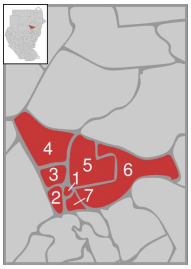

Figure 6. Localities of Khartoum State, the Republic of The Sudan

1: Khartoum city, 2: Ombada, 3: Omdurman, 4: Karary, 5: Bahri, 6: Sharq Elnil, 7: Jabal Awliya

3.2 Study population

Khartoum State is the most densely populated state in Sudan, with an estimated population of approximately 5-7 million (21%) of the total population of 37 million (Ministry of Education, Department of Census and Statistics). The population in Khartoum is considered to be the most rapidly growing in Sudan. The Central Bureau of Statistics (CBS) estimates that children under 15 years of age comprise 36 percent of the total population of Khartoum. In 2001 the World Bank estimated that primary school enrolment in Sudan was 46% of the eligible pupils

(Library of Congress Report, 2004). Enrolment varies widely and in Khartoum City is as high as 78%.

In the present study, the target population comprised the 12-year-old children enrolled in public and private schools of Khartoum State, who met the specified inclusion criteria.

Primary education in The Sudan: Education in public schools is officially funded by the government. Schools are concentrated in urban areas where Arabic is the medium of instruction in all public schools and most private schools. In 2001 the World Bank estimated that primary school enrolment in Sudan was 46% of the eligible pupils (Library of Congress Report, 2004). Enrolment varies widely with as high as 78% in Khartoum State. The majority of the primary schoolchildren in Khartoum city attend public schools (88%) while the remaining (12%) attend private schools as of the census of 2006 (Ministry of Education, Department of Census and Statistics). There is little information about oral health in children outside the school system.

3.3 Sampling design

This school-based survey was conducted between October 2007 and March 2008.

3.3.1 Sample calculation

A two stage probability proportional to size cluster sampling technique was used (Bennett et al., 1991). The sample size was calculated using an estimated dental caries prevalence and oral impact (OIDP) prevalence of 50%, a design effect of 2, and a precision of 0.06. The minimum sample size to satisfy these requirements was estimated to be 1100; 550 children in each school sector with dropouts taken into account. This calculated sample was stratified (probability proportional to size) according to gender and the number of students in each

locality Table 1. The primary sampling unit and unit of analysis was the schoolchild and the cluster was the school. The cluster size was determined at 30 students per school.

3.3.2 Sampling procedure

School rolls (boys, girls and mixed primary schools – public and private) were obtained from the Ministry of Education. In all, 37 schools were randomly selected as follows: eight public boys' schools, eight public girls' schools, five public mixed gender schools, eight private boys' schools and eight private girls' schools. Schoolchildren were selected randomly from any of the classes, ranging from Grade 2 in remote public schools to Grade 8 in private schools in the city centre. Those children who were confirmed to be 12 years of age were asked to stand up, and the first thirty in line were selected. The desired number of children was not always available in the randomly selected schools. Extra schools were therefore chosen on the basis of geographic proximity. In all, 58 schools were eventually included. All 12-year-olds in the selected schools were eligible for the study. The child's age was confirmed primarily from the school registries, but was in some cases self-reported.

Table 1. Sample distribution of schoolchildren according to student density in each locality and school sector.

LOCALITY	**PUBLIC (n=666 743)**		**PRIVATE (n=90 147)**	
	No of students	**sample**	**No of students**	**sample**
Khartoum	61 851	9.3%: 50	27 308	30.3%: 166
Jabal Awaliya	130 433	20.0%: 108	10 656	11.8%: 65
Omdurman	56 902	8.5%: 47	15 684	17.4%: 96
Ombada	155 062	23.3%: 128	6 329	7.0%: 39
Karary	89 471	13.4%: 74	9 969	11.1%: 61
Bahri	69 712	10.5%: 58	15 237	16.9%: 93
Sharq Elnil	103 307	15.5%: 85	4 964	5.5%: 30
Total	666 743	100.0%: 550	90 147	100.0%: 550

The schoolchildren were randomly selected from each class, according to the following criteria:

3.3.3 Inclusion criteria

1. Child Sudanese by birth.
2. Aged 12 on their last birthday.
3. Free from any serious illness. Those attending school during the three days of examination to be assumed to be free from serious illness.

3.3.4 Exclusion criteria

1. Multiple extractions (four or more extractions).
2. Antibiotics in the past three months. Use of antibiotics may confound bacterial levels in saliva.
3. Complaints of known systemic diseases expressed during the examination.

3.4 Survey instruments

3.4.1 Clinical Examination

The principal researcher, (NMN), a qualified dentist, carried out the clinical examination (appendix 1). The details are presented in Paper I. Caries was assessed under direct sunlight using the decayed, missing and filled tooth index (DMFT) and in accordance with the WHO caries diagnostic criteria for epidemiological studies. *Significant caries index* (SiC) was calculated as the mean DMFT of the one third of the study group with the highest caries score (Bratthall, 2000). The variable 'active caries' reported later, included decayed teeth in both the deciduous and permanent dentitions, diagnosed according to WHO criteria (WHO, 1997).

Oral hygiene status was assessed in terms of the gingival index (GI) (Loe and Silness, 1963; Tang et al.) and plaque index (PI) (Silness and Loe, 1964). GI was initially coded as shown in Table 2 and PI criteria are shown in Table 3. GI and PI were scored for all teeth present. A single score was taken for each tooth on the labial surface. The mean of the 6 index teeth was reported for each child. Some uncertainty arose in differentiating between scores 0 and 1: in doubtful cases, score 1 was applied. Dean's Index was used to record dental fluorosis (Rozier, 1994). Cases were grouped as fluorosed (questionable, very mild, mild, moderate and severe) and not fluorosed.

Figure 7. A schoolchild undergoing clinical examination in a private school in Karary locality.

Table 2. Criteria for scoring the Gingival Index (Loe and Silness, 1963).

Criteria		
0	Normal	The color of the gingiva is pale pink to pink. The surface after drying is matt. The level of the gingival margin does not matter. The gingiva should be firm on probing.
1	Mild inflammation	Slight change in color, slight oedema; ***No bleeding on probing*** The gingival margin is slightly more reddish or bluish-reddish than normal
2	Moderate inflammation	Redness, oedema and glazing; ***bleeding on probing***. Gingiva is red or reddish-blue and glazy. There is enlargement of the margin due to oedema.
3	Severe inflammation	Marked redness and oedema, ulceration; ***tendency to spontaneous bleeding.***

Table 3. Criteria for scoring the plaque Index (Silness and Loe, 1964).

Criteria	
0	No plaque in the gingival area
1	A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may only be recognized by running a probe across the tooth surface.
2	Moderate accumulation of soft deposits within the gingival pocket, on the gingival margin and/or adjacent tooth surface, which can be seen by the naked eye
3	Abundance of soft matter within the gingival pocket and/or on the gingival margin and adjacent tooth surface

Following the examination, the child was given oral hygiene instruction: how to brush and how frequently. Each child was given a 30ml tube of toothpaste as a gift from Colgate, Oslo, Norway. Children who needed treatment were referred to the closest dental care provider.

3.4.2 Questionnaires

A structured interview was conducted privately with each schoolchild and included questions on socio-demographics and oral health related habits (Appendix 2) (Paper I), the Food Frequency Questionniare (FFQ) (Appendix 3) (Paper II), Food Behaviour Checklist (Appendix 4) (Paper II), the Child-OIDP inventory (Arabic translation of questions Appendix 5) (Paper IV). The Child-OIDP was back-translated into and from Arabic as described in Paper IV. The interviews were conducted by seven data collectors, trained by the principal researcher (NMN). The short FBC interview was conducted, on three consecutive days, by a trained teacher from every school who sat with each child privately in the classroom during working hours.

Pilot study: Initially, a pilot study was carried out to validate the questionnaires. Modifications were then made, including a shift to face-to-face individual interviews and use of the Child-OIDP in preference to the adult-OIDP questionnaire.

Five schoolchildren were interviewed using open-ended questions, by prompting questions about meal times and types of foods. This sample had a representation from both genders, and schools from both sectors. The suggested items were also discussed with colleagues. Based on these results, the seven most frequently reported food items were selected: sweet biscuits, chocolates, popsicles (coloured, flavoured iceblocks), soft drinks, sweetened hot beverages, dessert and sweets. These were incorporated in the FFQ and FBC.

3.4.3 Laboratory techniques and Saliva sampling (Paper III)

One hundred and forty children were randomly selected for saliva sampling from the total interviewed participants. The samples were analysed using Quantitative real-time polymerase chain reaction (Q-PCR/qrt-PCR). In the present study, the comparative C_T method was used to calculate relative quantification (Livak and Schmittgen, 2001). Details in Paper III.

3.4.3.1 Saliva sample collection on Indicating FTA cards

Unstimulated saliva samples were collected in clean plastic cups. The saliva was pipetted and then spotted on Indicating Whatman FTA cards (Whatman BioSciences Ltd., Abington, Cambridge, UK), as shown in Figure 8.

Figure 8. The saliva being pipetted and then spotted on Indicating Whatman FTA cards in the field.

FTA cards were designed for easy collection, shipment, archiving at ambient temperature and purification of nucleic acids from a wide variety of biological samples for PCR analysis such as blood, buccal cells, tissue cells, cultured cells, microorganisms and plant tissue.

3.4.3.2 Preparation of FTA discs for PCR amplification

The discs were punched out from the centre of the card circles, and each transferred to a separate tube for preparation (Figure 9) as described in Paper III. The discs were then transferred after preparation to the PCR plate for analysis.

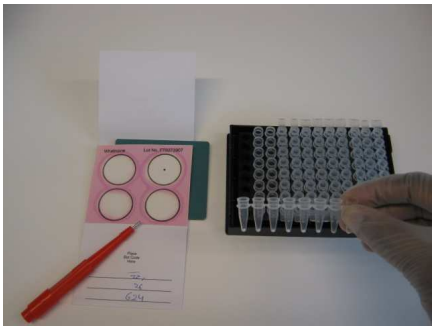

Figure 9. Left: Colour change from pink to white on FTA card after saliva spotting. Figure shows a 1.2 mm Harris Micro Punch. Right: Punched out discs transferred into tubes for processing.

3.4.3.3 DNA Amplification

Card testing prior to saliva sample analysis*:* Bacteria were cultured on fastidious anaerobe agar (FAA) and incubated at 37 °C for two days. After harvesting, DNA was extracted from *S. mutans* UA159 (ATCC) and *S. sobrinus* OMZ176 (CCUG) using the FastDNA ® spin kit (Qbiogene, CA, USA) to be used as the template in PCR analysis source of bacteria. Primers were designed using Invitrogen primer design software (Invitrogen Corporation, Carlsbad,

CA, USA), to detect specifically the 16S rRNA gene of *S. mutans* UA159 and *S. sobrinus* OMZ176. The primer sequences were as follows: *S. mutans*: forward primer: 5'-GGTGACGGCAAGCTAATCTC-3', reverse primer: 5'- GCTGGCCCCTAAAAGGTTAC-3'. Amplicon size was 199bp. *S. sobrinus*: forward primer: 5'-TGCTATCTTTCCCTAGCATG -3', reverse primer: 5'- GGTATTCGGTTTGACTGC -3'. The PCR temperature profile consisted of an initial denaturation step at 95ºC for 2 min, followed by 25 cycles of a denaturation step of 95ºC for 40 s, a primer annealing step at 55ºC for 30 s, an extension step at 72ºC for 5 min and a final step of 72ºC for 5 min. The PCR products were analysed by 1.0% agarose gel electrophoresis and stained with ethidium bromide for visualisation. Each of the primers was tested for specificity and sensitivity against each other and *Lactobacillus acidophilus*. They were found to be specific and sensitive. The reaction was run with samples on FTA cards and directly. Thus, the technique was optimised and tests conducted on the collected saliva samples.

3.4.3.4 Quantitative real-time PCR amplification

The primers and probes used in the qRT-PCR targeted the *gtfB* and *gtfT* genes of the *S. mutans* and *S. sobrinus*, respectively. Another universal primer that targeted the 16S rRNA gene was used to quantify the total bacterial load on the samples. The primers and probes sequences have been published previously and proved to be sensitive and specific (Table 1 in Paper III) (Yoshida et al., 2003).

3.5 Data Handling

All data handling procedures are described in the respective papers and manuscripts. Statistical analyses were conducted using SPSS 15.0 (SPSS Inc., 2006) and Stata version 10 (StataCorp LP, 2009). A Higher Caries Experience group (HCEG) was defined (Paper II) to

examine the attributes of a higher caries risk group. The characteristics of data and statistical analysis are illustrated on Table 4.

Table 4. Characteristics of data and statistical tests used in the specific papers.

Statistical test/method	Paper I	Paper II	Paper III	Paper IV
Chi-Square test	+	+	+	
Cohen's Kappa	+	+	+	+
Principal Component Analysis	+			
Poisson regression	+			
Logistic regression		+		+
Cronbach's alpha				+
Mann Whitney	+			
Odds ratio		+	+	
Spearman's correlation			+	
Wilcoxon's test		+		
Student's t test		+		
GLM ANOVA		+		
Tukey's test		+		

Statistical differences between groups e.g. caries experience groups, private and public school attendees were evaluated by Pearson's chi-square test, which is suitable for the comparison of frequencies in two or more groups (Kirkwood and Sterne, 2006). Cohen's Kappa coefficient tested the inter- and intra-observer agreement for the DMFT clinical index, FFQ and Child-OIDP. Cronbach's alpha was used to test the internal reliability.

Student's T-test for independent samples was used to compare the mean values of sugary snack intakes between groups. When more than two groups were being compared, the GLM ANOVA – analysis of variance - was used. Patterns within the groups were studied using Tukey's post hoc test. When the data were not normally distributed Wilcoxon's non-parametric test was used. The Mann Whitney non-parametric test was used to assess whether two independent samples of observations have equally large values. The Spearman rank correlation test was used to describe the relationship between two ordinal characteristics.

Multivariate analysis was performed using Poisson regression reporting prevalence ratio, a better model for evaluation of skewed outcomes (Barros and Hirakata, 2003). Binary logistic models were applied to evaluate the association of outcome measures with explanatory factors and to calculate the corresponding odds ratio and 95% confidence interval. Goodness of fit of the models was checked with the Hosmer and Lemeshow Goodness of Fit test. Variance was evaluated using the Nagelkerke's coefficient of determination. Statistical significance was evaluated at p=0.05 throughout the study.

Principal component analysis with Kaiser Criteria (eigenvalue greater than one) was used to construct a good subset of socioeconomic status (SES) predictors. Lifestyle, household assets and education level were combined (Vyas and Kumaranayake, 2006). The details are presented in Paper I.

3.6 Ethical consideration

Procedures for obtaining consent and ensuring confidentiality were proposed by the ethical research committees in The Sudan. Written permission to conduct the study was thus obtained from the authorities at the Ministry of Health and Ministry of Education, locality administration and individual school administration. Verbal informed consent was obtained from the participants.

4 RESULTS

4.1 Sample profile

A total of 1109 (response rate 99%) (49.9% boys, 50.2% public school attendees) from 58 schools completed the interview followed by the clinical examination.

Paper I: *Oral health status of 12-year-old schoolchildren in Khartoum State, The Sudan; a school-based survey*

The mean DMFT for 12-year-olds was 0.42. Private school attendees had significantly higher DMFT (0.57) than public school attendees (0.40). The untreated caries prevalence (deciduous and permanent teeth) was 30.5%. Caries experience (DMFT > 0) affected 24% of the schoolchildren. Furthermore, the SiC was 1.4 for the adjusted sample and 1.6 and 1.4 for private and public school attendees respectively. Forty eight percent of the examined schoolchildren visited a dentist for treatment, and of those 96% visited because they suffered toothache or trauma. There was no statistically significant association between reason for visit and caries experience. The mean GI for the six index teeth was 1.05 (CI 1.03 – 1.07) and the mean PI was 1.30 (CI 1.22 – 1.38). . The prevalence of fluorosis was low (11.9%). Fluorosis and oral hygiene indices were not associated with any of the non biological determinants and caries experience. Multivariate analysis disclosed that caries experience (DMFT > 0) was significantly and directly associated with socioeconomic status (IRR 1.23 (95% CI 1.02-1.47)). Private school attendees were associated with a higher mean DMFT. Almost one third (30.3%) of the private school attendees experienced dental caries versus 23.5% of the public school attendees (details in Paper 1).

Paper II: *Correlation between caries experience in Sudanese schoolchildren and dietary habits according to a food frequency questionnaire and a modified 24-hr recall method.*

BMI calculations showed the representative prevalence as follows: underweight schoolchildren (35.8%), healthy children (55.8%), those at risk of becoming overweight (5.2%) and those overweight (3.5%). The following variables were tested individually with the independent outcomes, and only those that showed a statistically significant association were inserted in the multiple variable ANOVA model: SES, school sector, gender, parental education, locality, caries experience and BMI. Using sum FFQ score (mean 20.0, SD 3.5) as the dependent variable and SES, parental education and locality as fixed factors disclosed that locality ($F=3.2$, d.f.= 6, $p=0.004$) and SES ($F=4.0$, d.f. = 1, $p=0.46$) were statistically significant with no statistically significant interaction between the variables. However, the effect size was small (<0.02) for both. *Post-hoc* comparisons using the Tukey HSD test indicated higher mean consumption in the Sharq Elnil district than in Khartoum and Ombada, and higher mean consumption in Bahri than in Khartoum.

No significant association was found between the total frequency of intake of sugar-containing items reported on the FBC questionnaire and caries experience (DMFT >0: n=298). The seven food items were run in a multiple variable logistic regression model (Nagelkerke 0.026) alongside socio-demographic variables, with the Higher Caries Experience Group (HCEG) as the dependent. This disclosed a statistically significant association for consumption of soft drink (OR 1.5 95% CI (1.0 – 2.4)).

Paper III: *Caries experience and quantification of Streptococcus mutans and Streptococcus sobrinus in saliva of Sudanese schoolchildren*

The mean ratio of fold differences of *S. mutans* to *S. sobrinus* was 0.77 (sd 5.4) and 2.29 (sd 6.0) for samples obtained from caries-free and caries-active individuals, respectively. This

suggested a higher proportion of *S. sobrinus* than *S. mutans* in the caries-active group than in the caries-free group. It was 3 times more likely to detect both bacteria in individuals with caries activity over their counterparts. Furthermore, it was three times less likely to detect *S. sobrinus* alongside *S. mutans* in caries free individuals. There were no significant associations found between children with caries active lesions and their oral hygiene expressed in terms of GI, PI and tooth brushing frequency. An association was found between children with caries active lesions and the frequent consumption of sticky dessert and higher SES.

Paper IV. *Evaluation of oral health-related quality of life among Sudanese schoolchildren using Child-OIDP inventory*

The instrument showed acceptable psychometric properties and is considered as a valid, reliable (Cronbach's alpha 0.73) and practical inventory for use in this population. An impact was reported by 54.6% of the schoolchildren. The highest impact was reported on eating (35.5%) followed by cleaning (28.3%) and the lowest impacts were on speaking (8.6%) and social contact (8.7%). Problems which contributed to all eight impacts were toothache, sensitive teeth, exfoliating teeth, swollen gums and bad breath. Toothache was the most frequently associated cause of almost all impacts in both private and public school attendees. After adjusting for confounders in the 3 multiple variable regression models (whole sample, public and private school attendees), active caries maintained a significant association with the whole sample (OR 2.0 95% CI 1.4-2.6) and public school attendees (OR 3.5 95% CI 2.1-5.6), and higher SES was associated with only public school attendees' Child-OIDP (OR 1.9 95% 1.1-3.1).

5 DISCUSSION

This section deals with important methodological issues and considers the main findings of the papers constituting the present thesis. Psychometric evaluation of Child-OIDP is described in detail in Paper IV.

5.1 Methodological aspects of the study

Data for the studies were collected using standard survey methods under field conditions, providing estimates of variables for a specific target population (Moser and Kalton, 1971). The questionnaires included close-ended questions with several answers to improve the accuracy of responses. The main strength of this approach and one of the advantages of a sample survey approach is that it yields information on several variables in a large number of subjects, at relatively low cost. As discussed in the separate papers, this design is however, subject to errors with respect to sampling, non-coverage, non-response and measurement (Locker, 2000). The major sources of error are highlighted in the following section.

The interview as a whole, including the clinical examination, took approximately 20 minutes. The variety of questions probably eliminated questionnaire fatigue.

5.1.1 Reliability

Test-retest: Several measures were taken to ensure acceptable data quality. For this, pilot studies were conducted and field assistants were trained on how to conduct the interviews. Reliability Cohen's Kappa was applied for test-retest reliability to examine measurement bias. Test-retest reliability (reproducibility) refers to the extent of measurement consistency between different points in time. The interpretation of the Kappa values were as follows: <0 = no agreement, 0.0-0.2 = slight agreement, 0.21-0.40 = fair agreement, 0.41-0.60 = moderate

agreement, 0.61-0.80 = substantial agreement, 0.81-1.00 = almost perfect agreement (Landis and Koch, 1977). With regard to clinical examination (one trained dentist), the Kappa value for DMFT was 0.83 for 45 schoolchildren re-examined within 14 days, indicating almost perfect agreement. Reproducibility for GI and PI was not tested because all children were given oral hygiene instruction after the clinical examination and it was expected that in response, GI and PI scores would have improved at re-examination 14 days later. In this case, it would be difficult to distinguish between observed differences due to lack of consistency or due to true changes of the characteristics.

The principal questionnaire on socio-demographic and behavioural characteristics, the food frequency questionnaire and the Child-OIDP were reintroduced to a sample of 20 randomly selected 12-year-old schoolchildren. For logistical reasons, the test–retest interval for the questionnaires was 10 days. Kappa values for test-retest of the principal questionnaire ranged from 0.55 (knowledge) to 0.97 (wealth index). The data gathered by the questionnaire can improve in the 10-day interval between the reproducibility tests, thus these finding were accepted. The other Kappa values were of acceptable agreement.
Reproducibility test results of the FFQ showed that the Kappa-values for the sugar-sweetened items ranged from -0.03 to 0.89 (sugar-sweetened hot beverage, chocolates). Based on the Kappa results, the sugar sweetened hot beverage report was excluded from the analysis.

With respect to the Child-OIDP questionnaire, weighted Cohen's Kappa was 0.70 for eating. The Kappa value was 1.00 for the following Child-OIDP items; speaking, cleaning teeth, relaxing, sleeping, smiling, social contact and emotional state. These values were in moderate to substantial agreement according to Landis and Koch (Landis and Koch, 1977). Measurement bias was thus minimal in the Child OIDP questionnaire.

Internal consistency denotes the interrelation of items in a scale and Cronbach's alpha was calculated for this purpose. This test was conducted on FFQ, FBC and Child-OIDP questionnaires. Alpha coefficients above 0.80 are rated as exemplary, from 0.70 to 0.79 as extensive, and those in the range 0.60 – 0.69 indicate only moderate internal consistency (McDowell, 2006). The value for the FFQ and FBC (n=1109) was 0.50 for both instruments. In this context the items are independent of each other, suggesting that no similar scores should be expected. Thus, a score of 0.50 was acceptable for the FFQ and FBC.

For Child-OIDP the standardized Cronbach's alpha coefficient was 0.73 for the entire sample: 0.78 for public and 0.67 for private school attendees, all within the range of moderate to extensive consistency.

5.1.2 Validity

Validity is the ability of a tool to measure what it is intended to measure (McDowell, 2006). Internal validity implies validity of inference for the source population of study subjects. Several types of bias can affect the internal reliability (Sackett, 1979).

Diagnostic bias: Dental caries is best diagnosed in a dental surgery using visual, tactile and radiographic records. However, following the WHO standardized recording criteria in the field and under natural sunlight, only frank dentine caries could be diagnosed. This, however, enabled comparison of findings with other studies using the same index. Caries experience is thus under-estimated in all (Paper I).

Information bias: Face validity is the validity of a test at face value, and it reflects the immediate understanding of the questions. No major changes in the questionnaire were necessary after the pilot study, indicating good face validity. The interviewer confirmed that all the children understood the questions properly before answering.

Subjective oral health conditions were assessed using self-report methods, which are prone to recall and information/social desirability bias. Socially desirable answers were likely controlled for by interviewing each student individually, away from their class teachers and colleagues. The dentist interviewer, although a stranger to the child, could unintentionally have influenced the children to provide socially desirable answers.

Confounding: Potentially confounding variables were controlled for through stratification and in multiple variable models. These limitations may have compromised the internal validity of the study.

External validity is the validity of generalized inferences in scientific studies. In this study, sample calculation and sampling procedures were optimised to ensure that the results of this study could be generalized to all 12-year-old schoolchildren in Khartoum State, thus minimizing selection bias. Paper I presents both the results of analysis of the sample with equal numbers of schoolchildren from the private and public sectors (1:1) and adjusted values according to the population of schoolchildren (public/private ~ 7:1).

Sampling error: The cluster sampling design employed provided advantages of simplicity and cost effectiveness and practicability in developing regions where school registers were incomplete. Furthermore, all estimates were adjusted for at the analysis stage using Stata. The cluster sizes were small, averaging 20 students per school. In all, 58 clusters were included. After statistical analysis, the point estimates were the same before and after adjusting for cluster sampling. The only changes observed where in the slight narrowing of the confidence interval after adjustment.

The number of saliva samples tested was not calculated to yield results generalisable to the target population, but to test the hypothesis that an association existed between salivary parameters and the caries and the non-caries group.

Effect on non-response error: Adequacy of response rates may be rated as good (more than 80%), acceptable (70 – 79 %), suspect (55 - 69%), and unacceptable (less than 55% as (Locker, 2000). The response rate in this study was good (99%), giving further strength to the external validity of the study. A few children (fewer than 10, mostly girls) opted not to give saliva samples. This was understandably because of the procedure of spitting into a cup. No information was obtained from the non-participants. Although non-response is not a random process, it is unlikely that non-response error, which is a function of response rate and the magnitude of the difference between responders and non-responders, has biased the results of the present study.

5.1.3 Cross cultural adaptation

Both the dietary habit questionnaires were based on the results of five in-depth interviews, thus minimizing the likelihood that the questionnaires were culturally inappropriate.

The original Child OIDP questionnaire was an English language version. It was translated to and from Arabic and initially tested for cultural adaptability in a group of 12-year-old schoolchildren. Ideally a questionnaire should have been designed specifically for the Sudanese child population, in the local language/dialect. However, with the limited resources available it was more feasible to test a pre-designed questionnaire. The pilot study and discussion with colleagues demonstrated that this questionnaire was culturally acceptable.

5.2 Comments on the main findings

Dental caries and its sequelae have been the main concern of most dentists worldwide. This study reported results that may be extrapolated to all 12-year-old children living in the State of Khartoum. This state was specifically selected for study because it is the most

cosmopolitan and most densely populated in the country and includes various ethnic groups. People migrate to Khartoum not only because as the capital it offers better living opportunities, but also because of internal displacement as a result of war and drought. The index age of 12years was adopted in order to enable collation with previous studies in The Sudan and elsewhere.

5.2.1 Oral health status (Papers I and IV)

Dental caries prevalence and severity in terms of DMFT was very low (0.4). The impression gained from previous studies of oral health in The Sudan, was a trend towards increasing caries prevalence as described in the introduction (section 1). In contrast, the findings disclose a decline in caries experience among Sudanese 12-year-old schoolchildren. DMFT prevalence among the 12-year-olds of countries neighbouring The Sudan, reported after the year 2000, show that current DMFT values in Khartoum State are in the low range, comparable with the African populations in Tanzania and Nigeria (Lagos) where DMFT values of 0.3 and 0.46 (Agbelusi and Jeboda, 2006) were reported among 12-year-old children in 2004 and 2003/04 respectively. However, culturally similar neighbouring countries report higher values: Saudi Arabia reported a DMFT of 5.9 in 2002 (WHO Oral Health Country/Area Profile Programme) and the United Arab Emirates a DMFT of 1.6 in 2009 (El-Nadeef et al., 2009). The global caries burden was calculated to 1.61 DMFT for the year 2004, representing a continuous decline in most recent years (Bratthall, 2005). The condition in Khartoum State, in terms of current mean DMFT, is encouraging. However, despite the improvement, caries is unevenly distributed in the child population; a small proportion of individuals carry most of the disease burden. In addition, the proportion of teeth with active caries that went untreated (D component of DMFT) has improved only slightly from the last report in 1986: from 98% of 12-year-olds, to 90% in the present study (Ibrahim et al., 1986).

Furthermore, the burden of disease was measured not only by the above clinical tools, but also subjectively. This report provides new and detailed evidence of the Child-OIDP of public and private school attendees in Khartoum State (details in Paper IV). The prevalence of oral OIDP in 12-year-old schoolchildren in Khartoum State (54.6%) was almost twice that reported in a similar age group in Tanzania (28.6%)(Mtaya et al., 2007). With the exception of the UK, all the remaining countries had higher impact prevalence, highlighting socio-cultural variations in the Child-OIDP (Yusuf et al., 2006, Tubert-Jeannin et al., 2005, Bernabe et al., 2008, Cortes Martinicorena et al., 2009, Castro et al., 2008, Bianco et al., 2009). Despite the high prevalence of impact on daily performance, the severity of impact was rarely high: most reports were of little or moderate intensity, and private school attendees reported a higher frequency of severe and very severe intensities compared to their public school counterparts. Despite the low prevalence of dental caries experience (24%), a significant association was found with an average moderate intensity of Child-OIDP. The finding that more children reported a subjective impact caused by toothache (55%) than indicated by objectively assessed prevalence of caries experience (24%) suggested that clinical examination might underestimate treatment need.

5.2.2 General risk assessment based on the risk factor model in this population (based on Figure 3)

An attempt is made to analyse the caries risk in this population using the model illustrated in Figure 3. Not all the variables in this model were investigated in this study. Figure 10 illustrates the model with the examined variables.

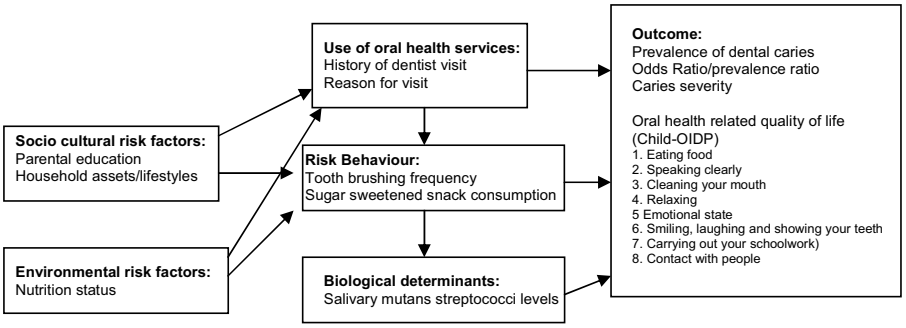

Figure 10. Examined variables based on the Peterson model.

Utilization of dental services in this population was evaluated in terms of dental attendance habits: 52% had never previously been examined by a dentist. The reasons for going to the dentist and the care index (F component of DMFT) are similar to those in developing countries (Petersen, 2003).

Environmental risk factor, represented by nutritional status, was expressed in terms of BMI, which may be considered as a marker for nutritional status in some cultures. Although the water fluoride level was not known, this was estimated indirectly by recording the severity of fluorosis. Under socio-cultural risks, an association was disclosed between caries experience and children of higher SES. The indicators of socioeconomic status (SES) used in the present study were education and lifestyle indicators (household assets, house ownership, dwelling structure materials, family size and house size). Risk behaviour was evaluated in terms of brushing frequency and intake of sugary snacks. However, the type of toothpaste was not recorded. The individual contributions of these variables are discussed in Papers I, II and IV. The combined contribution of the variables was examined in regression models (Paper I, II, IV) and the main findings are discussed below as indicators of caries experience and impact on daily performance.

5.2.3 Indicators of poor oral health (Papers I, II, III, IV)

Caries experience was associated with the private school sector, higher SES and the prevalence of *S. sobrinus* in saliva. Frequent consumption of soft drinks was associated with the higher caries group. Child-OIDP was associated with active caries in all the children and a higher SES in public school attendees. These findings further suggest the need for subjective assessment of oral health to complement conventional objective clinical assessment.

Recently there has been an increased concern about social gradients of dental caries, because oral health inequality has been increasing, even in countries with well-developed health care systems (Watt, 2007). In the present studies, schoolchildren of higher socioeconomic status were more likely to experience dental caries and public school attendees with a higher SES more likely to report an oral health related impact on their daily performance. This is in contrast with a previous report from The Sudan, over two decades ago (Ibrahim et al., 1986) and does not support the general belief that lower socioeconomic status is usually associated with caries experience and disease as a whole. In a review of the epidemiology of SES and health, Marmot concluded that the causes of inequalities in health within countries are similar to those between countries and emphasized the association between SES and health (Marmot, 1999). A literature review on social class and dental caries found higher caries experience in lower social classes, although five studies did not find any difference and two reported lower caries level in lower social classes (Carmichael et al., 1980). A study comprising data from 99 countries compared the mean DMFT among 12-year-olds and SES variables such as the human development index, mean years of schooling and the Gini Index (Standard economic measure of income inequality) (Hobdell et al., 2003). The authors perceived the findings as exploratory rather than definitive. The higher the SES status of a country, the higher the reported mean DMFT. The results of the present series of studies support this conclusion.

Hobdell et al. attributed this association mainly to the F component of the index, suggesting that dental treatment is more readily available to children of higher SES. In the present material, the F component was similarly greater in private school attendees and children with a higher SES, although overall the component was very low.

Today economic conditions in The Sudan are changing dramatically. There is more access to refined food products and urban life style has changed. The association of caries experience with higher SES suggests that unless preventive action is taken, caries prevalence will increase as education and income increase.

Despite the high reported frequency of snacks, no association was found between the total consumption frequency of the 7 sweetened items (sum FFQ score and sum FBC score) and caries experience (DMFT>0) in the whole sample. This may be accounted for by the low inter-individual variation in sugar-sweetened snack intake. Frequent daily brushing (93.7%) may have also contributed to protection against dental caries. Similar findings have been reported in recent cross-sectional studies (Burt and Pai, 2001). Burt et al. reviewed the clinical evidence for frequency of sugar intake and concluded that the difficulty experienced in identifying the clinical impact of dietary habits might be due to the interaction between diet and oral hygiene (Burt et al., 1988). More recent experimental studies suggest that there is no simple relationship between the sucrose content of food and dental caries (Mundorff et al., 1990).

Caries experience, in addition to it being low, was skewed. To explore associations further, a HCEG (DMFT > 1, n=141) as described in Paper II was defined to investigate closely the attributes of the higher risk group, even though the proportion of subjects in this group with high DMFT was extremely low. Moreover, the findings of the multivariate logistic regression

model on the FBC results showing the children in the HCEG being 1.5 times more likely to report frequent consumption of soft drinks were in agreement with those of past studies (Levy et al., 2003; Moynihan and Holt, 1996) (Lim et al., 2008). In the US, high consumption of carbonated soft drinks appears to be more characteristic of children aged 6-10 years (Sohn et al., 2006). However, the data are inconclusive (Tahmassebi et al., 2006) .

Despite efforts to include the most commonly consumed items, compiled through the mixed methods attempt, there is a possibility that some items might have been overlooked. The FBC as a modified 24 hour recall questionnaire would have benefited more by inclusion of the timing and the amount of intake thus providing better grounds for comparison. The 24 hour recall method for dietary habit data collection is recommended in cross sectional studies (Guenther et al., 1997). However, in future studies, 24 hour recall questionnaires may be administered on more than three occasions. Some authors have proposed that at least 7 days are needed to rank subjects to an acceptable degree of accuracy (Nelson et al., 1989).

Multivariate approaches, rather than the use of single parameters, should improve caries risk prediction for individuals as well as groups of subjects (van Houte, 1993). Since caries increments vary among populations in different countries and within the countries themselves, prevalence and incidence rates should be determined individually, and for each population single microbial factors should be studied as caries risk predictors with optimal procedures for sampling and analysis, especially in developing countries (Krichevsky and Krasse, 1986; van Houte, 1993). Thus, the microbiological determinant was investigated in this study: the relative proportion of *S. sobrinus* in the caries active subjects was significantly higher, suggesting that this strain could be an indicator of caries experience and a caries risk indicator in this population. Although no association was found with sugary snack intakes, microbiological tests may be also used to provide objective evidence of other caries risk

factors, such as high carbohydrate intake, as an a adjunct to other evaluative factors and as an aid to the determination of the need for preventive measures (Krasse, 1985). However, it remains a challenge to find an affordable means of carrying out such screening methods to improve the cost effectiveness of community-based programmes in developing countries.

Two distinct approaches may be adopted to preventive strategies: the whole population approach, or the risk approach, which targets certain individuals. This is further divided into the high risk approach, whereby individuals with high levels of caries are identified and the directed population approach, a combination whereby groups with higher rates of caries are identified (Rose, 1993). This approach assumes that caries is a problem in a certain group and that the rest of the population is unaffected.

From the present results, it was difficult to discern a high caries risk group clearly: the differences between groups were statistically significant, but too small to categorize high risk groups. Also, targeting high risk groups specifically is less effective when the difference in caries experience between high and low caries risk groups is not substantial. It is also thought to be palliative and temporary in nature; it neither addresses the problem, nor prevents the emergence of new cases. The present findings highlight the inaccuracy of dental caries predictors and the limitations of applying the individual high risk approach as a public health strategy (Batchelor and Sheiham, 2002; Peres et al., 2009).

In this present material, a population based approach is therefore recommended. All children should be targeted, and the programmes should be integrated with other health promotion programmes, with special reference to the common risk factor concept.

5.2.4 Conclusions

In Khartoum State, the prevalence (24%) and severity (DMFT 0.42) of dental caries and prevalence (11.9%) of fluorosis were low. The oral hygiene standard was deemed acceptable.

Almost half the sample perceived a moderate oral health related impact on their daily performances, mostly with respect to eating. The most commonly cited impacting factors were erupting teeth and toothache.

Higher SES was found to be a risk indicator of clinically diagonosed poor oral health status in this population, and an indicator of OIDP in public school attendees. Frequent consumption of soft drinks may be considered as a caries risk indicator of the higher caries risk group. The caries active subjects had significantly higher relative proportions of *S. sobrinus* to *S. mutans*, suggesting that salivary levels of *S. sobrinus* may be regarded as a caries risk indicator.

The Arabic Child-OIDP showed acceptable psychometric properties and is considered a valid, reliable and practical inventory for use in this population.

5.2.5 Recommendations

Results of this study may be used in the estimation of need for health promotion and dental care among schoolchildren in Khartoum State. It may be useful for purposes of evaluation, priority setting, planning and allocation of resources for oral health promotion and treatment programmes.

At times of instability in The Sudan, the implications of general health indicators are staggering. Because oral health is seldom life-threatening, it may have low priority for

national governments - teeth may be considered expendable. Commitment is needed to integrate oral disease prevention into programmes to prevent chronic diseases and into public-health systems in The Sudan.

There is a great need for conducting surveys and longitudnal studies across The Sudan targeting different age groups from both private and public schools, to help understanding the risk factors' association with development of dental caries.

6 REFERENCES

1. Acevedo AM, Ray MV, Socorro M, Rojas-Sanchez F (2009). Frequency and distribution of Mutans Streptococci in dental plaque from caries-free and caries-affected Venezuelan children. *Acta Odontol Latinoam* 22(1)*:*15-20.

2. Agbelusi GA, Jeboda SO (2006). Oral health status of 12-year-old Nigerian children. *West Afr J Med* 25(3)*:*195-198.

3. Aleksejuniene J, Holst D, Brukiene V (2009). Dental caries risk studies revisited: causal approaches needed for future inquiries. *Int J Environ Res Public Health* 6(12)*:*2992-3009.

4. Anderson CA, Curzon ME, Van Loveren C, Tatsi C, Duggal MS (2009). Sucrose and dental caries: a review of the evidence. *Obes Rev* 10 Suppl 1(41-54.

5. Antunes JL, Peres MA, de Campos Mello TR, Waldman EA (2006). Multilevel assessment of determinants of dental caries experience in Brazil. *Community Dent Oral Epidemiol* 34(2)*:*146-152.

6. Axelsson P (2006). The effect of a needs-related caries preventive program in children and young adults - results after 20 years. *BMC Oral Health* 6 Suppl 1(S7.

7. Aziz Ghandour IA, Ibrahim FA, Shehata AH (1988). The prevalence of dental caries, fluorosis, and dental attitudes among primary schoolchildren in Omdurman--Sudan. *Odontostomatol Trop* 11(3)*:*103-106.

8. Barros AJ, Hirakata VN (2003). Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 3(21.

9. Batchelor P, Sheiham A (2002). The limitations of a 'high-risk' approach for the prevention of dental caries. *Community Dent Oral Epidemiol* 30(4)*:*302-312.

10. Beighton D, Manji F, Baelum V, Fejerskov O, Johnson NW, Wilton JM (1989). Associations between salivary levels of Streptococcus mutans, Streptococcus sobrinus, lactobacilli, and caries experience in Kenyan adolescents. *J Dent Res* 68(8)*:*1242-1246.

11. Bennett S, Woods T, Liyanage WM, Smith DL (1991). A simplified general method for cluster-sample surveys of health in developing countries. *World Health Stat Q* 44(3)*:*98-106.

12. Bernabe E, Sheiham A, Tsakos G (2008). A comprehensive evaluation of the validity of Child-OIDP: further evidence from Peru. *Community Dent Oral Epidemiol* 36(4)*:*317-325.

13. Bianco A, Fortunato L, Nobile CG, Pavia M (2009). Prevalence and determinants of oral impacts on daily performance: results from a survey among school children in Italy. *Eur J Public Health*.

14. Blay D, Astrom AN, Haugejorden O (2000). Oral hygiene and sugar consumption among urban and rural adolescents in Ghana. *Community Dent Oral Epidemiol* 28(6)*:*443-450.

15. Bratthall D (2000). Introducing the Significant Caries Index together with a proposal for a new global oral health goal for 12-year-olds. *Int Dent J* 50(6)*:*378-384.

16. Bratthall D (2005). Estimation of global DMFT for 12-year-olds in 2004. *Int Dent J* 55(6)*:*370-372.

17. Bratthall D, Hansel Petersson G (2005). Cariogram--a multifactorial risk assessment model for a multifactorial disease. *Community Dent Oral Epidemiol* 33(4)*:*256-264.

18. Burt B, Eklund A (1992). DENTISTRY, DENTAL PRACTICE, AND THE COMMUNITY. Fourth ed.: Saunders Company, Philadelphia.

19. Burt BA, Eklund SA, Morgan KJ, Larkin FE, Guire KE, Brown LO *et al.* (1988). The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. *J Dent Res* 67(11)*:*1422-1429.

20. Burt BA, Pai S (2001). Sugar consumption and caries risk: a systematic review. *J Dent Educ* 65(10)*:*1017-1023.

21. Carlos JP, Gittelsohn AM (1965). Longitudinal studies of the natural history of caries. II. A life-table study of caries incidence in the permanent teeth. *Arch Oral Biol* 10(5)*:*739-751.

22. Carmichael CL, Rugg-Gunn AJ, French AD, Cranage JD (1980). The effect of fluoridation upon the relationship between caries experience and social class in 5-year-old children in Newcastle and Northumberland. *Br Dent J* 149(6)*:*163-167.

23. Castro RA, Cortes MI, Leao AT, Portela MC, Souza IP, Tsakos G *et al.* (2008). Child-OIDP index in Brazil: cross-cultural adaptation and validation. *Health Qual Life Outcomes* 6(68.

24. Chawla HS, Gauba K, Goyal A (2000). Trend of dental caries in children of Chandigarh over the last sixteen years. *J Indian Soc Pedod Prev Dent* 18(1)*:*41-45.

25. Cinar AB (2009). Oral and General Health Promotion for Children: A Holistic Approach: Basics, Concepts, Behavioral Aspects, A Research-based Evidence Saarbrucken: Vdm Verlag

26. Cleaton-Jones P, Fatti P (1999). Dental caries trends in Africa. *Community Dent Oral Epidemiol* 27(5)*:*316-320.

27. Cleaton-Jones P, Fatti P, Bonecker M (2006). Dental caries trends in 5- to 6-year-old and 11- to 13-year-old children in three UNICEF designated regions--Sub Saharan Africa, Middle East and North Africa, Latin America and Caribbean: 1970-2004. *Int Dent J* 56(5)*:*294-300.

28. Cortes Martinicorena FJ, Rosel Gallardo E, Artazcoz Oses J, Bravo M, Tsakos G (2009). Adaptation and validation for Spain of the Child-Oral Impact on Daily Performance (C-OIDP) for use with adolescents. *Med Oral Patol Oral Cir Bucal*.

29. Dowty AM (1982). Oral health of children in southern Sudan. *Community Dent Oral Epidemiol* 10(2)*:*82-85.

30. Edelstein BL (2005). Pediatric caries worldwide: implications for oral hygiene products. *Compend Contin Educ Dent* 26(5 Suppl 1)*:*4-9.

31. El-Nadeef MA, Al Hussani E, Hassab H, Arab IA (2009). National survey of the oral health of 12- and 15-year-old schoolchildren in the United Arab Emirates. *East Mediterr Health J* 15(4)*:*993-1004.

32. Emslie RD (1966). A dental health survey in the Republic of the Sudan. *Br Dent J* 120(4)*:*167-178.

33. Eriksen HM, Dimitrov V (2003). Ecology of oral health: a complexity perspective. *Eur J Oral Sci* 111(4)*:*285-290.

34. Fujiwara T, Sasada E, Mima N, Ooshima T (1991). Caries prevalence and salivary mutans streptococci in 0-2-year-old children of Japan. *Community Dent Oral Epidemiol* 19(3)*:*151-154.

35. Guenther PM, Kott PS, Carriquiry AL (1997). Development of an approach for estimating usual nutrient intake distributions at the population level. *J Nutr* 127(6)*:*1106-1112.

36. Harris R (1963). Biology of the Children of Hopewood House, Bowral, Australia. 4. Observations on Dental-Caries Experience Extending over Five Years (1957-61). *J Dent Res* 42(1387-1399.

37. Harris R, Nicoll AD, Adair PM, Pine CM (2004). Risk factors for dental caries in young children: a systematic review of the literature. *Community Dent Health* 21(1 Suppl)*:*71-85.

38. Hirose H, Hirose K, Isogai E, Miura H, Ueda I (1993). Close association between Streptococcus sobrinus in the saliva of young children and smooth-surface caries increment. *Caries Res* 27(4)*:*292-297.

39. Hobdell MH, Oliveira ER, Bautista R, Myburgh NG, Lalloo R, Narendran S *et al.* (2003). Oral diseases and socio-economic status (SES). *Br Dent J* 194(2)*:*91-96; discussion 88.

40. Ibrahim YE, Ghandour IA, Udani TM (1986). The prevalence of dental caries among urban, semi-urban and rural school children in the Sudan. *Odontostomatol Trop* 9(3)*:*157-162.

41. Ismail AI, Tanzer JM, Dingle JL (1997). Current trends of sugar consumption in developing societies. *Community Dent Oral Epidemiol* 25(6)*:*438-443.

42. Keyes P (1962). Recent advances in dental caries research. Bacteriological findings and biological implications. *Int Dent J* 12)*:*443-464.

43. Kirkwood BR, Sterne JAC (2006). Essential Medical Statistics. 2nd ed.: Blackwell science Ltd.

44. Kleinberg I (2002). A mixed-bacteria ecological approach to understanding the role of the oral bacteria in dental caries causation: an alternative to Streptococcus mutans and the specific-plaque hypothesis. *Crit Rev Oral Biol Med* 13(2)*:*108-125.

45. Krasse B (1985). Caries Risk: A Practical Guide for Assessment and Control: Quintessence Pub Co.

46. Krichevsky MI, Krasse B (1986). Microbiological diagnosis in dental caries and periodontal disease. Considerations and conclusions. *Oral Microbiol Immunol* 1(1)*:*87-90.

47. Lagerlof F, Oliveby A (1994). Caries-protective factors in saliva. *Adv Dent Res* 8(2)*:*229-238.

48. Landis JR, Koch GG (1977). The measurement of observer agreement for categorical data. *Biometrics* 33(1)*:*159-174.

49. Larson JS (2006). The World Health Organization's definition of health: Social versus spiritual health *Social Indicators Research* 38)*:*181-192.

50. Report: Library of Congress – Federal Research Division (2004). COUNTRY PROFILE: SUDAN. www.memory.loc.gov/frd/cs/profiles/Sudan.pdf

51. Levy SM, Warren JJ, Broffitt B, Hillis SL, Kanellis MJ (2003). Fluoride, beverages and dental caries in the primary dentition. *Caries Res* 37(3)*:*157-165.

52. Lim S, Sohn W, Burt BA, Sandretto AM, Kolker JL, Marshall TA *et al.* (2008). Cariogenicity of soft drinks, milk and fruit juice in low-income african-american children: a longitudinal study. *J Am Dent Assoc* 139(7)*:*959-967; quiz 995.

53. Livak KJ, Schmittgen TD (2001). Analysis of relative gene expression data using real-time quantitative PCR and the 2(-Delta Delta C(T)) Method. *Methods* 25(4)*:*402-408.

54. Locker D (2000). Response and nonresponse bias in oral health surveys. *J Public Health Dent* 60(2)*:*72-81.

55. Loe H, Silness J (1963). Periodontal Disease in Pregnancy. I. Prevalence and Severity. *Acta Odontol Scand* 21(533-551.

56. Loesche WJ (1986). Role of Streptococcus mutans in human dental decay. *Microbiol Rev* 50(4)*:*353-380.

57. Loveren Cv (2000). Diet and dental caries: cariogenicity may depend more on oral hygiene using fluorides than on diet or type of carbohydrates. *European Journal of Paediatric Dentistry* 2(55-62.

58. Mandel ID (1987). The functions of saliva. *J Dent Res* 66 Spec No(623-627.

59. Marmot M (1999). Epidemiology of socioeconomic status and health: are determinants within countries the same as between countries? *Ann N Y Acad Sci* 896(16-29.

60. Marsh P, Martin MV (2009). Oral Microbiology. 5th ed.: Edinburgh: Elsevier

61. Marsh PD (2003). Are dental diseases examples of ecological catastrophes? *Microbiology* 149(Pt 2)*:*279-294.

62. McDowell I (2006). Measuring health: a guide to rating scales and questionnaires New York: Oxford University Press.

63. Report from Department of Census and Statistics, Ministry of Education, Khartoum, Sudan.

64. Moller IJ (1966). Clinical criteria for the diagnosis of the incipient carious lesion. *Adv Fluorine Res* 4(67-72.

65. Moser C, Kalton G (1971). Survey methods in social investigation London: Heinemann.

66. Moynihan P, Petersen PE (2004). Diet, nutrition and the prevention of dental diseases. *Public Health Nutr* 7(1A)*:*201-226.

67. Moynihan PJ, Holt RD (1996). The national diet and nutrition survey of 1.5 to 4.5 year old children: summary of the findings of the dental survey. *Br Dent J* 181(9)*:*328-332.

68. Mtaya M, Astrom AN, Tsakos G (2007). Applicability of an abbreviated version of the Child-OIDP inventory among primary schoolchildren in Tanzania. *Health Qual Life Outcomes* 5(40.

69. Mundorff SA, Featherstone JD, Bibby BG, Curzon ME, Eisenberg AD, Espeland MA (1990). Cariogenic potential of foods. I. Caries in the rat model. *Caries Res* 24(5)*:*344-355.

70. Narvai PC, Frazao P, Roncalli AG, Antunes JL (2006). [Dental caries in Brazil: decline, polarization, inequality and social exclusion]. *Rev Panam Salud Publica* 19(6)*:*385-393.

71. Nelson M, Black AE, Morris JA, Cole TJ (1989). Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *Am J Clin Nutr* 50(1)*:*155-167.

72. Nicolau B, Marcenes W, Bartley M, Sheiham A (2003). A life course approach to assessing causes of dental caries experience: the relationship between biological, behavioural, socio-economic and psychological conditions and caries in adolescents. *Caries Res* 37(5)*:*319-326.

73. Editorial. Oral health: prevention is key. (2009). *Lancet* 373(9657)*:*1.

74. Peres MA, Barros AJ, Peres KG, Araujo CL, Menezes AM (2009). Life course dental caries determinants and predictors in children aged 12 years: a population-based birth cohort. *Community Dent Oral Epidemiol* 37(2)*:*123-133.

75. Petersen PE (2003). The World Oral Health Report 2003: continuous improvement of oral health in the 21st century--the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol* 31 Suppl 1(3-23.

76. Petersen PE (2005). Sociobehavioural risk factors in dental caries - international perspectives. *Community Dent Oral Epidemiol* 33(4)*:*274-279.

77. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C (2005). The global burden of oral diseases and risks to oral health. *Bull World Health Organ* 83(9)*:*661-669.

78. Petersson GH, Isberg PE, Twetman S (2010). Caries risk assessment in school children using a reduced Cariogram model without saliva tests. *BMC Oral Health*.10:5.

79. Rose G (1993). The strategy of preventive medicine. 2nd edn ed.: Oxford University Press.

80. Rozier RG (1994). Epidemiologic indices for measuring the clinical manifestations of dental fluorosis: overview and critique. *Adv Dent Res* 8(1)*:*39-55.

81. Rugg-Gunn AJ, Hackett AF (1993). Nutrition and dental health. Oxford: Oxford University Press.

82. Raadal M, Elhassan FE, Rasmussen P (1993). The prevalence of caries in groups of children aged 4-5 and 7-8 years in Khartoum, Sudan. *Int J Paediatr Dent* 3(1)*:*9-15.

83. Sackett DL (1979). Bias in analytic research. *J Chronic Dis* 32(1-2)*:*51-63.

84. Schwartz S, Susser E, Susser M (1999). A future for epidemiology? *Annu Rev Public Health* 20(15-33.

85. Silness J, Loe H (1964). Periodontal Disease in Pregnancy. Ii. Correlation between Oral Hygiene and Periodontal Condtion. *Acta Odontol Scand* 22(121-135.

86. Sohn W, Burt BA, Sowers MR (2006). Carbonated soft drinks and dental caries in the primary dentition. *J Dent Res* 85(3)*:*262-266.

87. Sreebny LM (1982). Sugar availability, sugar consumption and dental caries. *Community Dent Oral Epidemiol* 10(1)*:*1-7.

88. Tahmassebi JF, Duggal MS, Malik-Kotru G, Curzon ME (2006). Soft drinks and dental health: a review of the current literature. *J Dent* 34(1)*:*2-11.

89. Tang J, Yu Y, Ma Y (2005). The epidemic tendency of dental caries prevalence of school students from 1991 to 2005 in China. *J Huazhong Univ Sci Technolog Med Sci* 30(1)*:*132-137.

90. Tubert-Jeannin S, Pegon-Machat E, Gremeau-Richard C, Lecuyer MM, Tsakos G (2005). Validation of a French version of the Child-OIDP index. *Eur J Oral Sci* 113(5)*:*355-362.

91. Van Houte J (1993). Microbiological predictors of caries risk. *Adv Dent Res* 7(2)*:*87-96.

92. Vyas S, Kumaranayake L (2006). Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan* 21(6)*:*459-468.

93. Watt RG (2007). From victim blaming to upstream action: tackling the social determinants of oral health inequalities. *Community Dent Oral Epidemiol* 35(1)*:*1-11.

94. WHO (2006) Health System Profile-Sudan: Summary of Recent and planned reforms. Regional Health Systems Observatory- EMRO, pp. 50-52.

95. WHO (1997). Oral health surveys. Basic methods.

96. WHO (2002). Global Oral Health Data Bank: Geneva: World Heath Organization.

97. WHO Oral Health Country/Area Profile Programme (2007).

98. Woodward M, Walker AR (1994). Sugar consumption and dental caries: evidence from 90 countries. *Br Dent J* 176(8)*:*297-302.

99. Yoshida A, Suzuki N, Nakano Y, Kawada M, Oho T, Koga T (2003). Development of a 5' nuclease-based real-time PCR assay for quantitative detection of cariogenic dental pathogens Streptococcus mutans and Streptococcus sobrinus. *J Clin Microbiol* 41(9)*:*4438-4441.

100. Yousif MA, Miskeen E (2009). Dental Health Service in Gezira Locality, Sudan. *Sudanese Journal of Public Health* 4(3)*:*325-330.

101. Yusuf H, Gherunpong S, Sheiham A, Tsakos G (2006). Validation of an English version of the Child-OIDP index, an oral health-related quality of life measure for children. *Health Qual Life Outcomes* 4(38.

102. Zhang Q, van Palenstein Helderman W, Yee R, Bian Z, Fan M, Holmgren C (2008). Situational analysis of dental caries and existing oral health care of children and adolescents in Hubei Province, People's Republic of China: implications for change. *Oral Health Prev Dent* 6(1)*:*13-21.

7 APPENDICES

APPENDIX 1
CLINICAL EXAMINATION ASSESSMENT SHEET

Date: ____/____/____

Site Code:_____ School: _____

Name: _____ Class: _____

1. School Details

1 ☐ Public
2 ☐ Private

2. Gender

1 ☐ Male
2 ☐ Female

3. Age in years (at last birthday)

_____

4: Tick if saliva sample was taken: _____

5. Place where you grew up

1 ☐ Always stayed in this city / village
2 ☐ Lived in other place

6. Body Mass index	Weight: _____ kg Height _____ m
7. Dentition status; total number of teeth	_____in upper jaw / _____ in lower

Upper right								***Upper left***							
	7	6	5 E	14 D	13 C	12 B	11 A	1 A	2 B	3 C	4 D	5 E	6	7	
	7	6	E 5	D 4	C 3	B 2	A 1	A 1	B 2	C 3	D 4	E 5	6	7	
Lower right								***Lower left***							

RED is permanent tooth, BLUE is deciduous tooth
0-Sound, 1-Decayed, 2-Filled, with decay, 3-Filled, no decay, 4-Missing due to caries, 5-Missing for other reason, 6-Fissure sealant, 7-Bridge abutment, special crown or veneer/implant, 8-Unerupted tooth (crown)/unexposed root, T-Trauma

8. **Gingival Index**:

Upper right								*Upper left*							
	7	6	5 E	14 D	13 C	12 B	11 A	1 A	2 B	3 C	4 D	5 E	6	7	
	7	6	E 5	D 4	C 3	B 2	A 1	A 1	B 2	C 3	D 4	E 5	6	7	
Lower right								*Lower left*							

RED is permanent tooth, BLUE is deciduous tooth
0–Normal gingiva, 1– Mild inflammation, 2- Moderate inflammation, 3– Severe inflammation

9. **Plaque Index**:

Upper right								*Upper left*							
	7	6	5 E	14 D	13 C	12 B	11 A	1 A	2 B	3 C	4 D	5 E	6	7	
	7	6	E 5	D 4	C 3	B 2	A 1	A 1	B 2	C 3	D 4	E 5	6	7	
Lower right								*Lower left*							

RED is permanent tooth, BLUE is deciduous tooth
0–No plaque, 1–A film of plaque, 2-Moderate accumulation of plaque, 3–Abundance of plaque

10. Sign of fluorosis on anterior teeth:

1 ☐ No
2 ☐ Questionable
3 ☐ Very mild
4 ☐ Mild
5 ☐ Moderate
6 ☐ Severe

APPENDIX 2
PERSONAL INFORMATION

City Code:_____

Name: _____

School: _____

Class: _____

1. Sex

1 ☐ Boy
2 ☐ Girl

2. Place where you grew up

1 ☐ Always stayed in this city / village
2 ☐ Lived in other places

3.Tribe: ……

4. Where do you live now?

1 ☐ Home
2 ☐ Hostel

5. In case you live in a home: who do you live with?

1 ☐ My parent(s)
2 ☐ Uncle/aunt
3 ☐ Grandparent(s)
4 ☐ Other(s)

6. At what level did your mother finish her full time education? (Please tick one only)

1 ☐ Primary school
2 ☐ Secondary school
3 ☐ Further education (college)
4 ☐ Higher education (university/higher learning institution)
5 ☐ No formal education
6 ☐ Other (please specify)
……
7 ☐ Khalwa
8 ☐ Other

7. What kind of work does your mother do?

1 ☐ House wife
2 ☐ Teacher
3 ☐ Government official
4 ☐ Other (please specify)

8. At what level did your father finish his full time education? (Please tick one only)

1 ☐ Primary school
2 ☐ Secondary school
3 ☐ Further education (college)
4 ☐ Higher education (university/higher learning institution)
5 ☐ No formal education
6 ☐ Other (please specify)

……
7 ☐ I don't know

9. What kind of work does your father do?

…….....

10. In case you live in a home: who owns the house your family is living in at the moment? (Please tick one only)

1 ☐ Rented house
2 ☐ Owned by the family

3 ☐ Owned by the government
4 ☐ Owned by my employers
5 ☐ I don't live in a home (go to Q18)
6 ☐ I don't know

11. How many bedrooms does the house you are living in have? (Please tick one only)

1 ☐ 1
2 ☐ 2
3 ☐ 3
4 ☐ 4
5 ☐ More than 4

12. Does any member of your family (with whom you live) own a television?

1 ☐ Yes
2 ☐ No

13. What source of energy do you use for lighting the house at night? (Please tick one box)

1 ☐ Electricity
2 ☐ Paraffin lamp
3 ☐ Gas light
4 ☐ Candle light
5 ☐ Other (Please specify)
……
14. What source of energy do you use in the home for cooking? (Please tick one box)

1 ☐ Electricity
2 ☐ Gas
3 ☐ Paraffin
4 ☐ Charcoal
5 ☐ Firewood
6 ☐ Other (Please specify)
……

15. How many children are living in your house now? (Please tick one box)

1 ☐ 1
2 ☐ 2
3 ☐ 3
4 ☐ More than 3
16. Are you living in an extended family?

1 ☐ yes
2 ☐ no

17. What is your birth order?

……
18. Do you have a refrigerator at home?

II The following are questions about your mouth and teeth. Please tick (☐) only one answer for each question

Oral health awareness

1. What do you think is the state of your mouth and teeth?

1 ☐ Very good
2 ☐ Satisfied
3 ☐ Dissatisfied
4 ☐ Very dissatisfied

2. Are you satisfied with the appearance of your teeth?

1 ☐ Very good
2 ☐ Satisfied
3 ☐ Dissatisfied
4 ☐ Very dissatisfied

Dental experience

3. Have you visited a dentist before or sought professional dental treatment?

1 ☐ Yes
2 ☐ No

4. Why do you visit a dental clinic?

1 ☐ Regular follow-ups
2 ☐ When I experience dental pain
3 ☐ Others

5. What form of treatment have you received before in the dental clinic?

1 ☐ Filling
2 ☐ Fissure sealant
3 ☐ Extraction
4 ☐ Orthodontic treatment
5 ☐ Space maintainer
6 ☐ Other

6. What do you do if you have a complaint from your teeth?

1 ☐ Visit a primary health care centre
2 ☐ Visit a private clinic
3 ☐ Visit a governmental dental hospital
4 ☐ Visit the closest dental unit

5 ☐ Use home medication
6 ☐ Other

Oral hygiene habits

7. Do you brush your teeth?

1 ☐ Yes
2 ☐ No

8. If you brush your teeth everyday, how many times do you brush your teeth in one day?

1 ☐ Once
2 ☐ Twice
3 ☐ Three times
4 ☐ Other / please specify
…….

9. If you brush your teeth, but not everyday, please tick how often

1 ☐ Once every two days
2 ☐ Once every three days
3 ☐ Once a week
4 ☐ Irregularly
5 ☐ Other

10. If you brush your teeth, at what time of the day?

1 ☐ Morning
2 ☐ Afternoon
3 ☐ before going to bed
4 ☐ Other / please specify
…….

11. Why do you brush your teeth?

1 ☐ To keep them clean
2 ☐ So my mouth can smell good
3 ☐ To prevent dental disease
4 ☐ Because everyone else brush their teeth
5 ☐ Other / please specify
……

12. What do you use to brush your teeth?

1 ☐ My own toothbrush
2 ☐ Any toothbrush
3 ☐ Miswak
4 ☐ Other / please specify
…….

13. What do you use when you brush your teeth?

1 ☐ Only water
2 ☐ water and toothpaste
3 ☐ water and other / please specify
……

14. What is your habit after finishing meals?

1 ☐ Rinse my mouth with water
2 ☐ Rinse my mouth with water and soap
3 ☐ Brush my teeth
4 ☐ Other / please specify

15. Do you floss your teeth?

1 ☐ Yes
2 ☐ No

16. If no, why?

1 ☐ I have never heard of flossing
2 ☐ No access to dental floss
3 ☐ I do not feel it is important
4 ☐ I do not know how to floss
5 ☐ Other / please specify
……..

17 Have you noticed if any of your close friends has bad teeth?

17. Do your parents follow up your tooth brushing habits ?

1 ☐ All the time
2 ☐ Sometimes
3 ☐ Never
4 ☐ Other ……..

APPENDIX 3
FOOD FREQUENCY QUESTIONNAIRE

City Code:_____
Name: _____
School: _____
Class: _____

We would like to ask you how often you usually take sugared snacks and drinks. Please tick (☐) only one answer for each question

1. How often do you eat sweet biscuits?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

2. How often do you eat chocolates?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

3. How often do you have ice sticks?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

4. How often do you have soft drinks (pepsi, coco cola etc)?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

5. How often do you take sugared tea?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

6. How often do you take sugared coffee?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

7. How often do you eat sweetened fruits / desserts?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

8. How often do you take sweets like candies, toffees, chewing gums etc.)?

1 ☐ More than one time a day
2 ☐ Once a day
3 ☐ 3-5 times a week
4 ☐ Less than three times a week

APPENDIX 4
FOOD BEHAVIOUR CHECKLIST

APPENDIX 4
ID NO. ……..

Date: __/___/____
City Code:_____

Name: _____

School: _____

Class: _____

Teacher : _____

Contact Details: _____

Day Number : 1___ 2____ 3_____

Did you consume any of the below items yesterday?

Sweet Biscuits: Yes ☐ No ☐

Chocolates: Yes ☐ No ☐

Soft drinks: Yes ☐ No ☐

Sweetened hot beverages: Yes ☐ No ☐

Sweets: Yes ☐ No ☐

Popsicles: Yes ☐ No ☐

Dessert: Yes ☐ No ☐

APPENDIX 5
CHILD OIDP – English version
Name .....
I.D. No. .....Class .....School.....

In the past three months (months:.....……..., …..……..., ….....)
Have you had any problem with your mouth or teeth?

Put for problem (s) you have had including those that are present and those that are no longer present.

☐ toothache 1
☐ sensitive tooth 2
☐ tooth decay, hole in tooth 3
☐ exfoliating primary tooth 4
☐ tooth space (due to an non-erupted permanent tooth) 5
☐ fractured permanent tooth 6
☐ colour of tooth 7
☐ shape or size of tooth 8
☐ position of tooth (e.g. crooked or projecting, gap) 9

☐ bleeding gum 10
☐ swollen gum 11
☐ calculus 12

☐ oral ulcers 13
☐ bad breath 14
☐ deformity of mouth or face (e.g. cleft lip, cleft palate) 15
☐ erupting permanent tooth 16
☐ missing permanent tooth 17

☐ other (specify)……. 99

Step 2: Assessing oral impacts on children.s quality of life.
From your answer sheet that covers the mouth/tooth problems you have had during the past three months, I would like to further know how they have affected your daily living.
1) In the past three months, has any of them caused you any difficulty in (performance)?
*(Please ask the question for each performance in the record form. If for a performance the answer is **NO**, then score 0 in both the severity and the frequency boxes for this performance and*
*move to the next performance. If the answer is **YES**, then please ask the three following questions for each performance.)*
2) Severity
I am going to ask you about the severity of this problem when it happened. Look at the scale from 1 to 3 below. The severity of the difficulty increases from the left side to the right side of the scale. Which number would you say reflects the effect that the difficulty in (performance) had on your daily life?

1	2	3
little effect	moderate effect	severe effect

3) Frequency
How often, on average, have you had this difficulty?
- Once or twice a month **1**
- Three or more times a month, or once or twice a week.....**2**
- Three or more times a week.....**3**

4) Perceived impairment(s)
According to problems of your mouth/ teeth (from Step 1), can you specify which of them are the causes of the difficulty in (performance)?
(select answer(s) from the list of oral problems completed in Step 1)

Child-OIDP record form

Performance	Severity	Frequency	Impairment (s)
Eating food(e.g. meal, ice-cream)			
Speaking clearly			
Cleaning your mouth (e.g. rinsing your mouth, brushing your teeth)			
Relaxing (including sleeping)			
Maintaining your usual emotional state without being irritable			
Smiling, laughing and showing your teeth without embarrassment			
Carrying out your schoolwork (e.g. going to school, learning in class, doing homework)			
Contact with people (e.g. going out with friend, going to a friend's house)			

CHILD OIDP – Arabic version

Name .....
I.D. No. .....Class .....School.....

الخطوة 1 :
في الأشهر الثلاثة الماضية (أشهر :.....،..... .....)
هل كان لديك أي مشكلة في فمك أو أسنانك؟

ضع علامة امام المشاكل التي تعاني منها الان او كنت تعاني منها في الماضي

1	الام الاسنان ☐
2	الاسنان الحساسة ☐
3	تسوس او نخور الاسنان ☐
4	الاسنان اللبنية الايلة للسقوط ☐
5	فراغ بين الاسنان بسبب سن دائم مفقود لم ينمو ☐
6	سن دائم مكسور ☐
7	لون الاسنان ☐
8	شكل او حجم الاسنان ☐
9	ترتيب او رص الاسنان ☐
10	نزيف في اللثة ☐
11	تضخم او تورم في اللثة ☐
12	مواد جيرية ☐
13	تقرحات في اللثة ☐
14	رائحة فم كريهة ☐
15	تغير خلقي او تشوه في شكل الوجه او الفم ☐
16	اندلاع او نمو الأسنان الدائمة ☐
17	سن دائم مفقود ☐
99	مشاكل اخرى ☐.....

الخطوة 2 : تقييم الآثار
أود أن أعرف كيف أثرت المشاكل التي ذكرتها قبل قليل على المعيشة اليومية.

ساذكر بعض الاداء اليومية واود منك ان تخبرني اذا في الأشهر الثلاثة الماضية
اولا: تسببت مشكلة في الفم او الاسنان في تصعيب اداء تلك المهمة
ثانيا: اذا كانت الاجابة بنعم ارجو ان تحدد مدى خطورة تلك المشكلة. اختر احد الاجابات التالية
تأثير بسيط 1
تأثير متوسط 2
تأثير شديد 3
ثالثا: كيف كان تردد هذه المشكلة :
-- مرة أو مرتين في الشهر..... 1
-- ثلاث مرات أو أكثر في الشهر ، أو مرة أو مرتين في الأسبوع..... 2
-- ثلاث مرات أو أكثر في الأسبوع..... 3
رابعا: ارجو ان تذكر مشاكل الفم والاسنان (من القائمة السابقة) التي تسببت في صعوبة تادية هذا الاداء اليومي
.....

الاداء اليومية	الخطورة	التردد	المشاكل المصاحبة
الاكل			
الكلام			
تنظيف الفم والاسنان			
الاسترخاء والنوم			
الحفاظ على الحالة العاطفية المعتادة دون تعكر في المزاج			
التبسم			
اداء العمل المدرسي(الذهاب الى المدرسة, التعلم في الصف, اداء الوظائف المدرسية في المن			
التعامل مع الناس (الخروج مع الاصدقاء, وزيارة الاصدقاء)			

8 ORIGINAL PUBLICATIONS