



**The association between dental caries and
anthropometric measures in 5-9-year-old Bangladeshi
children.**

Masuma Pervin Mishu

Thesis submitted for the degree of Doctor of Philosophy

Department of Epidemiology and Public Health

University College London

2018

I, Masuma Pervin Mishu confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

Background: Dental caries is the most common childhood disease worldwide. Previous research on the associations between dental caries and height, weight and body-mass-index (BMI) among children has produced inconsistent results. Dental caries also has a negative impact on oral health related quality of life (OHRQoL) in children. However, the precise nature and underlying mechanism of this relationship is yet to be fully investigated. Thus the PhD thesis aimed to assess the associations between dental caries and anthropometric measures (height, weight and BMI) among 5-9-year-old Bangladeshi children. A secondary aim was to examine whether any associations between dental caries and anthropometric measurements were explained by OHRQoL, in particular dental pain, eating difficulty, poor appetite and sleep disturbance.

Methods: A cross sectional observational study was conducted among 5-9-year-old children in Dhaka, Bangladesh. Data were collected from children and their parents from Dhaka Dental College Hospital and from three nearby primary schools. Multiple linear regression analysis was used to assess the associations of interest, adjusted for potential covariates.

Results: The final sample comprised 788 children. Dental caries and sepsis showed negative associations with height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ) and BMI-for-age z-scores (BAZ) after adjusting for all confounders. Children who had higher level of caries and sepsis had lower HAZ, WAZ and BAZ compared to caries and sepsis free children. Adjusting

for OHRQoL led to significant attenuation on associations between dental caries, sepsis and anthropometric outcomes. Moreover, OHRQoL showed significant inverse association with weight-for-age and BMI-for-age but not with height-for-age. Finally, amongst all potential mediators, adjusting for dental pain and eating difficulty led to significant attenuation on these associations. Therefore, dental pain and eating difficulty might be considered to partly explain the inverse associations. However, only eating difficulty showed significant inverse association with weight-for-age and BMI-for-age but not with height-for-age. Thus OHRQoL particularly eating difficulty might be considered on the hypothesized pathway of negative associations between dental caries, sepsis and weight-for-age and BMI-for-age.

Conclusion: The results of this study provide evidence that dental caries was associated with lower height, weight and BMI among the study population. Secondly, OHRQoL particularly dental pain and eating difficulty partly explained the negative association.

Acknowledgements

I am sincerely grateful to my primary supervisor Professor Richard Watt for his help, scholastic guidance and encouragement. I am thankful to my secondary supervisor, Dr. George Tsakos for his encouraging and thoughtful support particularly with methodological and statistical matters. I am also grateful to my tertiary supervisor Dr. Anja Heilmann for her wonderful dedicated supervision, particularly for her detailed comments to improve every details of my thesis. I am thankful to all of my supervisors for giving their precious time and for their insightful comments and suggestion. I can humbly utter that without the instruction, support and co-operation of three of my supervisors this research work would not have been possible.

I am so honored to have Professor Aubrey Sheiham as one of my supervisors for the first two years of my PhD and am deeply sad for his death. His loss could never be filled. He inspired me in dental public health. I am deeply grateful to him for sharing his wealth of knowledge and experience, and creative suggestions and encouragement. I am also thankful to Dr.Hynek Pikhart and Dr.Paola Zaninotto for their support to build my statistical concept.

My special thanks go to my daughter Fariha Zahin Nehlin for giving me immense support to complete my hard PhD journey. I am thankful to my parents Mr.Mohiuddin and Mrs. Farida Mohiuddin, my brother Mahdi, other family members, relatives and friends for being my source of inspiration. I would also like to thank to Commonwealth Scholarship Commission (CSC) for funding my PhD and all the members of the survey team and people in Bangladesh who were involved in the study, as well as all the children and their parents who participated in the study.

Last but not least I would like to offer my sincere thanks to all the fellow colleagues in the Department of Epidemiology and Public Health, especially Dental Public Health Group at UCL who made these years enjoyable and supportive and to the concerned officials/staff for their amazing and lively assistance.

Table of contents

Chapter 1	Introduction.....	21
Chapter 2	Literature review	25
2.1	Dental caries in children	27
2.2	Overview of child growth.....	29
2.2.1	Stages of growth.....	29
2.2.2	Factors influencing growth.....	30
2.2.3	Growth failure or failure to thrive (FTT).....	31
2.2.4	Catch-up growth	32
2.2.5	Growth assessment.....	32
2.3	Study context: dental caries and child growth in Bangladesh	34
2.4	Dental caries and child growth: Evidence from systematic reviews	35
2.5	Empirical studies on associations between dental caries and anthropometric measures of children	41
2.5.1	Studies reporting negative associations between caries and height, weight and BMI	41
2.5.2	Studies reporting no associations between caries and BMI ...	48

2.5.3	Studies reporting positive associations between caries and BMI	50
2.6	Possible explanations for inconsistent associations between caries and height, weight and BMI	53
2.7	Potential explanations on how dental caries could adversely affect child's height and weight	55
2.7.1	Dental caries and oral health related quality of life (OHRQoL)	55
2.7.2	Dental caries and dental pain	63
2.7.3	Dental caries and eating difficulty	65
2.7.4	Dental caries and poor appetite.....	68
2.7.5	Dental caries and Sleep disturbance	68
2.8	Effect of dental treatment on children's quality of life and body weight.....	71
2.8.1	Improved OHRQoL after dental treatment.....	71
2.8.2	Weight gain after dental treatment.....	72
2.9	Theoretical model of hypothesised mechanisms for how caries could affect children's height and weight	74
2.10	Summary and gaps in current knowledge.....	76

2.11	Study aim, objectives and hypotheses.....	77
Chapter 3	Methodology.....	79
3.1	Study location	80
3.2	Study design and sampling.....	82
3.2.1	Sample selection	82
3.2.2	Inclusion/exclusion criteria.....	84
3.3	Ethical approval	84
3.4	Pilot study.....	85
3.4.1	Objectives of the pilot study.....	85
3.4.2	Results of the pilot study	85
3.5	Calculation of the final sample size	86
3.6	Data collection	87
3.6.1	Developing contacts with hospital and school staff.....	88
3.6.2	Recruitment of field investigators.....	89
3.6.3	Recruitment of study population	91
3.6.4	Collection of clinical data	92

3.6.5	Collection of non-clinical data.....	93
3.7	Study measures.....	97
3.7.1	Outcome variables.....	98
3.7.2	Exposures: dental caries and dental sepsis	100
3.7.3	Potential mediators.....	103
3.7.4	Confounders	107
3.8	Data entry and cleaning.....	112
3.9	Data analysis plan	114
3.9.1	Descriptive statistics	114
3.9.2	Bivariate analyses	114
3.9.3	Regression modelling strategy	116
3.9.4	Linear regression models	118
Chapter 4	Results – Psychometric properties of the Bengali version of SOHO-5	121
4.1	Construct validity	122
4.1.1	Convergent validity	123

4.1.2	Discriminant validity	125
4.2	Reliability analysis	126
4.2.1	Internal consistency	126
4.2.2	Test-retest reliability	128
Chapter 5	Results - Main study	129
5.1	Description of the study sample	130
5.1.1	Response rate for the school sample	130
5.1.2	Response rate for the hospital sample	131
5.1.3	Anthropometric outcomes	135
5.1.4	Prevalence of clinical exposures: dental caries and dental sepsis	136
5.1.5	Distribution of potential mediators	140
5.2	Anthropometric outcomes, by exposures and covariates	145
5.2.1	Anthropometric outcomes, by dental caries and sepsis	145
5.2.2	Anthropometric outcomes by setting and demographic variables	147

5.2.3	Anthropometric outcomes by markers of early childhood health and nutritional status.....	151
5.2.4	Anthropometric outcomes by potential mediators.....	153
5.3	Clinical exposures (dental caries and sepsis) by covariates.....	155
5.3.1	Dental caries and sepsis by socio-demographic variables ...	155
5.3.2	Dental caries and sepsis by markers of early childhood health and nutritional status.....	158
5.3.3	Distribution of potential mediators by clinical exposure groups	159
5.4	Results of linear regression models.....	162
5.4.1	Testing the association between dental caries and sepsis and anthropometric outcomes and testing the effect of SOHO-5 on this association.....	162
5.4.2	Testing the effect of dental pain, eating difficulty, reduced appetite and sleep disturbance on the association between dental caries / sepsis, and anthropometric outcomes	183
5.5	Sensitivity analyses	202
Chapter 6	Discussion	206

6.1	Overview of key findings.....	207
6.1.1	Association between dental caries and anthropometric outcomes	208
6.1.2	Testing the relative role of potential mediators	208
6.2	Final proposed frame work of the association	211
6.3	Comparisons with previous research.....	212
6.3.1	Comparison with studies reporting similar findings.....	212
6.3.2	Comparing studies with dis-similar pattern of association between dental caries and anthropometric measures.	216
6.4	Underlying factors of a negative association between dental caries and anthropometric outcomes	220
6.5	Strengths and limitations of this study	224
6.5.1	Strengths.....	224
6.5.2	Limitations of the study.....	227
6.6	Recommendations.....	231
6.6.1	Implications for future research	231
6.6.2	Policy implications	232

6.7	Concluding remarks.....	235
	References.....	237
	Appendices	276
Appendix 1	Table for systematic review	277
Appendix 2	Ethical approval and Permission letters.....	281
Appendix 3	Information sheets and consent forms.....	290
Appendix 4	Pilot study.....	302
Appendix 5	Questionnaire used for the main study	328
Appendix 6	Sample size calculation	364
Appendix 7	Training and Calibration	367
Appendix 8	The procedure of clinical dental examination	372
Appendix 9	Procedure of anthropometric measurement	376
Appendix 10	Validity and reliability of the Bengali SOHO-5.....	379
Appendix 11	Sleep disturbance	385
Appendix 12	Sensitivity analysis.....	387
Appendix 13	Correlation coefficients matrix.....	394

Appendix 14	Photo Glossary of the survey	397
Appendix 15	Miscellaneous	401

List of Tables

Table 3.1 Summary of variables measured in questionnaires	95
Table 3.2 Categories of family socio-economic variables	109
Table 3.3 Summary of measures used for the regression modelling	117
Table 4.1 Children's SOHO-5 scores, by subjective indicators of oral health.	124
Table 4.2 Children's SOHO-5 scores, by dental caries and dental sepsis groups.....	125
Table 4.3 Internal consistency of SOHO-5: inter-item correlation matrix ...	126
Table 4.4 Internal consistency reliability of children's OHRQoL: Item total correlation coefficients and Cronbach's Alpha	127
Table 5.1 Socio-demographic and early childhood characteristics of study sample, by setting (max. N=788)	133
Table 5.2 Mean z-scores of anthropometric outcomes: WAZ, HAZ and BAZ of study sample, by setting (max. N=788).....	135
Table 5.3 Frequency of clinical exposures: dental caries and dental sepsis of study sample, by setting (max. N=788).....	137
Table 5.4 Dental caries and sepsis groups, by setting and in overall sample (max. N = 788)	139
Table 5.5 Frequency of SOHO-5 items and dental pain (child and parent reported) (max. N = 788).....	141
Table 5.6 Frequency of eating difficulty, appetite, and Sleep disturbance in children (max. N= 725).....	143
Table 5.7 prevalence of potential mediators by setting (max. N=788)	144

Table 5.8 Association between anthropometric outcomes (HAZ, WAZ and BAZ) with clinical exposure groups (max. N=788)	147
Table 5.9 Association between anthropometric outcomes (HAZ, WAZ and BAZ) with socio-demographic variables (max. N = 788)	148
Table 5.10 Anthropometric outcomes (HAZ, WAZ and BAZ) by the marker of early childhood health and nutritional status (max. N=723)	151
Table 5.11 Anthropometric outcomes (HAZ, WAZ and BAZ) by potential mediators (max. N=788)	153
Table 5.12 Frequency of dental caries and sepsis, by socio-demographic variables (max. N=788).....	156
Table 5.13 Frequency of dental caries and sepsis by the marker of early childhood health and nutritional status (max. N=723)	158
Table 5.14 Distribution of potential mediators, by clinical exposure groups	160
Table 5.15 Results of multiple linear regression models testing the association of dental caries and HAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	166
Table 5.16 Results of multiple linear regression models testing the association of dental sepsis and HAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	168
Table 5.17 Results of multiple linear regression models testing the association of dental caries and WAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	172
Table 5.18 Results of multiple linear regression models testing the association of dental sepsis and WAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	174

Table 5.19 Results of multiple linear regression models testing the association of dental caries and BAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	178
Table 5.20 Results of multiple linear regression models testing the association of dental sepsis and BAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)	180
Table 5.21 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental caries and HAZ: presented as Regression coefficient (95% CI)(N= 715).....	185
Table 5.22 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and HAZ: presented as Regression coefficient (95% CI)(N= 715).....	187
Table 5.23 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental caries and WAZ: presented as Regression coefficient (95% CI)(N= 715).....	191
Table 5.24 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and WAZ: presented as Regression coefficient (95% CI)(N= 715).....	193
Table 5.25 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the	

association of dental caries and BAZ: presented as Regression coefficient (95% CI)(N= 715).....	197
--	-----

Table 5.26 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and BAZ: presented as Regression coefficient (95% CI)(N= 715).....	199
--	-----

List of Figures

Figure 2-1 Important domains of OHRQoL	56
Figure 2-2 Hypothesised mechanisms linking dental caries to children's height and weight.....	75
Figure 3-1 Study location: Dhaka, capital city of Bangladesh	81
Figure 3-2 Types of data collected from the study participants	88
Figure 3-3 Histogram of the distribution (percent) of anthropometric outcomes: HAZ, WAZ and BAZ in the study population (N=788).....	99
Figure 3-4 Histogram of the distribution (percent) of dental caries and sepsis in the study population (N=788)	101
Figure 3-5 Dental caries groups, by setting and in overall sample (N=788)	102
Figure 3-6 dental sepsis groups (dichotomized), by setting and in overall sample (N=788)	102
Figure 3-7 Histogram of distribution (percent) of child reported SOHO-5 scores (N=788)	103
Figure 3-8 Analytical framework of the study	113
Figure 5-1 Flow chart of study participants	131
Figure 5-2 Bivariate association of anthropometric outcomes with dental caries groups.	145
Figure 5-3 Bivariate association of anthropometric outcomes with dental sepsis groups.....	146
Figure 6-1 Final proposed framework of association	211

Acronyms

AAPD- American academy of paediatric dentistry

BMI- Body Mass Index

BAZ- BMI-for-age z-score

CPQ- Child Perception Questionnaire

DMFT- Decayed, Missing Filled Tooth

DMFS- Decayed, Missing Filled Surface

ECOHIS- Early Childhood Oral Health Impact Scale

FTT- Failure to Thrive

HAZ- Height-for-age z-score

ICDAS- International Caries Detection and Assessment System

LMICs- low and middle-income countries

OHRQoL- Oral Health Related Quality of Life

OIDP- Oral Impact on Daily Performance

PPQ- Parental Perceptions Questionnaire

PUFA- Pulp, Ulceration, Fistula, Abscess

RCT- Randomized Control Trial

SD- Standard Deviation

SOHO-5- Scale of Oral Health Outcomes for 5-year-old children

WAZ- Weight-for-age z-score

WHO- World Health Organization

Chapter 1 Introduction

Chapter 1 Introduction

Dental caries is one of the most common childhood diseases worldwide (Petersen 2003; Selwitz et al. 2007; Marcenes et al. 2013; Fung et al. 2013). It is a major public health problem, affecting 60%-90% of children globally with particularly high prevalence among children from poorer and disadvantaged backgrounds (Petersen et al. 2005; Edelstein 2006; Bagramian et al. 2009). In most of the low and middle-income countries (LMICs) dental caries is prevalent and more than 90% of decay remains untreated (WHO 2003; Moynihan & Petersen 2004). According to the World Health Organization (WHO), growth failure and childhood malnutrition are also important public health concerns in those countries (WHO 2014).

In high-income countries, there has been an increasing interest in the association between dental caries and higher body mass index (BMI) among children as the causes of dental caries and higher BMI are similar, namely, high sugar consumption (Swinburn et al. 2004; Moynihan & Petersen 2004). However, the direction of the association between dental caries and BMI appears to be context-specific. A systematic review reported three main patterns of relationships between dental caries and BMI: no association, a positive relationship and an inverse relationship (Hooley et al. 2012). Those studies finding a positive association between dental caries and BMI were mostly from high-income countries whereas the studies that found an inverse association were mostly from LMICs. Another systematic review and meta-analysis reported a significant relationship between obesity and dental caries in children, although this finding was significant for studies from high-income

countries only (described in the review as industrialized countries) and the association was moderated by socio-economic status, caries status and age of the child (Hayden et al. 2013). Findings from LMICs indicate that there is an inverse relationship between caries and height, weight and BMI of young children (Alkarimi et al. 2014; Mishu et al. 2013; Benzian et al. 2011). Findings on the relationship between caries and height, weight and BMI are also inconsistent due to variability among studies in defining caries and use of non-standardized BMI cut off points (Kantovitz et al. 2006; Hooley 2014).

Research has also examined longitudinal relationships between dental caries and child growth (Alkarimi et al. 2012; Monse et al. 2012). Several studies have shown that untreated caries may negatively affect child growth (Acs et al. 1999; Mohammadi et al. 2009). Several mechanisms have been proposed to explain the adverse impact of caries on child growth (Sheiham 2006). Severe dental caries often leads to pain and discomfort that affects children physically and psychologically (Locker 1989) and therefore, dental caries has a detrimental effect on the quality of life of children (Barbosa & Gavião 2008; Bönecker et al. 2012). Apart from affecting overall quality of life of young children, dental caries particularly affects food intake and sleep (Acs et al. 1992; Low et al. 1999; Vania et al. 2011; Acharya & Tandon 2011), which in turn might affect child growth.

Despite the evidence of potential effects of dental caries on growth, very few studies have assessed the underlying mechanisms of this association. Thus this thesis examined the relationships between dental caries in children and their height, weight and BMI in a lower-middle-income country, namely,

Bangladesh. It then explored the potential underlying factors that might explain the observed associations, namely oral health related quality of life (OHRQoL), with particular focus on dental pain, eating difficulty, poor appetite, and sleep disturbance related to caries.

This thesis is organized as follows: It begins by presenting the general concepts of dental caries and child growth followed by a review of the literature on associations between dental caries and height, weight and BMI among children, and the impact of dental caries on children's OHRQoL, dental pain, eating difficulty, poor appetite and Sleep disturbance (Chapter two). The literature review assesses the evidence and identifies a gap in knowledge that leads to the study aim, objectives and hypotheses. Chapter three presents the methodology in which data collection methods, measures and data analysis plans are described. Following the validity and reliability tests of the Bengali version of the Scale of Oral Health Outcomes for 5-year-old children (SOHO-5) in Chapter four, Chapter five presents the main results of the analyses. Finally in Chapter six, the main findings of the project are discussed and compared with other relevant studies, followed by recommendations and conclusion.

Chapter 2 Literature review

Chapter 2 Literature review

This chapter firstly provides a context for the project by giving an overview of dental caries and growth of children, followed by a review of the relevant existing literature on associations between dental caries and height, weight and BMI of children, and possible underlying mechanisms. This chapter ends with a synthesis of the main findings and a conceptual model summarising the main pathways that emerged from the literature. Limitations of past research and gaps in current knowledge are also highlighted.

Dental caries is a common childhood disease that mostly remains untreated for children of low and middle-income countries (LMICs). Growth failure is also one of the most important public health issues for children in those countries due to its multiple adverse impacts (Lucas et al. 2010; WHO 2014). Over the past three decades, the question whether there is an association between dental caries and growth failure among children in LMICs has received increasing attention (Marcenes et al. 2013). Before probing deeper into the association, an overview of dental caries and child growth along with their measurement is presented.

2.1 Dental caries in children

Dental caries is defined as an “*infectious microbial disease of teeth that results in the localized destruction and dissolution of the calcified tissue and formation of a cavity*” (Cowson & Odell 2008). Dental caries is biofilm-mediated, sugar-driven, multifactorial, dynamic disease that can occur both in primary and permanent dentitions (Pitts et al. 2017). Dental caries is one of the most common childhood diseases globally (Petersen 2003; Selwitz et al. 2007; Marcenes et al. 2013). According to recent WHO ‘Global Burden of Disease’ report, untreated tooth decay is the most prevalent disease among 291 major diseases and injuries (WHO 2015). Despite the improvements in oral health in most high-income countries over the last decades, the prevalence is still high among children from LMICs (Petersen et al. 2005; Edelstein 2006; Bagramian et al. 2009). Alarmingly overall more than 90% of decay remains untreated in those countries (Petersen 2003; Moynihan & Petersen 2004). Untreated caries may gradually affect the enamel and dentine, and then the pulpal part of the tooth and may cause dental sepsis. Thus untreated caries and associated infection may cause dental pain and discomfort which have a negative impact on daily activities such as eating and sleeping, and children’s quality of life (Sheiham 2006); and these factors might have negative impacts on their growth.

Measurement of dental caries

For the last 70 years, measurement of dental caries has been done worldwide using the DMFT/dmft index (Klein et al. 1938). According to WHO, the DMFT/dmft index to measure dental caries is an aggregate measure of teeth with a visual distinct cavity in dentine (D/d), teeth missing due to caries (M/m) and filled (F/f) permanent and deciduous teeth where upper case letters are used for the permanent dentition and lower case letters are used for the deciduous teeth (WHO 2013). This classic index provides information on caries and restorative and surgical treatment but fails to provide information on the clinical consequences of untreated dental caries, such as pulpal involvement and dental abscess (Monse et al. 2010). In view of the global epidemic of untreated caries in children, it is important to investigate the dental sepsis of children (Pine et al. 2006). PUFA/pufa is an index that has been developed to assess the presence of oral conditions resulting from untreated caries. PUFA/pufa index is measured in the same cumulative way and recorded separately from the DMFT/dmft to score consequences of dental caries in soft tissues: the presence of a visible pulp (P/p), ulceration of the oral mucosa due to root fragments (U/u), fistula (F/f), or an abscess (A/a) (Monse et al. 2010). Some recent studies also used the newly developed International Caries Detection and Assessment System (ICDAS), a more detailed index that considers both cavitated and non cavitated lesions in enamel and dentine (Pitts & Ekstrand 2013).

For the assessment of severity of caries in children, the American Academy of Paediatric Dentistry (AAPD) defines early childhood caries as presence of

one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces (dmfs) in any primary tooth in a child of 71 months of age or younger (AAPD 2008). If children's dmfs score is ≥ 4 (age 3), ≥ 5 (age 4), or ≥ 6 (age 5) then it is indicative of severe early childhood caries. Several studies reviewed in this thesis reported this classification; also some studies used their own study specific classification to define severity of caries. The following section presents an overview of child growth.

2.2 Overview of child growth

Growth is a normal physiological process and an important indicator of overall good health and well-being of a child (Cappa & Loche 2003; Simm & Werther 2005; Stanhope et al. 1994).

2.2.1 Stages of growth

Childhood growth may be divided into three phases known as 'Infancy-Childhood-Puberty' model for growth, each with separate controlling mechanisms (Harvey 1995). Infancy is characterised by rapid but rapidly decelerating stage of growth that tails off by the end of the first year. This phase of growth is largely nutritionally determined and insulin and insulin like growth factors play a contributory role (Hindmarsh 1988). Optimal feeding results in healthy growth and under feeding results in growth retardation during this period. In some low-income countries, the nutritionally determined early phase of growth is often compromised, causing short stature of children. Therefore, the next phase of childhood growth starts from a lower base line (Costello 1989; Karlberg. et al. 1988). The second phase of growth

is childhood, which mostly depends on growth hormone secretion and other endocrine pathways along with nutritional control (Hindmarsh et al. 1987). Finally, puberty or pubertal growth spurt is the time of superimposed growth acceleration due to the combined effects of growth hormone and sex steroids (Stanhope et al. 1987; Gibson et al. 2000; Brook 1982). Growth after the age of 8-9 years is interlinked with puberty and cannot be considered independently, therefore, this issue was a factor to consider during selection of study sample for this project. The following section highlights the factors influencing child growth.

2.2.2 Factors influencing growth

Child growth is a complex phenomenon affected by many different factors (Rogol et al. 2002). A complex interaction of different genetic, nutritional, environmental growth factors and hormones is required in a highly regulated and timely fashion for normal growth (Monzavi & Cohen 2002; Cappa & Loche 2003; Simm & Werther 2005). The main important factors influencing growth are as follows:

Genetic factors are among the strongest influences (Czerwinski et al. 2007) and 95% of normal children reach a final height within a range around the mid-parental centile ± 9 cm (Harvey 1995). Secondly, along with the influence of genetic factors, environmental influences are also very important (Cameron 2012). Ethnic differences and secular trends are the factors to consider as growth patterns and timing of puberty depend on genetic and environmentally determined ethnic differences. Hence, children from different populations show international differences in size and shape due to genetic,

environmental and nutritional factors (Tanner & Whitehouse 1976, Polnay 2002). Adequate nutrition is essential for normal growth particularly during the infantile phase, which is considered as a problem in low-income countries (Fazili et al. 2012). On the other hand, over nutrition is another public health challenge especially for high-income countries. Emotional and socio-economic factors are often related to nutrition. For instance, it has been shown that stress is related to poorer growth among children, and removal from a stressful environment and relationships can have beneficial effects on growth (Cameron 2012). Stress may decrease appetite and also cause disordered neuro-hormonal control of growth. Thirdly, growth is regulated by a complex interplay of endocrine pathways. The important hormones related to growth are growth hormone; thyroid hormone (Thyroxine); cortisol; androgens; testosterone and female sex steroids (Polnay 2002). Problems with one or combination of these factors result in growth failure or failure to thrive.

2.2.3 Growth failure or failure to thrive (FTT)

A wide range of different criteria for FTT are used in the medical literature which include “weight or height below the third percentile for age”, “weight less than 80% of ideal weight-for-age” or “failure to maintain a previously established growth pattern” (Accardo 1982). Thus FTT includes insufficient increase in weight and length during childhood, and rates of growth failing to meet the expected rate for a child of that age (Nützenadel 2011). Growth failure can occur at any time during childhood (Jolley 2003). FTT in infancy (Jolley 2003) and in childhood is a common consequence of malnutrition due

to inadequate caloric intake, caloric absorption, or excessive caloric expenditure (Cole & Lanham 2011). Early childhood caries is considered to be associated with FTT (Acs et al. 1999).

2.2.4 Catch-up growth

“Catch-up growth is a height velocity above the statistical limits of normality for age or maturity during a defined period of time, following a transient period of growth inhibition” (Boersma Bart & Jan 1997).

The effect of catch-up growth is to take the child onto the original pre retardation curve. The velocity of catch-up depends on the severity of growth failure and timing of exposures (Tanner 1981). Different community based longitudinal studies suggest that a healthy environment is the key factor that might influence catch-up growth (Adair 1999; Simondon et al. 1998). Catch up growth is seen after dental treatment (Acs et al. 1999); this topic has been described separately in a later part of this chapter.

2.2.5 Growth assessment

One of the most important marker for good health in childhood is normal growth (Stanhope et al. 1994). Therefore, for health monitoring and research purpose, understanding the measurement and assessment of growth of children is very important.

“Anthropometry (the measurement of the size, proportions and composition of the human body) provides the single most portable, universally applicable, inexpensive and non-invasive technique for assessing growth of the human body” (WHO 1995).

Physical growth refers to an increase in body size (length or height and weight), and growth indicators such as height and weight measurement reflect health and nutritional status. To screen and monitor children's development, growth references are commonly used. Precise measurements of height and weight are carried out accurately and plotted on a growth chart and compared with an appropriate reference population (Stanhope et al. 1994; Simm & Werther 2005). Height is the best single index of growth that is more significant than weight as a long-term indicator (WHO 1995), so height measurement with a cut-off at 0.4 centile is considered as a satisfactory criterion for screening of growth failure (Harvey 1995). The measurement of weight can be useful if it is linked to height and age, otherwise it can be misleading (Tanner 1976; WHO 1995). Weight increase is taken as an indicator of satisfactory growth. Measurement of height or weight at one time point is not an indicator of growth since growth is a dynamic process, which needs multiple measurements over a minimum 6 months period (Simm & Werther 2005). Many studies used the term 'malnutrition' to characterize weight, height, and BMI (Weight (kg)/height (m)²) deficiency. WHO child growth reference reported the age-adjusted z-score of height, weight, and BMI. The z-score of height, weight, and BMI is a measure of the standard deviation (SD) away from standardized mean of height, weight, and BMI. It is considered one of the most appropriate measures of weight in children and adolescents because it accounts for the wide, natural variation in growth. The

use of z-scores allows comparisons of individual's weight, height or BMI, adjusted for age and sex relative to a reference population, expressed in standard deviations (SD) from the reference mean. Children who have z-scores below 2 SD (<-2 SD) from the normal reference mean value of height-for-age (stunting), weight-for-age (underweight), weight-for-height z-scores (wasting) and BMI-for-age are considered as growth failure or malnourished by the WHO (Onis et al. 2007). Globally, stunting affected at least 165 million children and wasting affected at least 52 million children in 2011, with the highest prevalence in South Asia and Sub-Saharan Africa (Black et al. 2013).

The study population of this project was children of Bangladesh; hence in order to understand the context of the study the following section presents an overview of dental caries and child growth in Bangladesh.

2.3 Study context: dental caries and child growth in Bangladesh

Bangladesh is a lower-middle-income country in South East Asia. The details of socio-demographic information of this country are presented in the methodology chapter. There is no nationwide data on the burden of dental caries of children in Bangladesh. In 2003, the prevalence of dental caries of 12-year-old Bangladeshi children was reported as very low in the Global map on dental caries according to WHO oral health data bank (Petersen 2003). An earlier review reported an average DMFT score of 1.5 for 8-11-year-old children (Helderman et al. 1996). Later another study conducted in socially deprived urban slums and rural areas found a mean dmft/DMFT of 1.4 for 6-

12-year-old children, with more prevalent d/D component, which indicates that most of the carious cavities were untreated, and 26.4% of participant children were underweight (Mishu et al. 2013).

Despite some improvement in nutritional status over the last two decades, malnutrition is still a major problem for children in Bangladesh (Rabbani et al. 2016). Analysing data from the Bangladesh Demographic and Health Survey from 1996 to 2014, Rabbani et al. (2016) reported that the stunting and severe stunting rate among under-five-year-old children was 34% in 1996/97, which was reduced to 11.6% in 2014. According to the recent WHO child malnutrition report in Bangladesh, the prevalence of stunting; underweight and wasting among children under five years of age is 36.1%, 32.6% and 14.3% respectively (WHO 2016). Though it was not possible to capture child growth through a cross sectional study design; most of the literature referred to in this thesis considered height and weight measurements as indicators of child growth or nutritional status.

2.4 Dental caries and child growth: Evidence from systematic reviews

So far five systematic reviews have been published (summarized in Appendix 1), which reported an inconsistent pattern of findings on studies published from 1980 to 2014 (Kantovitz et al. 2006; Hooley et al. 2012; Silva et al. 2013; Hayden et al. 2013; Li et al. 2015). Although three of the reviews focused on caries and obesity, as childhood obesity is a major health

problem in most high-income countries, these studies failed to agree on any specific conclusions on the pattern of the association.

The earliest systematic review on obesity and dental caries was conducted by Kantovitz et al. (2006). They reviewed evidence on the association between dental caries and obesity in childhood, adolescence and/or adulthood from 33 articles published between 1984 and 2004. They excluded all studies related to oral health and nutritional deficiency, and underweight. Out of 33 critically assessed papers, seven papers were selected, five of which included children between 2-15-year age group. The systematic review found only three studies on children to provide high level of evidence on the study topic. Of the three 'A grade' studies, 1 study with German elementary school children found a positive correlation between dental caries and BMI in a sample of 842 children aged 6-11 years (Willershausen et al. 2004). Another study found no correlation analysing data from over 5,000 3-year-old children from a children's health survey in Taiwan (Chen et al. 1998), while the third study was not able to identify an association between dental caries experience and BMI status in more than 500 5-13-year-old children in Denmark (Tuomi 1989). Thus no clear conclusion could be drawn as there were conflicting findings and further well-designed randomised studies to explore the relationship were recommended. However, the search criteria were limited to randomised, cross-sectional and retrospective studies and inclusion of all age groups made the findings rather vague. Also the exclusion of studies reporting an association of caries and underweight provided only a snapshot of one side of the association between caries and obesity but not the whole picture of the possible associations between caries and BMI.

A more recent systematic review by Hooley (2012) on BMI and dental caries in children and adolescents covering literature from 2004 to 2011 included 48 studies. Overall, the systematic review reported three main patterns of associations between BMI and dental caries: no association (23 of the 48 studies), a positive relationship (17 studies), and an inverse relationship (nine studies). After assessing for bias, only five studies were considered as 'A rated'. The reports of those five studies were also similar to the previous findings; as two studies found positive associations, one study found a negative association and two studies found no associations. Additionally, they reported about a study conducted in India that found children with obesity and overweight had increased prevalence of dental caries in both primary and permanent dentition compared to normal weight children (a U-shaped pattern) (Sharma & Hegde 2009). Furthermore, the possible explanations of the inconsistent associations were individual level factors like disparity in level of dental caries, ethnicity, socio-economic status, parental education level, and access to health services. The review considered the country level variables using human development index and reported that:

“The evidence supporting an inverse relationship between dental caries and BMI comes from studies in developing countries”, and “The studies that support a positive association between BMI and dental caries include those in which samples were from highly developed countries with high standards of living and improved access to public health” (Hooley et al. 2012).

An important point of this systematic review was that it was the first review that provided a complete picture of the different patterns of association between caries and BMI of children with a plausible explanation.

The only systematic review with a meta-analysis on the association between obesity and dental caries in children was conducted by Hayden et al. (2013) that included papers between 1980 and 2010. Initially 212 studies were identified following PRISMA guidelines (Moher et al. 2009) and 35 full articles were reviewed following the quality assessment guidelines by 'University of Wales' (Weightman & Mann 2004). 14 articles met the selection criteria and were included in the meta-analysis, though only seven studies were found to be of highest quality. The authors concluded that a significant overall positive relationship between obesity and dental caries in the permanent dentition exists when standardized definitions for the assessment of child obesity were used. Subgroup analyses revealed a significant relationship between overweight/obesity and dental caries in studies involving children from 'industrialized countries' but not 'newly industrialized countries'. One of the limitations of this study was children who were 'underweight' were not included. Studies, which did not specify or separately analysed by dentition type were also excluded. However, among children in the mixed dentition stage the effect of caries of both primary and permanent dentition could occur simultaneously.

Hayden et al.'s (2013) findings of a relationship of caries and obesity was critically analysed and evaluated by Hooley (2014) who addressed other associated factors related to this association (Hooley 2014). Hooley (2014) reported that the association was moderated by country level variables, since most of the studies that reported a positive association were from countries with a lower Human Development Index (i.e. were more highly developed). The association was also confounded by the level of caries and distribution of

BMI in the study samples. For example, underweight participants were underrepresented in studies reporting a positive association and vice versa. Finally, the author highlighted that underweight children were often combined with normal-weight children for comparison with overweight and obese children. Therefore, he recommended that child weight categories should not be combined in order to reduce the risk of attenuating differences between the target and comparison groups. The authors also highlighted the common problem of use of non-standardized BMI cut-off points.

In the same year another systematic review was published by Silva et al. (2013), aiming to identify the evidence of an association between obesity and dental caries, that included studies published between 2005 and 2012. The authors identified 537 studies and 28 studies were included in the review after assessing the quality using the 'Downs & Black' criteria (1998). Among reviewed articles, good scientific evidence was found from 13 articles, out of which six studies observed a positive association. Thus they concluded that the evidence regarding the association is insufficient. However, study limitations highlighted in the review included the small number of longitudinal studies (total five studies) and lack of clarity of the possible role of diet, socio-economic and other confounding factors, as most of the studies did not adjust for these factors. Moreover, the review acknowledged that due to the heterogeneity of the studies, it was not possible to perform a meta-analysis.

The most recent systematic review that considered only longitudinal studies on anthropometric measurements and dental caries in children, also reported conflicting findings (Li et al. 2015). The review identified 17 longitudinal

studies as effective studies. Among those studies, anthropometric measurements were used to predict caries in 15 studies that reported inconsistent findings; and two studies where dental caries was used to predict anthropometric measurements found an inverse association. The authors concluded:

“The quality of reporting of these studies varied considerably. Evidence of the association between anthropometric measurements and dental caries is conflicting and remains inconclusive” (Li et al. 2015).

Again the variation of clinical assessments and measurements; study settings; age and ethnicity of participants; and other confounders influenced the results.

To sum up, a consistent pattern in the association could not be confirmed by any of the reviews. All of the reviews reported insufficient evidence regarding the association between dental caries and obesity. The reviews ended up with observing three patterns of association: negative association, positive association and no association. One limitation that all reviews mentioned was not controlling for potential confounding factors by most of the studies. Another key limitation was heterogeneity in measuring and defining caries and obesity. Lastly, apart from the last review, most of the included studies in the previous reviews were cross sectional in design and thus the causal mechanism of the association remained unclear.

The following section reviews the empirical studies in light of these three patterns of associations with particular focus on negative pattern of associations.

2.5 Empirical studies on associations between dental caries and anthropometric measures of children

A number of studies provide evidence of associations between dental caries and anthropometric measures among children. Most of the individual studies reviewed in this section were from LMICs that were not fully covered by the existing published systematic reviews or recently published after the systematic reviews.

2.5.1 Studies reporting negative associations between caries and height, weight and BMI

2.5.1.1 Dental caries as a risk factor for lower height, weight and BMI

Evidence that dental caries is associated with lower height, weight and BMI as indicators of impaired growth or malnutrition comes mainly from cross-sectional population based studies from LMICs (Benzian et al. 2011; Mishu et al. 2013; Alkarimi et al. 2014; Gemert-Schriks et al. 2011; Mohammadi et al. 2012; Ngoenwiwatkul & Leela-adisorn 2009). Two recent studies that have considered weight-for-age z-score (WAZ) and height-for-age z-score (HAZ) also found an inverse association between dental caries and WAZ and HAZ score even after adjustment of socio-economic status and other variables (Mishu et al. 2013; Alkarimi et al. 2014). However, these studies did not comprise nationally representative samples; the latter study was conducted in a single military school with 417 children in Saudi Arabia. Another study among 380 6-year-old Suriname children also found a negative correlation

between anthropometric measures and the number of untreated carious surfaces/caries experience, although the study did not have any healthy comparison group (Gemert-Schriks et al. 2011).

Current studies mainly used BMI as an indicator of malnutrition or optimal weight status and reported negative associations between caries and BMI (Benzian et al. 2011; Ngoenwiwatkul & Leela-adisorn 2009; Goodson et al. 2013). However, the association was dependent on the severity of dental caries as Benzian et al (2011) in their study concluded that:

“Although a significant association existed between BMI and caries, only children with caries progression into the pulp (odontogenic infections) appeared to have an increased risk of a below normal BMI as compared to those without odontogenic infections” (Benzian et al. 2011).

This finding implies that early stages of caries were not a risk factor for lower BMI whereas children with caries with pulp involvement had an increased risk of being below normal BMI as compared to children without odontogenic infections. This finding is further supported by hospital-based studies. In a case control study with Turkish children, Ayhan et al. (1996) evaluated the effect of nursing bottle caries and rampant caries on height, weight and head circumference. The study revealed that children who had rampant or nursing caries were significantly lighter and shorter compared to children with healthy teeth. The mean weight for children with caries was between 25th-50th percentiles and was between 50th-75th percentiles for controls without caries. Also, 7% of cases and only 0.7% of controls weighed less than the 20th percentile. However, some of these hospital-based studies did not consider

demographic and socio-economic variables and other potential confounders such as low birth weight and nutritional status.

The final evidence about the effect of caries on underweight comes from studies of 'catch-up growth' following comprehensive dental treatment. Evidence for an effect of dental treatment of pulpally involved or infected teeth on gaining body weight comes from a randomized control trial (RCT) conducted in the Philippines with 164 underweight preschool children with a mean age of 59.9 months and with severe dental decay, which found that the extraction of severely decayed primary teeth resulted in significant weight gain. This study reported that within a four months follow-up period the 85 children with immediate extraction had significant increase in WAZ and BMI-for-age z-scores (BAZ) compared to another group of 79 children waiting for dental treatment (Monse et al. 2012). However, the study failed to demonstrate any significant change in HAZ, possibly due to the short follow-up period.

Though two other RCTs failed to provide evidence of significant improvement of weight after dental treatment (Alkarimi et al. 2012; Gemert-Schriks et al. 2011). The earlier Saudi community-based RCT with 86 schoolchildren with severe dental caries (42 children were in test group who got early dental treatment and 44 were in control group who got treatment six months after the test group), aged 6-7 years in Saudi Arabia found no significant difference in anthropometric outcomes (WAZ and BAZ) between two groups. The key limitations of Alkarimi's study were the short follow-up period of 34.8 (+1.1) weeks and small sample size. However, Gemert-Schriks et al. (2011)

in the RCT part of their study did not find any significant improvement in weight and height after a three year follow-up period. In that study all 380 children from 17 different schools located in Suriname were randomly assigned to four different treatment groups ranging from full dental treatment to no invasive treatment at all. Body growth was evaluated by children's height, weight and BMI and participants were evaluated after six months and one, two and three years, but no significant differences in growth pattern between the treatment groups were observed. One explanation of this might be a lack of power due to several treatment groups. As this study had four intervention groups, the number of participants in each group might have been too small to show any statistical significant differences.

2.5.1.2 Malnutrition as a risk factor for dental caries

While the above-mentioned studies assessed the relationship between caries and anthropometric measures on the assumption that caries negatively affects growth, there is some evidence that the relationship may be bidirectional. A systematic review showed that malnutrition may be a risk factor for dental caries as malnutrition is associated with structural defects (hypoplasia) and hypo-mineralization of tooth enamel and altered salivary flow rates, buffering capacity and antimicrobial components, all of which might increase susceptibility to dental caries (Psoter et al. 2005). The finding of a Brazilian longitudinal study indicates that life course events such as under nutrition and childhood infections during tooth development may be associated with enamel defects in socio-economically underprivileged communities (Chaves et al. 2007). Similarly, a prospective four-year

longitudinal study of 209 Peruvian children also reported malnutrition as a risk factor for dental caries (Alvarez et al. 1993). These findings are further supported by cross-sectional studies providing evidence that malnutrition is associated with dental caries even after adjusting for socio-economic factors (Alvarez et al. 1988; Alvarez et al. 1990; Oliveira et al. 2008). Oliveira et al (2008) in their study on Brazilian preschool children found that nutritional status was related to dental caries of children. Using caries as the outcome variable, the study found that underweight children were 5.6 times more likely to have severe caries than children of normal weight/height. This finding was in accordance with other studies that found low body weight or low BMI as a risk factor for caries in 12-14-year-old children of Thailand (Narksawat et al. 2009) and 5-9-year-old children in Turkey (Koksal et al. 2011). However, these studies did not control for important potential confounders, such as socio-economic factors (Floyd 2009). Similar associations were observed in other recent studies conducted in India (Chauhan et al. 2016; Chopra et al. 2015), Iran (Bafti et al. 2015), Saudi Arabia (Bhayat et al. 2016; Farsi et al. 2016), and Serbia (Markovic et al. 2015). Chauhan and colleagues (2016) in their study of 275 disadvantaged 6-15-year-old tribal children in India found that caries was more prevalent in malnourished children even after accounting for oral hygiene and sugar intake and caries prevalence increased with increase in severity of malnutrition. Though this study measured height, weight, mid-arm and head circumference; only BMI was reported in the results. On the other hand, Chopra et al. (2015) found that dental caries was higher in both underweight and overweight children compared to normal weight children. The study added that dental caries and

deviations from normal weight were two conditions, which share several broadly predisposing factors such as diet, socio-economic status, lifestyle and other environmental factors.

Some studies dichotomized BMI into normal and overweight and found that caries was more prevalent among normal weight children; however the categorization did not allow assessing whether caries was more prevalent among under-weight children (Bafti et al. 2015, Farsi et al. 2016). Farsi and colleagues (2016) in their study found that caries was two times more prevalent among normal and underweight than overweight and obese 12-year-old boys in Madina city of Saudi Arabia even after accounting for possible confounders and dietary habits. A similar finding was reported by another study from Serbia with 422 children and adolescents aged 6-18 years that considered underweight and normal weight children together and found a negative association between caries and overweight (Markovic et al. 2015). The above-mentioned studies were intended to test the association between caries and obesity and thus did not consider underweight as a separate group.

These findings were in accordance with three recent cross-sectional studies in China with school-aged children (Liang et al. 2016; Peng et al. 2016; Yang et al. 2015). However, these studies did not assess the severity of dental caries and none took socio-economic and other related variables into account. Liang and colleagues (2016) in their study in China categorised their large sample of 32,461 pupils aged 7-9 years into underweight, normal weight, overweight and obese groups using a BMI classification based on

Chinese criteria. The authors observed lower odds of presence of caries in deciduous teeth among overweight or obese children. Though this study calculated BAZ based on WHO criteria, the country specific categorization of BAZ restricts the comparability of the study. As categorization reduced the opportunity to use the full range of data, this study also evaluated the shape of the relationship between BAZ as a continuous variable and dental caries in primary dentition and reported that full-range BAZ was associated with dental caries.

All above-mentioned studies considered BMI status as an exposure to explain the prevalence or level of dental caries in children. However, due to cross-sectional study designs and data analysis methods, the reverse causality issue of whether malnourished (wasted and stunted) children experienced more dental caries or dental caries was one of the factors causing the growth failure (wasting and stunting), could not be ascertained.

Interestingly, some studies have considered only height and found that taller children had less caries than their shorter counterparts (Nicolau et al. 2005; Freire et al. 2008). These two cross-sectional studies, conducted among Brazilian adolescents (between age of 13 to 15 years), found that taller children had lower level of dental caries. This finding was also supported by another longitudinal study in Peru that reported stunting as a significant risk factor for caries increment in permanent teeth over a 3.5 year period of time (Delgado-Angulo et al. 2013).

2.5.2 Studies reporting no associations between caries and BMI

Some studies did not find any significant associations between dental caries and children's BMI (Alves et al. 2013; Edalat et al. 2014; Sede & Ehizele 2014; Jong-Lenters et al. 2015; Kottayi et al. 2016; Kumar et al. 2017). Most of these studies did not use the entire range of BMI, rather they grouped their study population into obese and non-obese. Edalat et al. (2014) considered 202 preschool children in Iran aged 3-6 years and showed the percentages of children with lower HAZ, WAZ and BAZ having severe early childhood caries, but without showing any statistical significance test. This paper, reporting results only from descriptive statistics, would appear to be over-ambitious on its claim of non-linear correlations between severe early childhood caries and HAZ, WAZ and BAZ deficiency.

Alves et al. (2013) with a representative sample of 1,837 12-year-old Brazilian children using WHO classification of BAZ reported that overweight or obese children are not at risk of dental caries; however, the study failed to elucidate the association with underweight children in their study as they did not assess underweight separately. Similarly, Kottayi et al. (2016) showed the prevalence of caries among 2,000 12-14-year-old overweight and normal-weight children in a district of India and found no significant difference between these two weight categories. The study used BMI categorization by the International Obesity Task Force and again due to categorization missed the opportunity to examine the association for underweight children. In the same way, another study of 1,092 children in India aged 11-14 years found no association between BMI categories and dental caries using the Indian

Academy of Paediatrics 2015 growth charts to categorise children as underweight, overweight, normal or obese, based on their BMI. Moreover, by using detailed data on socio-economic status the study showed that high socio-economic status, overweight children experienced lower caries rates than normal-weight children (Kumar et al. 2017). Similarly, Sede & Ehizele (2014) in their study in Nigeria did not find any difference in dental caries prevalence between obese and non obese children. This study also considered other oral diseases as outcomes but failed to account for any confounders.

Likewise, another population based study in the Philippines failed to draw a definite conclusion on the effect of dental caries on BMI, after adjusting for socio-economic factors (Heinrich-Weltzien et al. 2013). The study of 1,962 6-7-year-old children taking part in the National Oral Health Survey in 2005-2006 in the Philippines, taking account of BMI and dental caries, concluded that underweight was associated more strongly with demographic and socio-economic conditions than with dental variables and definite conclusions about the association between dental caries and weight status could not be drawn from that study (Heinrich-Weltzien et al. 2013).

An overall observation is that the evidence of no association mainly came from the studies aiming to find associations between caries and obesity by using BMI categories and studies that considered adolescents in their sample. One possible explanation might be that the dichotomization of BMI into obese and non obese (or, overweight and non-overweight) reduced the opportunity of using the full range of data to explore the association. Also the

use of different criteria of BMI classification makes the comparability of these studies questionable.

2.5.3 Studies reporting positive associations between caries and BMI

Research from high-income countries, and some middle-income countries reported positive associations between dental caries and overweight or obesity. Considering the context of the project, individual studies reporting positive associations from high-income countries were not reviewed in this thesis. A limited number of studies from lower middle to middle-income countries like China (Yao et al. 2014), Iran (Shahraki et al. 2013; Bagherian & Sadeghi 2013), and India (Sakeenabi et al. 2012; Honne et al. 2012; Bhoomika et al. 2013) reported a positive association between dental caries and higher BMI.

Sakeenabi et al. (2012) in their study in India among 1,550 school children aged 6 and 13 years, showed that there was a significant association between overweight and obese children and dental caries prevalence using multivariate logistic regression adjusted for socio-economic status and other confounders. This study categorized BMI into four groups (underweight as a distinct group) for the descriptive analysis, but for the logistic regression, they considered dichotomization as obese versus rest of the group and reported that in 6-year-olds, obese children were 3.6 times more likely to have dental caries than subjects who were not obese. Considering low and normal weight together, another study by Honne et al. (2012) in South India which investigated the relationship between obesity, over weight, sugar consumption and dental caries among 463 school children aged between 13

and 15 years, showed that obese and overweight children had 3.7 times higher chance of having caries than low to normal weight children. Bhoomika et al. (2013) with a sample of 100 caries free children (50 boys, 50 girls) and 100 children with severe early childhood caries of 3-6-year-old age group found that the mean BMI of severe early childhood caries children was more when compared to the caries free children.

Another cross-sectional study from the routine health screening data for primary school children aged 5-14 years in Wannan area, China supports the positive association. Overweight and obesity status were determined using the International Obesity Task Force standard BMI cut-off points. After adjusting for gender and age, the study found a statistically significant association as overweight children were 1.5 times and obese children were 2.9 times more likely to have caries than children with underweight and normal weight children (Yao et al. 2014). However, the study found that underweight and normal weight children had higher prevalence of dental caries compared to over weight or obese children. Again the study considered normal / healthy weight and underweight together as their reference group and did not consider socio-economic status.

A cross-sectional study in a city of Iran with 1,213 children aged 6-11 reported that the mean decayed and filled teeth in the overweight group was higher than in low and normal weight groups. However, the analysis did not account for any confounders (Shahraki et al. 2013). In another study the subjects were divided into severe early childhood caries and caries-free groups. Then data was analysed by t-test, one-way ANOVA, multiple

regression and logistic regression tests and reported an association between higher decayed, extracted and filled surfaces (defs scores) and overweightness. However, regardless of collecting data from 12 private and state-funded preschools, the study did not account for any socio-economic variables that may have impacted the association (Bagherian & Sadeghi 2013).

All these studies used different BMI categories. The level of dental caries was also a factor to consider, as one study with 180 Brazilian children aged 6-14 years used both DMFT/dmft and ICDAS II visual criteria. Considering non-cavitated caries, it reported that although no significant difference was observed in caries prevalence for the permanent dentition, a significant mean dmft difference existed in non-obese children (mean dmft of 1.66) compared to obese children (mean dmft of 0.95). Considering ICDAS II criteria, the study also found that a higher prevalence of non-cavitated enamel lesions (D1-3) was observed in obese children (10.5%) compared to the non-obese children (1.9%) (Ferraz et al. 2016).

Thus this inconsistent pattern of association warrants further investigation. The possible explanations of these inconsistent findings are described below.

2.6 Possible explanations for inconsistent associations between caries and height, weight and BMI

The positive association between caries and BMI found in high-income countries might be explained by the excessive availability and consumption of food and drinks containing high quantities of sugars in those countries, that are the risk factors for both obesity and dental caries (Marshall et al. 2007; Hayden et al. 2013). In high income countries, obesity in children has increased, which might explain why these studies only considered BMI as a dichotomized variable (high BMI or not high BMI). The predominance of untreated caries or 'd' component in dmft also affect the association (Norberg et al. 2012). Unlike the children from LMICs, the children from high-income countries are more likely to receive treatment of dental caries, thus they are less likely to suffer the adverse consequences of caries.

Given the country level differences, this inconsistency in associations among different studies could also be due to methodological limitations. In terms of dental caries measurement, there is a lack of standardised diagnostic criteria in caries definitions, caries detection methods and use of different indices. For example in the definition of severe early childhood caries in young children, the 'American Academy of Paediatric Dentistry' criteria include non-cavitated lesions for caries, whereas the WHO criteria include only cavitated lesions. Most of the studies that reported associations between caries and obesity used a more sensitive measure of dental caries (e.g., included initial caries) and involved samples with a lower caries severity (e.g., lower mean dmft/DMFT scores) than studies finding an inverse association (Hooley

2014). Studies used various criteria for assessing anthropometric measures and different cut off points for their classification. Some studies did not provide any evidence on the reliability of clinical measures of caries detection and anthropometric measures or relied only on BMI and used unadjusted formulas to calculate BMI (Sakeenabi et al. 2012, Honne et al. 2012). Another limitation of most studies is the failure to include the full range of BMI in the sample (Hooley et al. 2012). Therefore, the inconsistent associations shown in different studies should be considered with caution.

As the study population of this study was from Bangladesh, a lower middle-income country, and most of the study findings from LMICs supported an inverse association, the following part of the literature review focuses on the explanation for the inverse pattern of association considering the context of this thesis.

2.7 Potential explanations on how dental caries could adversely affect child's height and weight

The findings from intervention studies on the effect of treatment of dental caries on the improvement of anthropometric measures (Monse et al. 2012) suggests that untreated severe dental caries could affect growth negatively. Therefore, there has been an increasing interest in the underlying mechanisms of this relationship (Sheiham 2006). The following part of this review addresses the potential underlying factors and mechanisms of how dental caries negatively affects the height and weight of children. As mentioned earlier, an overall good quality of life, proper nutrition and healthy sleep patterns are considered as core elements of child growth. Therefore, this section has reviewed the evidence on the association between dental caries and OHRQoL of children, followed by review of the studies focused on dental pain, eating difficulty, poor appetite and sleep disturbance.

2.7.1 Dental caries and oral health related quality of life (OHRQoL)

Oral health related quality of life (OHRQoL) is the measures of the extent that oral status and conditions disrupt normal social-role functioning and bring about major changes in behaviour (Locker 1989). OHRQoL is a multidimensional construct which also contains a subjective assessment of an individual's oral condition, functional and emotional well-being, expectations and satisfaction with care and sense of self (Sischo & Broder 2011). It mostly relates to the impact that oral conditions have on the individual's daily functioning such as eating, sleeping and other daily activities. Indeed, evidence is growing to support links between oral health

and general health and oral and general quality of life (Scarpelli et al. 2013; Paula et al. 2015). OHRQoL is mainly based on the following four domains (Figure 2-1):

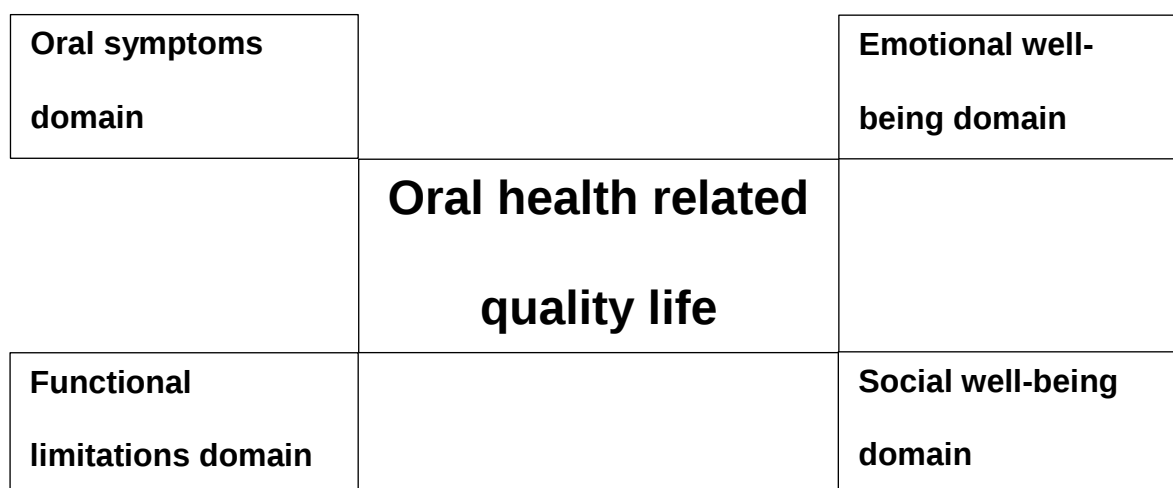


Figure 2-1 Important domains of OHRQoL

Oral diseases have a negative impact on the functional, social and psychological well-being of children and their families and dental caries adversely affects OHRQoL (Filstrup et al. 2003; Pahel et al. 2007; Do & Spencer 2007). Different scales have been used to measure the OHRQoL of children, using parent reports, child reports, or both. Across these different scales there is consistent evidence that higher caries levels are significantly associated with overall poorer OHRQoL, higher subscale scores for oral symptoms, and impacts on functional and emotional well-being (Brown & Al-Khayal 2006; Foster Page & Thomson 2012; Barbosa et al. 2013; Chakravathy et al. 2013; Pulache et al. 2016). However, some of these questionnaires are relatively long and not suitable to use in most settings (Brown & Al-Khayal 2006) or for preschool children.

A limited number of scales are available for preschool children (Li et al. 2008; Lee et al. 2011; Tsakos et al. 2012; Abanto et al. 2013). As young children are often considered unreliable respondents, until recently proxy ratings were preferred (Jokovic et al. 2003). The Early Childhood Oral Health Impact Scale (ECOHIS) has been widely used in preschool children (Kumar et al. 2014). It has been shown that preschool children with caries had higher mean ECOHIS scores (Martins-Júnior et al. 2012; Martins-Júnior et al. 2013; Scarpelli et al. 2013; Li et al. 2015), and the severity of early childhood caries was related to the level of negative impacts on OHRQoL of children and their parents even after adjustment for child's age and family socio-economic status (Abanto et al. 2011; Wong et al. 2011). In addition, increasing child caries experience was found to be associated with worsening child and family quality of life. A recent health centre-based cross-sectional study in Brazil using Brazilian ECOHIS (B-ECOHIS) confirmed the finding even within different socio-economic strata (Chaffee et al. 2017). This finding is in line with the finding of another cross-sectional study in Brazil, using the same scale and reporting that cavitated lesions had an impact on OHRQoL even after hierarchical adjustment from distal to proximal determinants: socio-demographic, health perception and oral health condition using Poisson regression (Gomes et al. 2014). This finding was in agreement with another matched case-control study (matched by age, sex and family income) with preschool children (Firmino et al. 2016) and several cross sectional studies with preschool and school children (Leal et al. 2012; Ramos-Jorge et al. 2014; Ramos-Jorge et al. 2015) using ICDAS criteria. These studies added an additional finding that carious lesions in more advanced stages of

progression and higher level of cavitated caries were associated with a negative impact on the quality of life of children.

Moreover, conditions such as pulpal involvement, dental infection (pufa) and history of tooth extraction were found to be related to higher ECOHIS scores (Leal et al. 2012), which was similar to another Brazilian study that used the Parental Perceptions Questionnaire (PPQ) for preschool children and reported considerable impact of caries on some aspects of quality of life, i.e. mainly toothache and problems eating certain foods (Gradella et al. 2011). Another parental proxy scale, the Infant and Toddler Child Quality of Life Questionnaire showed that children with chronic and acute dental caries had a poorer quality of life than caries-free children in relation to behaviour, mood, pain and parental impact (Easton et al. 2008). However, all these measures depend on parental responses. It has been argued that patients themselves are in the best position to assess their symptoms and quality of life. Besides, children and parents do not necessarily share similar views about OHRQoL (Theunissen et al. 1998). So, proxy reports may not represent the reality experienced by the child, but they can supplement the child's evaluation (Jokovic et al. 2003). Thus children should be the primary source of information regarding their OHRQoL (Gherunpong et al. 2004; Tubert-Jeannin et al. 2005; Bennadi & Reddy 2013) and both child and parental perspectives should be considered (Ferreira et al. 2012).

By using a self-reported scale namely the Child Perception Questionnaire for children aged 8-10 years (CPQ 8-10), a study in Brazil reported that decayed teeth (d/D component) were associated with having negative perceptions of

oral health status (Martins-Júnior et al. 2012). Along with untreated dental caries, its clinical consequences (PUFA/pufa) were found to be associated with functional limitations subscale (Mota-Veloso et al. 2016). However, these studies only considered d/D components, whereas missing and filled teeth might also have impacts on OHRQoL. The number of decayed and missing teeth was significantly associated with higher CPQ 8-10 and CPQ 11-14 scores (Barbosa et al. 2013). Similarly using preadolescent CPQ 11-14 and PPQ; a cross sectional study with 1,120 Chinese children showed that dental caries had a negative effect on children (Li et al. 2014). Further studies focused on different components of OHRQoL using CPQ 8-10 and CPQ 11-14, showed that an increase in the number of carious teeth had negative impact on psychosocial (Portuguese version) (Barbosa et al. 2016), oral symptom (Pulache et al. 2016), and functional domains (Alsumait et al. 2015). In their study Alsumait and colleagues (2015) measured each component of DMF and found that preventive treatment had a positive impact on children's emotional well-being and restorative treatments improved their oral function. However, this study in Kuwait was a cross-sectional study hence the findings need to be cautiously interpreted.

Some studies found that other factors, mainly socio-economic position were also related to the OHRQoL score. For example, a systematic review showed that children from more advantaged socio-economic backgrounds had better OHRQoL. Moreover, mothers' age, family structure, household crowding and presence of siblings were also significant predictors of children's OHRQoL (Kumar et al. 2014). A longitudinal study with Thai children with nine months follow-up, Gururatana et al. (2014) found that worse OHRQoL at 6-month

follow-up was predicted not only by untreated caries at baseline but also socio-economic status; by using structural equation modeling. The influence of socio-economic status was confirmed by two more cross-sectional studies in Brazil, which reported that along with dental history, socio-demographic characteristics (Barbosa et al. 2016), as well as psychosocial variables (Schuch et al. 2014) had an association with CPQ scores. Interestingly another Brazilian study using CPQ 11-14 concluded that both socio-economic and clinical variables had significant impact on both general and OHRQoL (Paula et al. 2015). This linking of quality of life in terms of general and oral health leads to the importance of assessing OHRQoL to explain the association of dental caries with growth of the children.

Measuring oral impacts in children is particularly relevant as oral health can impact on eating, smiling, speaking and is related to self-esteem, emotional well-being and social interaction. The Child Oral Impacts on Daily Performances (Child- OIDP) was developed to assess the prevalence and severity of impacts of oral conditions and factors related to the impacts (Gherunpong et al. 2004). Studies that used the Child- OIDP give an insight into the relationship between oral and general quality of life issues. Studies from a nationally representative sample in Thailand of children aged 12 and 15 years reported that severity of dental caries was associated with negative oral impacts on various daily performances, especially eating performance (Krisdapong et al. 2013a; Krisdapong et al. 2013b). Another study with 5-6-year-old Thai children reported that dental pain and eating difficulty were the most prevalent impacts (Krisdapong et al. 2014) and children with low socio-

economic status were more likely to have high level of caries and subsequent oral impacts.

A systematic review of child perceptions of OHRQoL showed that, by using appropriate questionnaire techniques, valid and reliable information can be obtained from children concerning their OHRQoL (Barbosa & Gaviao 2008) and a recent study in Brazilian primary healthcare centre showed that the response on OHRQoL of children of as young as 5 years is not influenced by their parents (Granville-Garcia et al. 2016). Nevertheless, only a limited number of self-reported scales for preschool children have been developed. Using such self-reporting scales, namely Michigan OHRQoL and Paediatric Oral Health Related Quality of Life, it was shown that children afflicted with early childhood dental caries had poorer OHRQoL than their healthy counterparts (Filstrup et al. 2003; Huntington et al. 2011). However, there were some limitations of these studies. Firstly, there were lack of information on validation of measurement in some studies (Gilchrist et al. 2014). Secondly, despite the evidence of impact of potential confounding factors, some studies did not consider socio-demographic or psychosocial factors when measuring OHRQoL (Foster Page et al. 2013; Li et al. 2014). Therefore, these factors should be taken into account when measuring OHRQoL.

For this project, the recently developed Scale of Oral Health Outcomes for 5-year-old children (SOHO-5) was used (Tsakos et al. 2012). The advantage of the SOHO-5 is that it discriminates well between different caries severity groups, in relation to active caries lesions, pulp involvement and dental

sepsis (Tsakos et al. 2012; Abanto et al. 2013). The item specific analysis of SOHO-5 showed that dental caries causes difficulty in eating, drinking, sleeping, speaking, playing and smiling (due to pain and due to appearance) (Tsakos et al. 2012).

Given its relatively recent development, the SOHO-5 scale has not yet been tested in many different countries. Moreover, to date there is no validated OHRQoL measuring scale available for children in the Bengali language. Therefore, the translation and validation of the SOHO-5 would be helpful for future use in clinical and research settings for around 211 million Bengali speakers in Bangladesh and the Indian State of West Bengal.

Most of the previously discussed studies showed the impact of dental caries on OHRQoL and did not consider its effect on the child's height, weight and BMI, although OHRQoL is reported to be associated with poor general health (Scarpelli et al. 2013). In line with this, a recent review showed the possible effects of early childhood caries on both the child's dental health and general health and well-being (Finucane 2012). Therefore, the contribution of OHRQoL in order to explain the pathways of association between dental caries and children's anthropometric measures needs to be properly explored. This should also include an individual assessment of important growth related components of OHRQoL. The following section examines the specific effect of dental caries on dental pain, eating difficulty, poor appetite and sleep disturbance and their association with children's height, weight and BMI.

2.7.2 Dental caries and dental pain

Pain is part of the symptoms domain of oral health related quality of life. Dental pain is also considered as the intermediate factor for impacts of caries on eating and sleep disturbance. Therefore, this section reviews evidence on dental caries as a major cause of dental pain, the direct and indirect impact of dental pain on growth, impact of dental pain on quality of life and measurement of dental pain.

Dental caries is a common cause of dental pain in childhood (Boeira et al. 2012). One in five children with decayed teeth present with toothache, and the probability of toothache increases by 5% to 6% for each additional deciduous tooth with caries (Slade 2001; Tickle et al. 2008) and pain is more likely in unrestored carious teeth (Tickle et al. 2008). Ferraz et al (2014) in their study with 540 Brazilian preschool children showed that each component of pufa was associated with dental pain. Other, more distal factors related to dental pain include low socio-economic status, restricted access to dental services, and low maternal education (Goes et al. 2007; Nomura et al. 2004; Lemes et al. 2015).

Dental pain and infection might have a direct impact on general health and growth of children through an increase of glucocorticoid production, which may affect normal growth and general health of children with severe early childhood caries (Acs et al. 1992; Ayhan et al. 1996; Ohlund et al. 2007). Although several studies have investigated the association between dental pain and quality of life, which might indirectly affect growth, direct effects of dental pain on child's growth have not yet been fully explored.

Dental pain is considered as the most prevalent cause of oro-facial pain which in turn is associated with poor general quality of life among children (Kumar et al. 2016). As mentioned earlier, studies examining individual domains of OHRQoL reported that dental pain was the most important factor leading to poor OHRQoL (Gradella et al. 2011). Children with caries experience were more likely to present with dental pain in a recent Brazilian case-control study with preschool children, where the most frequent responses on the B-ECOHIS were 'felt pain' (79.7%) (Firmino et al. 2016). Similarly, a study in India found that 28% of children were experiencing high-level oral impacts, of which 58% reported dental pain (Krisdapong et al. 2014). Thus, the presence of dental pain negatively affects children's OHRQoL (Ortiz et al. 2014).

However, it can be difficult to identify toothache in young children (Pau et al. 2003), as they may not verbalize their dental pain (Parke 2008). In a review Pau et al. (2003) recommended the need for standardized measurement criteria for dental pain as it has many components with strong functional impacts. Also it is often expressed through changes in behaviour (Baeyer et al. 2011). Thus, the presence of particular toothache related behaviours could give insight of toothache among younger children (Versloot et al. 2006). Several studies have focused particularly on the impact of dental pain on daily functioning, specifically on eating or chewing, drinking, sleeping, playing, and tooth brushing (Moura-Leite et al. 2008; Moura-Leite et al. 2011; Bönecker et al. 2012); these were shown to have marked impacts on children's psycho-social well-being (Shepherd et al. 1999; Moura-Leite et al.

2008). Moura-Leite et al. (2008) found that 59% of Brazilian children reported one or more negative impacts due to dental pain.

These studies have linked dental pain to daily functioning but not directly to child growth or anthropometric measures. Nevertheless, dental pain induced problems with eating and sleeping (Daher et al. 2014), which might explain the link between dental caries and child growth. Associations between dental caries and eating difficulty, poor appetite and sleep disturbance are reviewed in the following part.

2.7.3 Dental caries and eating difficulty

A commonly reported impact of dental caries on the functional limitation domain of OHRQoL is eating disturbance (Jokovic et al. 2003; Pahel et al. 2007; Martins-Júnior et al. 2012; Tsakos et al. 2012; Abanto et al. 2014; Yusuf et al. 2006; Tubert-Jeannin et al. 2005). A recent study showed that both dental pain and eating problems were major contributing items to child OIDP (Montero et al. 2016). Also a high prevalence of eating difficulty due to dental caries, for instance: 35% (Firmino et al. 2016), 46% (Krisdapong et al. 2014), and 37% (Pentapati et al. 2013) was reported by several studies. Moreover, eating of certain foods was also a commonly reported problem from children (Gradella et al. 2011). Gradella et al. (2011) analysing individual component of parental perception questionnaire reported that having severe caries was significantly related to toothache and problems eating certain foods among 2-4-year-old Brazilian children. In a cross-sectional study by Vania et al. (2011) reported changes in diet habits due to dental caries. Dental pain increases with the simple introduction of food into

the mouth and chewing, which may cause changes in the diet from solid to liquid or semi-liquid and reduces the ability to eat a varied diet, with subsequent reduction of caloric intake (Vania et al 2011; Clarke et al. 2006). Dental pain is particularly associated with a diet low in fruits, vegetables and non-starch polysaccharides that may result in a low uptake of fibre and beta carotene (Sheiham & Steele 2001). Tooth decay may therefore impede the achievement of dietary goals related to the consumption of fruits, vegetables and non-starch polysaccharides (Moynihan & Petersen 2004). Thus, difficulty in chewing or eating and alteration of food preference due to dental caries (Barbosa et al. 2013; Vania et al. 2011) may contribute to malnutrition (WHO 2003). Barbosa et al (2013) showed that a higher number of missing teeth correlated with an inferior masticatory performance in older children. However, in their study they tested the masticatory function by using artificial component (Optocal plus) that might have impact on the result due to artificial nature of chewable test material. A psychometric validation study of a new scale on self-applied 'Quality of Masticatory Function Questionnaire' among Brazilian adolescents showed that the caries group had significantly higher mean scores (worse masticatory performance) in food-mastication, specially for meat and fruits, compared to children without caries (Hilasaca-Mamani et al. 2016). This is in agreement with Schroth et al. (2013) who reported that children with severe early childhood caries had relatively poor nutritional health compared to caries-free controls and were significantly more likely to have low vitamin D, calcium, and albumin concentrations and elevated Parathyroid Hormone (PTH) levels. Moreover, severe early childhood caries may be a risk marker for iron deficiency anemia as children

with severe early childhood caries showed inadequate iron intake with low serum ferritin, iron depletion, and iron deficiency, and appear to have significantly lower haemoglobin levels (Clarke et al. 2006; Schroth et al. 2013). In a recent study in India, Bansal et al. (2016) reported that severe early childhood caries is strongly associated with iron deficiency anemia and lower body weight. One criticism of this study was the small sample size, as this study considered only 30 children with severe early childhood caries and 30 controls with caries status <2 deft (decayed, extracted and filled teeth), without a caries-free comparison group. Although this study collected data on OHRQoL, the data analysis did not assess whether OHRQoL, particularly eating difficulty, contributed to explain the association with body weight.

Protein-energy malnutrition and deficiencies of iron and iodine early on in life can lead to compromised growth and contribute to children not reaching their developmental potential (Black et al. 2013). In addition to this, other micronutrients, mainly iron, vitamin A, iodine, and zinc, also play a role in development and deficiencies of these essential micronutrients have an impact on poor growth (Wasantwisut 1997; Katona & Katona-Apte 2008) which is a serious public health concern in most LMICs (Caulfield et al. 2006; Chakravarty & Sinha 2002). Prosthetic rehabilitation of children with multiple teeth extraction due to dental caries showed improved masticatory function that contribute to the development of normal dietary habit (Sacramento et al. 2011). Therefore, the associations between dental caries, nutritional deficiency and poor growth warrant further investigation.

2.7.4 Dental caries and poor appetite

If dental caries remains untreated it may lead to infections and inflammation (acute and chronic) and result in similar immune responses and production of inflammatory mediators (cytokine mechanism) as a general infection (Hahn et al. 2000; Soet et al. 2003). Loss of appetite is a universal sign of infection. Infection from dental caries and pulpal involvement may therefore reduce appetite in children in a similar way to other infectious diseases (Langhans 1996; Plata-Salamán 1996), and the resulting decrease in food consumption might lead to under nutrition (Stephensen 1999). Some children react to dental pain with decreased appetite and increased irritability (Thomas & Primosch 2002). So far, only one RCT using a specific appetite scale showed that dental treatment could improve children's appetite significantly (Alkarimi et al. 2012). However, loss of appetite due to dental caries and its impact on children's height and weight has not been thoroughly studied yet.

2.7.5 Dental caries and Sleep disturbance

Another impact of dental caries on quality of life is sleep disturbance, which may indirectly affect child growth (Alkarimi et al. 2014). This section reviews the importance of sleep for healthy growth of children in general and then in particular the evidence on sleep disturbance due to dental caries.

Sleep disturbance is one of the most common medical concerns during childhood, which is associated with different environmental factors and other health conditions (Dewald et al. 2010; Jernelöv et al. 2013; Serra-Negra et al. 2014; Arora et al. 2014). Insufficient sleep, poor sleep quality, irregular

bedtimes in children and adolescents are related to poorer cognitive performance (Kelly et al. 2013; Dewald et al. 2010), day time sleepiness, anxiety, depression, attention deficit and behavioural disorders (Ohayon et al. 2000).

Normal sleep, especially slow wave sleep, is essential for child growth as approximately 70% of the growth hormone pulses during sleep coincide with slow wave sleep, and the amount of growth hormone secreted during these pulses correlates with the concurrent amount of slow wave sleep (Cauter & Plat 1996). There is good evidence that disturbed sleep due to adenotonsillar hypertrophy and sleep disordered breathing in children is a risk factor for growth failure (Bonuck et al. 2006; Strading 1990).

Dental caries leading to pain is a major cause of sleep disturbance in children (Shepherd et al. 1999; Moura-Leite et al. 2008; Moura-Leite et al. 2011; Abanto et al. 2011; Martins-Júnior et al. 2013). Nevertheless, few studies have been conducted on the impact of sleep disturbance due to dental caries on the growth of children. A cross sectional study in India reported that 3-6-year old children had problems falling asleep and maintaining sleep due to dental pain from caries. However, this study did not use a standard sleep disturbance scale and did not consider a healthy comparison group in their sample (Acharya & Tandon 2011).

Sleep disturbance due to caries may have impact on child growth as it is hypothesized that continuous waking during the night inhibits a relaxing slow wave sleep, with consequent stress and nervousness causing more

glucocorticoid secretion and deeper inhibition of growth hormone release (Acs et al. 1992; Sheiham 2006; Vania et al. 2011). This is in accordance with Duijster et al. (2013), who reported from a RCT conducted in the Philippines that decreases in oral health impacts on sleeping appeared to be most strongly associated with weight gain after dental treatment. However, the pattern of sleep disturbance in children due to dental caries and its association with anthropometric measures has so far not been explored in depth.

In the light of the aforementioned studies it can be hypothesised that dental caries may have negative impacts on children's quality of life and growth. The effect of dental treatment on improvement of OHRQoL and weight gain will provide further evidence of this association.

2.8 Effect of dental treatment on children's quality of life and body weight

2.8.1 Improved OHRQoL after dental treatment

Dental treatment can make a significant difference to the psychological and social aspects of life of a child (Sheiham 2006). Studies investigating parental perceptions of their child's quality of life following dental rehabilitation found that treatment of dental caries leads to significant improvements in pain, eating ability, quality of food eaten and sleep habits (Low et al. 1999; Acs et al. 2001; Anderson et al. 2004; Malden et al. 2008; Cunnion et al. 2010). An RCT of 3-5-year-old children showed that dental treatment improved OHRQoL of preschool children (Abanto et al. 2016). However, the sample size of this study was only 100 parent-child pairs and the follow-up period was only 7-14 days after treatment. Another study using dental discomfort questionnaire showed that dental treatment of children led to reduced toothache-related behaviours (eight questions on problem with tooth brushing, problem with chewing, avoid certain foods, crying during meals), although chewing or biting problems still persisted in some children after extraction of teeth (Versloot et al. 2005).

Children's self-reports also showed that treatment of early childhood caries improved their OHRQoL in a significant way (Filstrup et al. 2003; Abanto et al. 2013). Interestingly, children as young as 36 months were able to report their perceptions of improvement of their OHRQoL after dental treatment. Moreover, an innovative interventional study in Tanzania with 1,306 school children, where study participants were allocated into three groups: 104

children in Group A (atraumatic restorative treatment); 117 children in Group B (atraumatic restorative treatment and tooth extraction), and 1,085 children in Group C (oral hygiene instruction), collected data at the baseline and follow-up data after six months. The study observed that Child-OIDP score changed differently for different treatment intervention groups, where improvements following dental extraction and filling group were more than the other two groups (Mashoto et al. 2010). By using CPQ 8-10 de Paula et al. (2015) reported that children with dental caries showed significant improvement in OHRQoL four weeks after treatment. In a systematic review on change in children's OHRQoL following dental treatment under general anaesthesia for the management of dental caries, Knapp et al. (2017) reported that treatment under general anaesthesia appears to result in overall improvements in proxy-reported OHRQoL. However, these studies did not consider the height and weight of the children and heterogeneity of included papers limited the conclusions that could be drawn. Thus there is a need for further high-quality studies employing validated, child-reported measures of OHRQoL (Knapp et al. 2017).

2.8.2 Weight gain after dental treatment

Finally, studies that considered both OHRQoL and growth provide further evidence of an impact of dental caries on anthropometric measures via OHRQoL. Alkarimi et al. (2012) in her RCT showed that children who received treatment for dental caries had significantly less pain, less sepsis and higher satisfaction with teeth, improved smile and appetite compared to

controls. However, this study failed to show any improvement in growth, which may be due to the short follow-up period.

The result was accordance with Thomas & Primosch (2002) who reported from their interventional study on 50 children aged 2-7-year-old in Florida that following dental rehabilitation under general anaesthesia there was significant improvement in the children's quality of life but the increase in the mean percentile weight was non-significant. In addition, Duijster et al. (2013) from a RCT in the Philipines found that there were improvements in oral health related impacts, especially on sleeping, after extraction of severely decayed teeth in underweight children that were associated with weight gain after extraction. Another interventional study among 100 preschool children (50 children with severe early childhood caries, 50 without caries) of lower socio-economic status in India reported that at base line 40% children complained pain, 24% reported avoidance of hard food and 12% complained sleep disturbance and 18% noticed weight loss. After six months of dental rehabilitation, the study reported a significant improvement in weight and quality of life (Gaur & Nayak 2011). However, that study did not measure overall OHRQoL by using a valid questionnaire and the justification of small sample size was not made.

2.9 Theoretical model of hypothesised mechanisms for how caries could affect children's height and weight

Theoretical frameworks that focused on consequences of dental caries may provide a comprehensive understanding on underlying mechanism of the association between dental caries and child growth. The review of the literature suggests that severe untreated dental caries could lead to pain and infection and poor OHRQoL, which in turn may affect child growth. Potential mechanisms include reduced food intake and disturbed sleep. Previously Alkarimi et al. (2014) proposed a conceptual model to illustrate these associations. However, due to the complexity of that model it would be difficult to test that model through any study. Therefore, the following conceptual framework depicted in Figure 2-2 was adapted from Sheiham (2006) and Alkarimi et al. (2014) and shows the hypothesized mechanism of how caries might affect children's height and weight:

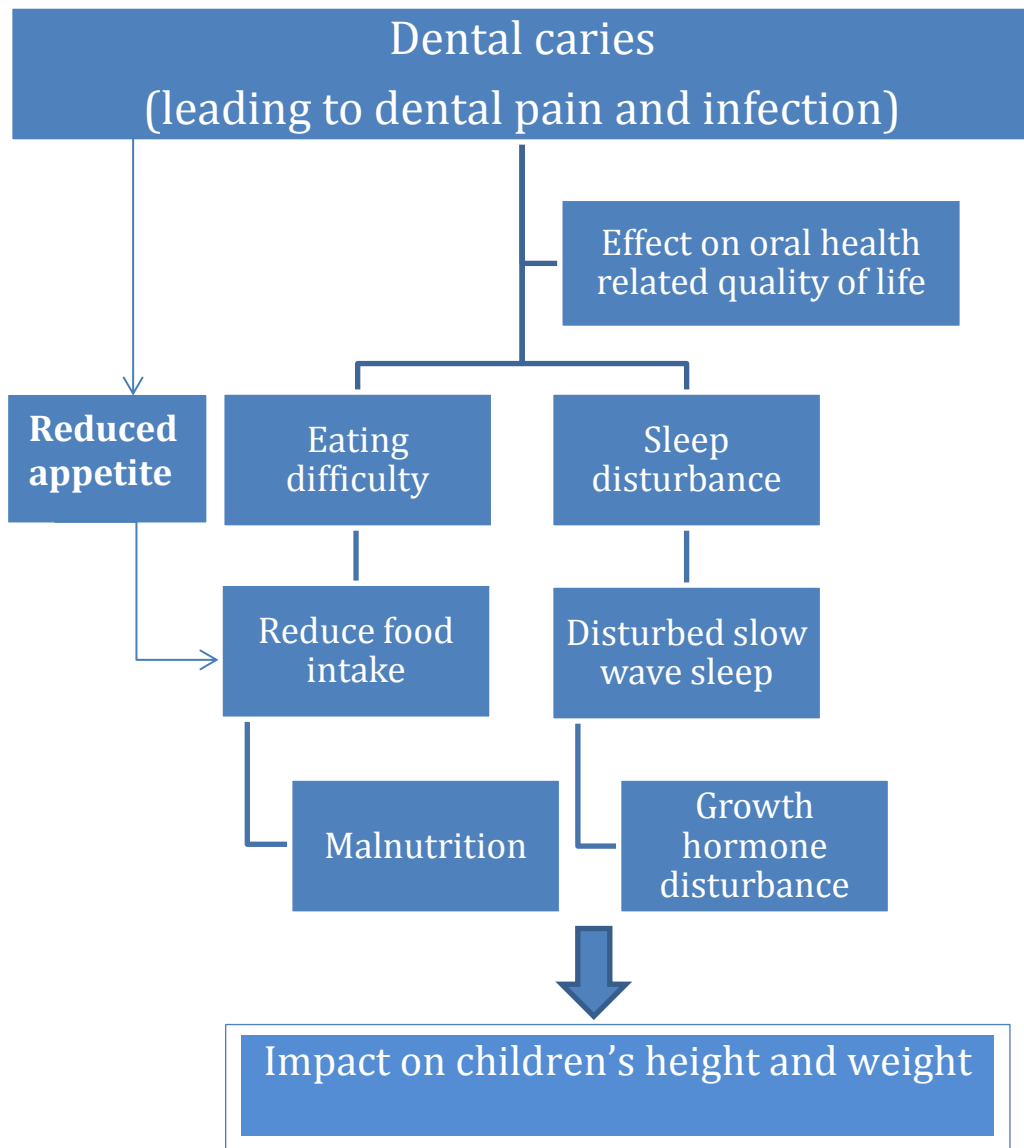


Figure 2-2 Hypothesised mechanisms linking dental caries to children's height and weight

2.10 Summary and gaps in current knowledge

Dental caries and underweight are key public health issues affecting children at an important phase of their development. But, there is still little research on the associations between these two conditions, particularly in the population of Bangladesh.

Most of the reviewed studies have examined links between either dental caries and anthropometric measures, or dental caries and quality of life, but have not considered these factors together. Moreover, the effects of individual important components of OHRQoL on anthropometric measures have rarely been assessed. Therefore, this thesis aims to address this gap in scientific knowledge by exploring, in detail, how dental caries is associated with children's height and weight via OHRQoL, particularly via caries related dental pain, eating difficulty, poor appetite, and sleep disturbance while taking potential confounding factors into account.

2.11 Study aim, objectives and hypotheses

Aim

The primary aim of this study was to assess the associations between dental caries and anthropometric measures among 5-9-year-old Bangladeshi children. A secondary aim was to examine the possible factors underlying these associations, that is, the effect of OHRQoL and particularly that of experience of dental pain, eating difficulty, loss of appetite and sleep disturbance.

Objectives

The specific objectives of this thesis were:

1. To adapt a measure of OHRQoL for young children (SOHO-5) to the Bengali language and to evaluate the validity and reliability of the Bengali SOHO-5 instrument.
2. To examine the associations between dental caries and dental sepsis with anthropometric measures (age adjusted height, weight, and BMI) of the children.
3. To examine the role of OHRQoL on the association between dental caries and sepsis and anthropometric measures of the children.
4. To explore the specific role of experience of dental pain, eating difficulty, loss of appetite, and sleep disturbance due to dental caries on the

association between dental caries and sepsis and anthropometric measures of the children.

Study hypotheses

Hypothesis for objective 2

The hypothesis related to this objective was that dental caries and sepsis would be inversely associated with children's age adjusted height, weight and BMI.

Hypothesis for objective 3

The working hypothesis of this objective was that dental caries and sepsis results in oral impacts (i.e. impaired / compromised OHRQoL), which in turn are negatively associated with age adjusted height, weight and BMI of children.

Hypothesis for objective 4

The hypothesis related to this objective was that dental caries and sepsis results in dental pain, eating difficulty, loss of appetite and sleep disturbance; these factors are hypothesized to partly or fully explain the inverse association between caries and sepsis with age adjusted height, weight and BMI of children.

Chapter 3 Methodology

3. Methodology

This chapter presents an overview of the study's geographical location, research design, study population, study measures, data collection methods, and data analysis plan.

3.1 Study location

The data collection was carried out in the city of Dhaka in Bangladesh (Figure 3-1). Bangladesh is a lower middle income country in South East Asia with a total land area of 130,172 square kilometres and total population of 163 million people (UN 2016).

Dhaka is the capital city of Bangladesh with an area of 1,528 square kilometres. It is one of the most densely populated cities in the world, with a total population of 17 million people and more than 45,000 people per square kilometre. Per capita average income is \$1314 per year (Bangladesh Bureau of Statistics 2014).

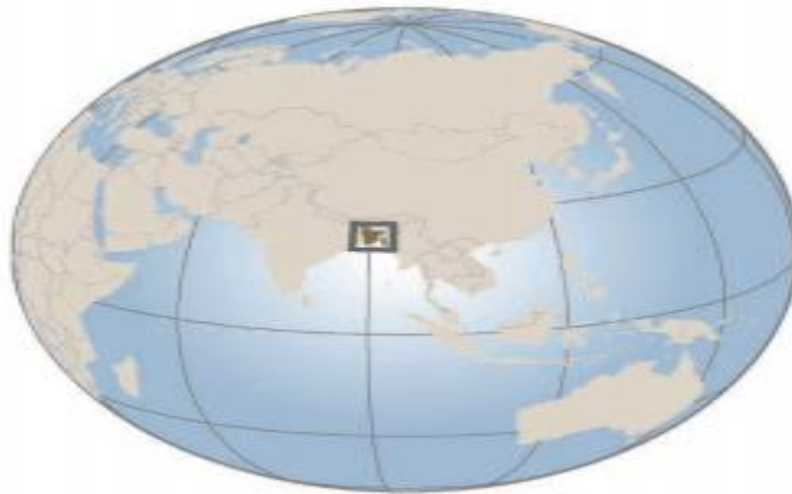


Figure 3-1 Study location: Dhaka, capital city of Bangladesh

3.2 Study design and sampling

The study was conducted as a cross-sectional observational study.

3.2.1 Sample selection

The study was conducted among 5-9-year-old children and their parents. The age range of 5-9 years was chosen based on the following considerations. Firstly, although childhood is a period of continuous growth, the growth between the ages of 5-9 years is relatively stable (Tanner & Whitehouse 1976). The upper age limit was set at 9 years before the start of any pubertal growth (Harvey 1995; Rogol et al. 2000). Secondly, to meet the objectives of the study it was considered important to include children's own reports of their oral health related quality of life. It has been suggested in the literature that the ability to answer a self-reported pain and problem related questionnaire usually improves considerably from the age of 5 (Landgraf & Abetz 1996). Children as young as 5 years of age can provide reports on pain (Connolly & Johnson 1999). Therefore, the lower age limit for this study was set at 5 years. Moreover, the outcome measures used in this study are based on WHO child growth standards, which are reported for children aged 0 to 59 months and children aged 5 to 19 years separately (WHO 2007).

Although Bangladesh has been considered as a country with a low level of dental caries (Petersen 2003), so far no representative epidemiological studies have assessed caries levels in children of Bangladesh. To meet the objectives of this study it was important to include children with a

range of caries levels. The study population was therefore selected from two settings: a clinical setting (a large dental teaching hospital), and a community setting (three local schools in the neighbourhood of the hospital).

Hospital sample

Participants were recruited among children receiving dental treatment at the Department of Paediatric Dentistry, Dhaka Dental College Hospital, which is the largest dental educational institution and dental hospital in Bangladesh. It is the only Government Dental Hospital in Bangladesh where people can access free dental treatment (DDCH 2017).

School sample

Dhaka Dental College Hospital is located in the Mirpur Thana area of Dhaka city. The schools were selected from the same area. In Mirpur Thana there are 55 schools (Online Dhaka 2014), of which 26 schools are situated within five kilometres vicinity of the hospital. Of those 26 schools, five schools were randomly selected and contacted to ask whether they would be willing to take part in the study. Three primary schools agreed to participate and gave permission for data collection: Model Academy, Kallyanpur School and Bashiruddin Primary School. All the children of year one and two (aged between 5-9 years) attending these schools and their parents were invited for the study.

3.2.2 Inclusion/exclusion criteria

Children aged 5-9 years coming for dental treatment to the hospital dental clinic between August 2015 and October 2015 and all students of year one and two in the primary schools were invited to join the study. The age of starting school varies in children of Bangladesh and year one and two children mostly cover the 5-9 year age group.

Children older than nine years, children with any systemic diseases and children who had acute infections, fever or diarrhoea during the week preceding the data collection were excluded. Students who took part in the pilot study were also excluded from the main study.

3.3 Ethical approval

Ethical approval was obtained from the UCL Research Ethics Committee and 'National Research Ethics Committee of Bangladesh' through the Bangladesh Medical Research Council. Permission was obtained from the director of the hospital and the principals of the primary schools to run the study in their institutions (Appendix 2). The parents were asked for written consent before their and their child's participation in the study (information sheet and consent form can be found in Appendix 3).

3.4 Pilot study

A pilot study was conducted in January 2015 in Bangladesh. The methodology for the pilot study is presented in Appendix 4.

3.4.1 Objectives of the pilot study

1. To test the adequacy, feasibility and appropriateness of the research instruments.
2. To assess the likely success of the proposed recruitment approaches.
3. To identify and resolve any potential logistical problems before running the main study.
4. To collect data to facilitate the sample size calculation for the main study.

3.4.2 Results of the pilot study

The pilot study achieved a sample size of 272 children, of whom 127 were recruited from the hospital setting and 145 were from one of the primary schools (Model Academy). The response rate for the parental questionnaire was 100% for the parents of the hospital sample and 65% for the parents of the school sample. The overall response rate was 82.5%. The pilot study demonstrated the overall feasibility of the procedures adopted for the study and suitability of the research instruments. However, it also identified some potential difficulties and resulted in some minor modifications of the procedures of questionnaire administration (the parental questionnaire used in the pilot study and details of amendments of the questionnaire following the pilot study are

presented in Appendix 4). The final versions of the questionnaires for parents and children used for the main study are presented in Appendix 5.

3.5 Calculation of the final sample size

The required sample size for the main study was calculated using the results obtained from the pilot study. The total sample of the pilot study (272 children) was divided into tertiles based on the severity of dental caries, assessed by dmft/DMFT index, which resulted in the following three groups:

- Group 1 (no caries or low level of caries): children with dmft+DMFT of 0 to 1,
- Group 2 (moderate level): children with dmft+DMFT of 2 to 4,
- Group 3 (severe level): children with dmft+DMFT of 5 or higher.

Mean BAZ scores were calculated for children with low, moderate and severe levels of dental caries. The mean difference in BMI-for-age z-scores (BAZ) between groups 1 and 2 was 0.36, while between groups 2 and 3 it was 0.37. The outcomes of this study were in z-scores, which means a z-score of 1 represents 1 standard deviation (SD) of the reference population mean of 0. The pilot study found a difference slightly larger than 0.33 (or one third) of an SD; So, the sample size calculation was carried out considering BAZ scores difference of 1/3 of a standard deviation between two caries groups, and standard deviation of 1 (as recommended by WHO) (Rousham et al. 2011).

Based on this calculation and considering 80% power and with the level of statistical significance (α) set at 0.05, the minimum required simple size was 145 children in each group (Appendix 6), resulting in a total of 435 children for three groups. The Open Epi version 3 online calculator has been used for this calculation (Dean et al. 2015). Considering a design effect of 1.5 (Killip et al. 2004), the estimated sample size became 653. Finally, assuming a response rate of 82% (following the results from the pilot study), the final total estimated sample size needed for the study was 797. The sample size was calculated so that the study would be able to detect a difference between the groups of one third of a standard deviation, as this was considered a meaningful difference.

3.6 Data collection

Data for the main study were collected over three months between August and October 2015. The data collection consisted of clinical (dental and anthropometric data) and non-clinical parts (questionnaire data). Figure 3-2 presents different types of data that were collected from children and their parents.

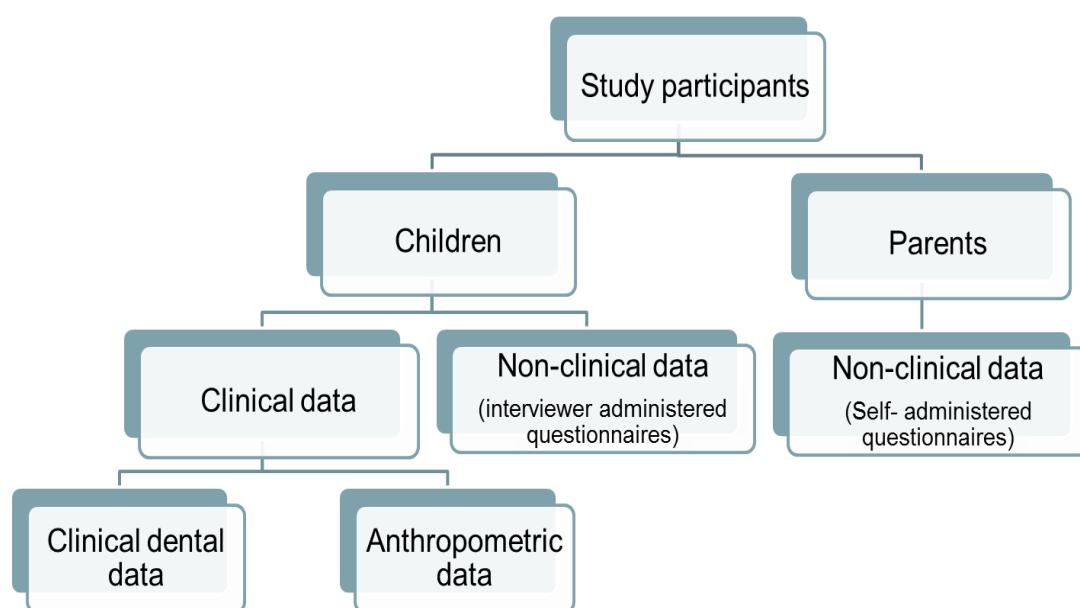


Figure 3-2 Types of data collected from the study participants

3.6.1 Developing contacts with hospital and school staff

Initial preparation included making contact with the hospital and school authorities, recruitment of study participants and consent procedures. Permission was obtained from the hospital and school authorities. Before beginning the main study, face-to-face meetings were organized between the researcher (PhD candidate) and the principal or head teacher of each of the schools and the director of Dhaka Dental College Hospital and respective duty doctors of the Department of Paediatric Dentistry. The purpose of the meetings was to present the research objectives, seek collaboration and agree suitable dates and times to run the survey. Then meetings were conducted with the respective class teachers regarding their cooperation for distribution of information sheets and obtaining

parental consent, and for the distribution and collection of parental questionnaires.

Study incentives: A toothbrush and toothpaste was given to every child surveyed as an incentive at the end of the survey for both settings. Additionally, at the end of data collection in each school section, a brief educational session including a tooth brushing demonstration was carried out to improve oral health awareness among children and teachers.

3.6.2 Recruitment of field investigators

In the survey team, there were six dentists (three dentists to carry out clinical oral examinations and three recording assistants). Five other investigators took anthropometric measurements and conducted interviews. Care was taken to recruit research team members who were enthusiastic and skilled, with experience in fieldwork in dental research. All recruited dentists had completed their internship and had experience of collecting survey data in Bangladesh.

3.6.2.1 Training and calibration of the survey team

The training and calibration was conducted in the paediatric department of the hospital. Initial contact was made with the hospital authority to run the training programme. An intensive two days training programme was conducted to ensure the survey team was fully familiar with the criteria and procedures involved in the clinical oral examination. After the training sessions a calibration test was conducted on caries detection with the

survey team. Further details on the training and calibration procedure are presented in Appendix 7.

Cohen's un-weighted Kappa coefficient was used to assess overall agreement within and between examiners (inter and intra-examiner consistency) in caries assessment. For the calibration, dental caries was defined as visible carious lesions with cavitation into the dentine and the tooth was taken as a unit of analysis. The average Kappa for the intra-examiner reproducibility was 0.92 and for the inter-examiner reproducibility (compared to one examiner as standard) was 0.88, revealing very good agreement.

During the main data collection, repeat oral examinations were carried out by one member of survey team (PhD candidate) on 20 randomly selected children one week after the first clinical oral examination. The average Kappa for diagnosis of visible cavitated caries lesions was 0.83, again indicating very good agreement.

3.6.2.2 Training on height and weight measuring and interviewing

A separate part of the training was on taking accurate height and weight measurements (procedure is presented in section 3.6.4.2). Interviewers were also trained beforehand on administration of the questionnaire and conducting interviews with the children in a friendly manner.

3.6.2.3 *Daily log and periodic meetings*

A daily log was maintained during the whole period of data collection and was shared with other examiners every day. The daily log had information on the place where data collection was undertaken, number of children surveyed, attendance of field staff and difficulties faced. Besides maintenance of the research log and daily discussion, a weekly meeting was organized by the researchers to do a retrospective analysis of the work done; difficulties and challenges faced and plan for the future work.

3.6.3 *Recruitment of study population*

3.6.3.1 *In the school setting*

All eligible children were given an information sheet and consent form (Appendix 3) through their class teachers to take home to their parents. The information sheets clearly explained the purpose of the study, procedures involved, the anonymity of participation, as well as that the participation was entirely voluntary and participants were free to withdraw at any time from the study without giving a reason. All clinical examinations and interviews took place in the classroom.

3.6.3.2 *In the hospital setting*

The parents of the eligible children were approached when they came to the pediatric dental department of Dhaka Dental College Hospital for their child's dental treatment. The parents of 5-9-year-old children were first invited verbally to take part in the study. The parents were then given the

information sheet and a consent form to sign. The study procedure was also explained to the child. Those children whose parents agreed and signed the consent form were recruited into the study. A separate room next to the out-patients' examination room was used for the study.

3.6.4 Collection of clinical data

All participating children underwent clinical dental examinations, as well as height and weight measurements.

3.6.4.1 Dental examinations

The dental examinations of the children were conducted following WHO guidance for oral health surveys (WHO, 2013). A non-invasive clinical dental examination was performed to measure children's dental caries experience. Criteria for assessing dental caries were adopted from the criteria that were used in the Children's Dental Health Survey 2013, UK (CDHS 2013) (Pitts et al. 2015). Dental examinations were conducted visually by dentists using hand torchlight with blue-white colour spectrum and a disposable plastic dental mirror, and following standard cross infection procedures. Examinations were done with the children sitting straight on a stool. Each child was examined by a dentist wearing a new pair of gloves and using disposable sterile instruments, and all used disposable instruments was discarded. The procedure for the dental examination, and the clinical assessment form used in the study are shown in Appendix 8.

3.6.4.2 Collection of anthropometric data

In this study both height and weight measurements of the children were taken as indicators of child growth. Height is considered as the best single index of growth (WHO 1995). Weight increase is taken as an indicator of satisfactory growth (Jolley 2003). Measurement of weight is useful if it is linked to height and age (Tanner 1976; WHO 1995). Also both measures were needed to calculate BMI.

Weight and height were measured in accordance with the Food and Nutrition Anthropometric Indicators Measurement Guide (Cogill 2003). Height was measured with the child standing without shoes using a portable stadiometer (Leicester height measure). Weight was measured with the child standing and wearing light clothes and not wearing shoes, by using a pre-calibrated digital Seca scale. Two measurements were taken for each child and the average was used for the analyses. The detailed procedures of the anthropometric measurements and the height and weight assessment forms are presented in Appendix 9.

3.6.5 Collection of non-clinical data

Non-clinical data were collected through questionnaires. Children in both settings completed an interviewer-administered questionnaire, which took no more than five to six minutes to complete, while their parents were requested to complete a self-administered questionnaire. The full questionnaires are shown in Appendix 5 and variables measured via questionnaires are summarized in Table 3.1

3.6.5.1 Interviewer-administered questionnaire for children

The Scale of Oral Health Outcomes for 5-year-old children (SOHO-5) questionnaire was used for the children (Tsakos et al. 2012). The SOHO-5 is an interviewer-administered questionnaire that was developed to assess the OHRQoL in young children through self-reports (Tsakos et al. 2012). SOHO-5 was used in this study because it is an internally consistent and validated measure. It contains seven questions assessing oral health-related impacts on daily life (described in section 3.7.3.1). Both a child and a parental version of the SOHO-5 are available. Initially validated in Scotland (UK), the SOHO-5 was also tested and validated in Brazil, showing agreement in mother and child responses (Abanto et al. 2014) and responsiveness to change after treatment of dental caries (Abanto et al. 2013). Moreover, the questionnaire is short with child friendly answer options that make it favourable to use in both research and clinical settings. In addition to SOHO-5, questions on toothache experience and satisfaction with oral health, and presence of holes in the teeth were included in the child questionnaire.

3.6.5.2 Self-administered questionnaire for the parent

In the school setting, the parental questionnaire was sent home with the child to be filled in by the parent, and returned to the class teacher. Detailed written instructions on how to fill in the questionnaire were provided to the parents. The telephone number of the researcher (PhD candidate) was also provided, in case parents needed further clarification, and the class teachers were also trained to clarify questions if needed. In

the hospital setting the parents completed the self-administered questionnaire during the time of their child's examination. However, parents who were unable to read and write were assisted to fill the questionnaire. The parental questionnaire had different parts. It contained the SOHO-5 parental questionnaire; questions on dental pain, eating difficulties, appetite, sleep disturbance, socio-economic background; as well as questions about markers of early childhood health and nutritional status (Brown et al. 1995; Bruni et al. 1996).

Table 3.1 Summary of variables measured in questionnaires

Variables	Child questionnaire	Parental questionnaire
OHRQoL: SOHO-5 child or parental questionnaire	V	V
Dental pain	V	V
Appetite		V
Eating difficulty		V
Sleep disturbance		V
Parental height and weight, socio-economic factors and markers of early childhood health and nutritional status		V

3.6.5.3 Cross-cultural adaptation of questionnaires

This section will provide a detailed account of the procedures followed for the cross-cultural adaptation of the questionnaires (child and parental) to use among the Bangladeshi population.

It is important that questionnaire translations are carried out with sensitivity to the local culture where the questionnaire would be administered (Acquadro 2009; Guillemin et al. 1993; Beaton et al. 2000). The questionnaires were developed in English and were translated into Bengali (Appendix 5).

The questionnaires went through forward-backward translation by three independent people who were not familiar with the field of study and constructs used in the questionnaire. First, two native Bengali speakers who are proficient in English worked independently to produce forward translation of the original questionnaire into Bengali. Then a consensus version was established by reconciling the differences between the translated versions. The consensus version was then backward translated into English by an independent person who is proficient in both languages (English and Bengali) and who was not involved in the forward translation process in order to ensure that the true meaning of the questions is not lost and the Bengali version carried the same questions as the English one.

The resulting backward translation was checked by the main researcher for discrepancies with the original English version, which revealed no

discrepancies, incorrect response categories or missing words/phrases. Therefore, the interpretations of the original questions were judged as adequate and the resulting Bengali translation was adopted for the study.

3.6.5.4 Validity and reliability test of Bengali SOHO-5.

The Bengali SOHO-5 was evaluated for validity (face, content and construct validity) and for reliability (internal consistency and test-retest reliability). The details of the validation and reliability testing, and relevant data analyses, are described in Appendix 10.

3.7 Study measures

Dental caries and dental sepsis were the main clinical exposures and height, weight and BMI were the main outcomes of the study. OHRQoL, experience of dental pain, eating difficulty, loss of appetite and sleep disturbance were included as potential mediators. Age, sex, parental socio-economic position, the markers of early childhood health and nutritional status and parental height and weight were considered as confounders in this study.

3.7.1 Outcome variables

Height, weight, and BMI were converted to z-scores, namely height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ), and BMI-for-age z-scores (BAZ) using WHO standard references 2007 (for children older than 5 years old) (Onis et al. 2007). The use of z-scores allowed comparisons of individual's weight, height or BMI, adjusted for age and sex relative to a reference population, expressed in standard deviations (SD) from the reference mean. The z-scores were calculated using Stata 13 and a Stata add-in called *zanthro* (Vidmar et al. 2013). Histograms for the three outcomes (HAZ, WAZ and BAZ scores) are shown in Figure 3-3. The measures were normally distributed and were used in the analyses as continuous variables.

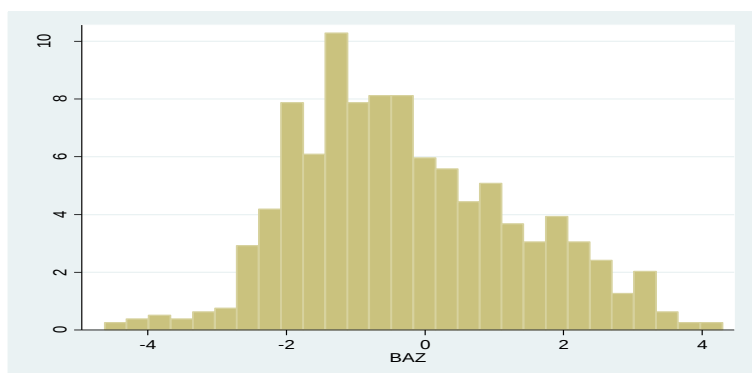
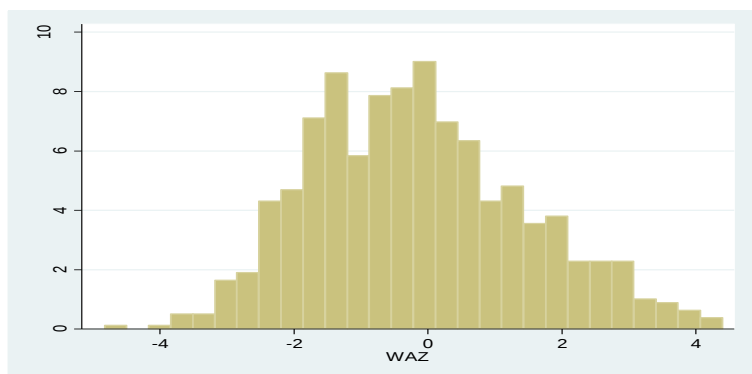
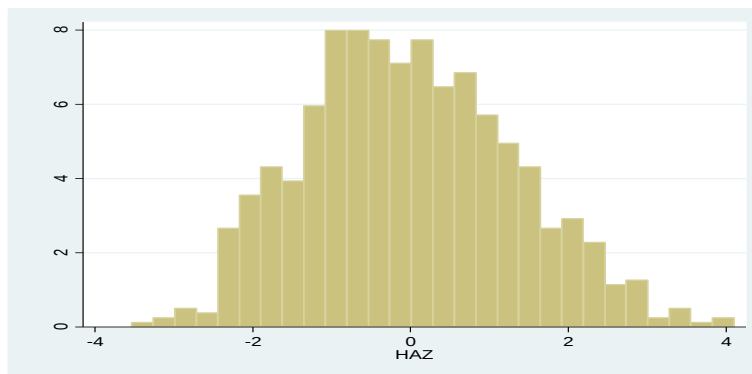


Figure 3-3 Histogram of the distribution (percent) of anthropometric outcomes: HAZ, WAZ and BAZ in the study population (N=788)

3.7.2 Exposures: dental caries and dental sepsis

Two separate exposures were considered in this study: dental caries and dental sepsis.

Dental caries: dmft + DMFT

The main exposure was children's dental caries experience, measured using the dmft and DMFT indices (lower case letters for the deciduous and upper case letters for the permanent dentition). As described in the literature review section 2.1, the dmft/DMFT is an aggregate measure of visually distinct cavities in dentin (d/D), teeth missing due to caries (m/M) and filled (f/F) deciduous and permanent teeth (dmft+DMFT).

Dental sepsis: pufa + PUFA

Measuring dental sepsis is also important because previous research has shown that caries progression into the pulp (odontogenic infections) is associated with an increased risk of being underweight (Benzian et al. 2011). As mentioned in Chapter two, section 2.1; the pufa and PUFA index records the presence of severely decayed teeth with visible pulpal involvement (p/P), ulceration caused by dislocated tooth fragments (u/U), fistula (f/F) and abscess (a/A) for deciduous (pufa) and permanent (PUFA) teeth (Monse et al. 2010). The pufa/ PUFA index was used to indicate dental sepsis. Figure 3-4 shows the histograms for dental caries and sepsis, which were positively skewed (longer right tail) with a high percentage of zeros.

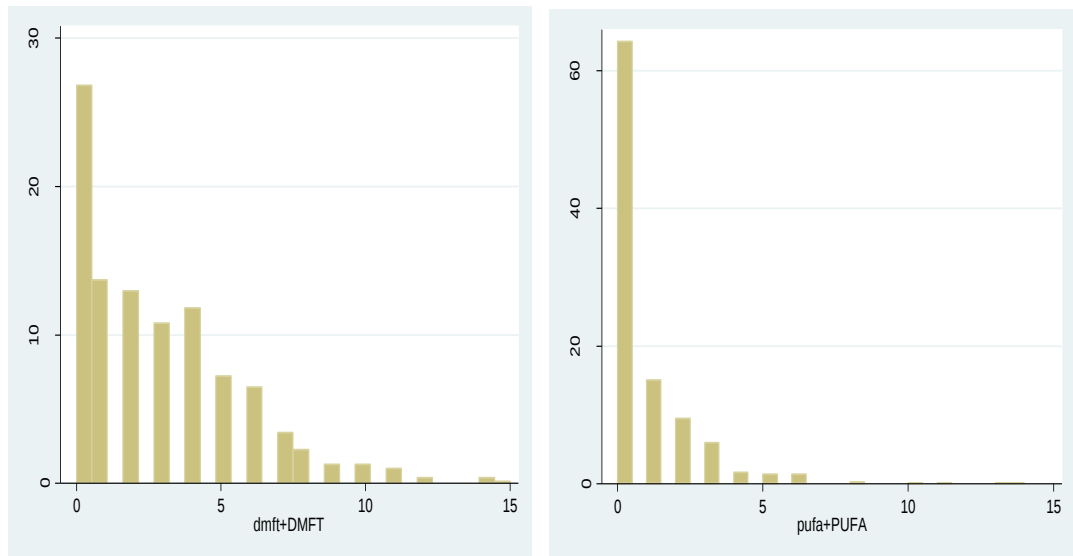


Figure 3-4 Histogram of the distribution (percent) of dental caries and sepsis in the study population (N=788)

Categorization of dental caries and sepsis

For analysis purposes, the dmft+DMFT scores were categorised into 4 groups where the caries free children formed a distinct group (26.8%), and those with dental caries experience were divided into tertiles, where 26.6% were in the mild caries tertile (dmft+DMFT = 1-2), 29.9% were in the moderate caries tertile (dmft+DMFT = 3-5) and 16.6% were in the severe caries tertile (dmft+DMFT = 6-15) (Figure 3-5).

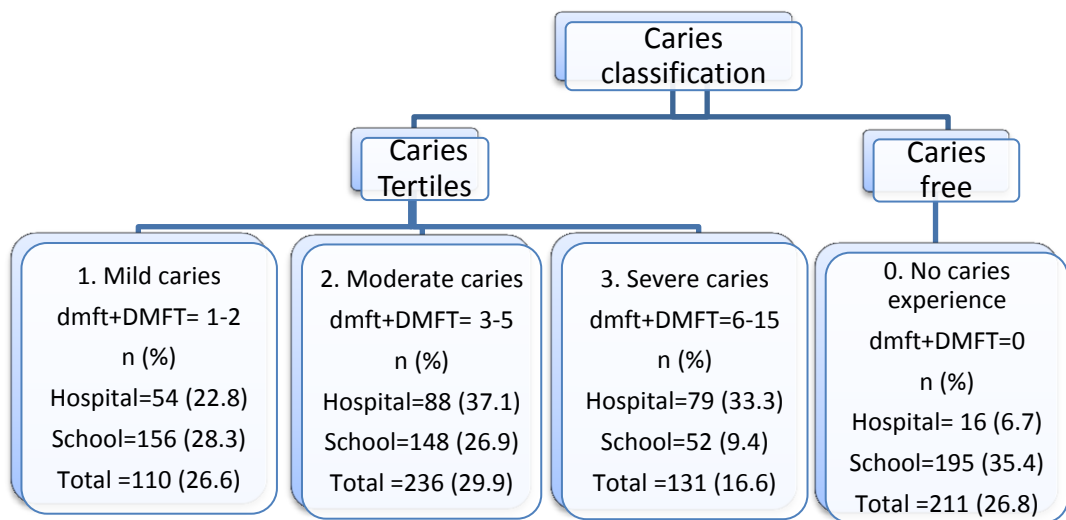


Figure 3-5 Dental caries groups, by setting and in overall sample (N=788)

Dental sepsis was dichotomised into 'no sepsis' ($\text{pufa} + \text{PUFA} = 0$) (64.2%) and 'having any sepsis' ($\text{pufa} + \text{PUFA} > 0$) (35.8%) groups (Figure 3-6). The binary classification was used due to a high proportion of children with a score of zero.

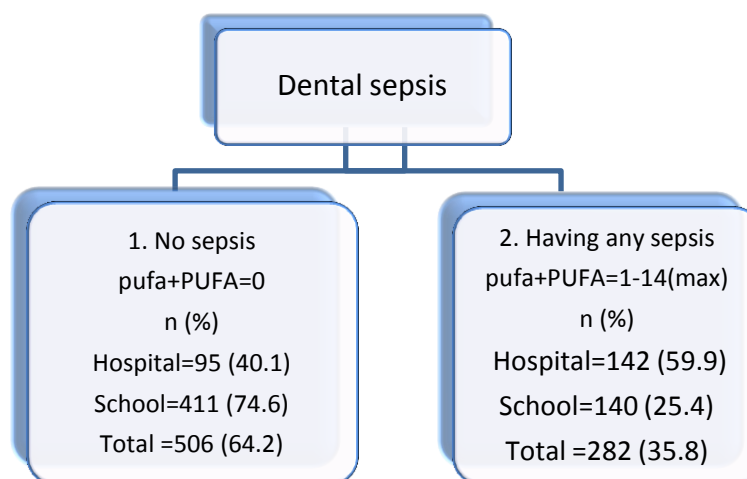


Figure 3-6 dental sepsis groups (dichotomized), by setting and in overall sample (N=788)

3.7.3 Potential mediators

3.7.3.1 Oral health related quality of life (OHRQoL)

SOHO-5: Child self-report

The SOHO-5 contains seven questions to assess oral health-related impacts, including difficulty in eating, drinking, speaking, playing and sleeping, avoid smiling due to appearance, and avoid smiling due to pain. All questions were assessed by using a 3-point scale with the answering options 'no' (coded 0), 'a little' (coded 1) and 'a lot' (coded 2). A cumulative SOHO-5 score, calculated for the seven items on oral health-related impacts, reflects the overall presence of oral health-related impacts. The total scores were dichotomized into 'score 0 = No oral impacts' and 'score 1-14 = Any oral impacts'. The child's self-reported SOHO-5 was used in the analysis, as self-report is considered as better than proxy report (Tubert-Jeannin et al. 2005). The distribution of SOHO-5 score was also positively skewed, with 43.4% of children with score 0 (Figure 3-7).

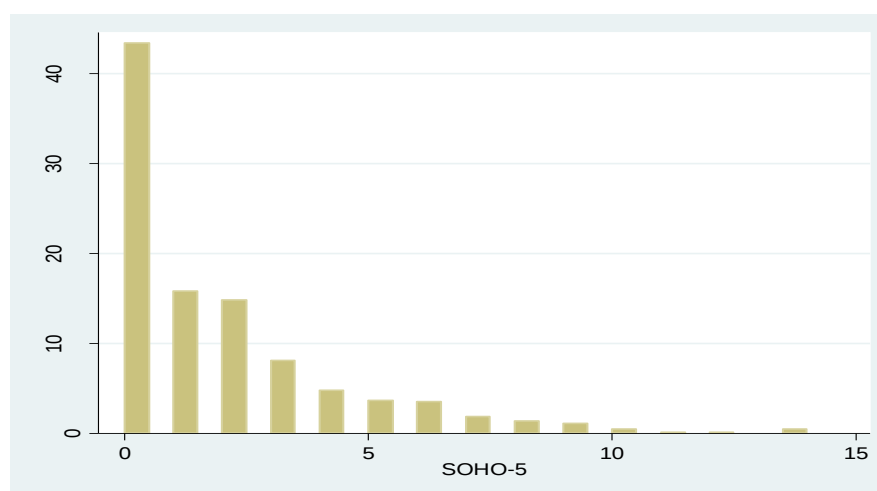


Figure 3-7 Histogram of distribution (percent) of child reported SOHO-5 scores (N=788)

3.7.3.2 Dental pain

The child questionnaire also contained a question about dental pain experience. Children were asked: *“Have your teeth ever hurt you?”*

Possible answer options were: “no”, “a little”, and “a lot”.

For further analysis this variable was converted into a dichotomized variable (‘no experience of dental pain’ versus ‘experience of dental pain’) by merging ‘a little’ and ‘a lot’ responses together.

3.7.3.3 Eating difficulties

Eating difficulties were assessed by asking about the child’s ability to eat three commonly eaten food groups in Bangladesh: rice and bread; meat and fish; fresh fruits and vegetables. For each food type, parents were asked *“Was your child’s ability of chewing/eating ever hampered due to problems with the teeth?”* Possible answers were:

- 0 = Good ability (not hampered)
- 1 = Mildly hampered
- 2 = Moderately hampered
- 3 = Seriously hampered

The average Pearson’s Correlation Coefficient of the three items was 0.8 ($P > 0.001$) and Cronbach alpha was 0.92. The responses for each of these three types of food were added together to form a scale ranging from 0 (no eating difficulty) to a maximum value of 9 (severe eating difficulty). For descriptive and regression analyses, the scores were dichotomised to distinguish between children whose parents reported no eating difficulties (score 0) and any eating difficulties (total score 1-9).

Parents were also asked “*Does the child try to avoid hard food due to problems with the teeth?*” (Gaur & Nayak 2011); “*Does the child prefer to chew on one side?*” (Versloot et al. 2006; Daher et al. 2014) and “*Do you need to make any change in food preparation due to dental problem of your child?*” Possible answers were “never”, “sometimes” and “often”. These questions were added in the questionnaire to get a better picture of eating difficulties due to dental problems. However, as the responses of the questions were correlated with the eating difficulty score (average Pearson’s correlation coefficient of 0.54, $p < 0.001$), they were not included in the final analyses.

3.7.3.4 Poor appetite

Children’s general appetite was assessed by a 5-point appetite scale (Brown et al. 1995) in the parental questionnaire. This instrument has been used previously in dental research (Alkarimi et al. 2012). Parents were asked how they would rate their child’s appetite. The answers were given on a Likert scale ranging from 1 to 5, where 1 indicated very good appetite and 5 indicated very poor appetite.

For assessing the specific impact of dental problems on reducing appetite, parents were asked “*Do you think dental pain is causing poor appetite of your child?*” Possible answers were “yes”, “no” and “not applicable”. For analysis purposes this was converted into a dichotomized variable as “reduced appetite due to dental cause” and “no reduced appetite due to dental cause”, by merging “no” and “not applicable” categories together.

3.7.3.5 Sleep disturbance

To assess caries related sleep disturbance, parents were asked “*How frequently does toothache cause the child’s sleep disturbance?*” Possible answers were:

- Never
- Once or twice in life
- Several episodes in a year
- Several episodes in a month

For analysis purposes the measure was converted into a binary measure due to a high percentage of ‘never’ responses. The resulting categories were ‘no experience of sleep disturbance due to toothache’ (those who responded ‘never’), and ‘any experience of sleep disturbance due to toothache’ (any other answer).

In addition, seven questions for assessing initiation and maintenance of sleep from the ‘sleep disturbance scale for children’ (Bruni et al. 1996) were used in the parental questionnaire (details on questions and scoring are shown in Appendix 11). However, the obtained scores from the sleep scale were not used in any analysis, as they were not significantly associated with the anthropometric outcomes.

3.7.4 Confounders

The following confounders were considered: child's sex and age, family socio-economic position, study setting and markers of early childhood health and nutritional status.

3.7.4.1 Demographic variables

Age: Age was measured in years. The participants of this study were between 5 and 9 years old.

Sex: Children's sex was coded as: 1 = Boys and 2 = Girls.

As the outcome variables were age and sex adjusted z-scores; age and sex were not included in the regression models.

3.7.4.2 Family socio-economic position

The categories for the family socio-economic variables are shown in Table 3.2. Parental education, occupation and family income are considered as important markers of family socio-economic position in child health research (Galobardes et al. 2006). In this study several dimensions of parental socio-economic condition were assessed through questions on parental level of education, occupation, gross household monthly family income and sufficiency of earnings. These questions were adopted from the Bangladesh Demographic and Health Survey 2011 (BDHS), a nationwide sample survey conducted in Bangladesh (BDHS 2011).

Parental education: Parental education was a categorical variable with five categories, namely: 'no education', 'primary', 'secondary', 'higher secondary', and 'tertiary' level of education. For regression analyses maternal education was used and re-categorized into four groups by merging 'no education' and 'primary education' together, as the numbers in these two groups were small.

Parental occupation: parental occupation was categorized into five groups. For analysis purposes paternal occupation was re-categorized as 'service' (that includes any kind of official job); 'business'; and 'others'. A small percentage of fathers were in the 'labour', 'domestic work', and 'other' occupation groups; these groups were merged into one as 'others'. Maternal occupation was re-categorized as 'domestic work' and 'others' as most of the mothers were in the 'domestic work' group. Parental occupation was used in bivariate analyses but was not included in the regression model to avoid difficulty in interpretation of results, as the categories were not hierarchical.

Family income: Monthly gross family income was categorized into four groups and was used as a covariate in all analyses.

Sufficiency of income: Parental perception about sufficiency of income with their expenditure was categorized into three groups. This variable was used in bivariate analyses but was not included in the regression model as it was not significantly associated with the anthropometric outcomes in the bivariate analysis.

All categories for the socio-economic variables are shown in Table 3.2.

Table 3.2 Categories of family socio-economic variables

Variable	Categories
Parental education	• No education • Primary • Secondary • Higher secondary • Tertiary
Parental occupation	• Service • Business • Labour • Domestic work • Other
Gross family income (Taka/month)	• up to 8000 • > 8000 to 20,000 • > 20,000 to 30,000 • >30,000 Taka/month
Income sufficiency	• Not sufficient • Moderately sufficient • Sufficient

3.7.4.3 Study setting

In this study, the setting was coded as: 1 = Hospital sample and 2 = School sample.

3.7.4.4 Markers of early childhood health and nutritional status

In this study, parents were asked about the child's history of premature birth and birth weight, as there is some evidence of associations between birth weight and later life height and weight, and dental caries. Children with low birth weight have lower weight and height-for-age z-score compared to normal birth weight children (Saigal et al. 2006) and have an

increased risk for enamel hypoplasia (Nelson et al. 2013) and dental caries (Rajshekar & Laxminarayan 2011).

In addition, history of breast feeding, long standing illness in the first two years, and being underweight in the first four years of life were recorded because it has been suggested that these factors might have an influence on childhood growth and development of dental caries (Kay et al. 2010; Saigal et al. 2006; Harris et al. 2004; Martin 2002). 'History of premature birth', 'breast feeding', 'long standing illness in first two years of life', and 'being underweight in first four year of life' were dichotomized variables with "yes" and "no" answer options. Breast-feeding months were also recorded on a continuous scale; however, the dichotomized prevalence of breast-feeding ('not breastfed' versus 'breastfed') was used for analysis. Birth weight was a categorical variable with three categories: underweight, normal weight and overweight (answers were based on parental recall and definition of child birth weight was up to parental consideration).

3.7.4.5 Parental height and weight

Self-reported parental height and weight were recorded in this study because height and weight of mothers and fathers are considered as important genetic indicators for children's growth (Kuh & Wadsworth 1989). It has been suggested that maternal height has an influence on her child's linear growth over the growing period (Addo et al. 2013) and maternal weight largely explains the association between birth weight and adult body mass index (Parsons et al. 2001). One study assessing the genetic growth target from parental heights confirmed that children

affected by severe early childhood caries tend to show a lower height percentile than that allowed by their parent-bound target, and was statistically different from the control group (children without dental caries) (Vania et al. 2011).

For validation purposes, 35 randomly selected parents were requested to have their height and weight measured by the investigators. This revealed that the objective measures were in very good agreement with their self-reports. Parental height was recorded on a continuous scale in meters and weight was recorded in kilograms. However, of the total 725 completed parental questionnaires, 37.0% (n=268) had missing data on maternal height, 38.2% (n=277) had missing data on paternal height, 32.5% (n=236) had missing data on maternal weight, and 37.4% (n=271) had missing data on paternal weight. As the percentage of missing data for parental height and weight was high, the variables were not used in the final analysis. A separate subsample analysis was however conducted among 371 participants for whom both parental height and weight information was available. This analysis replicated the analysis of the main analytical sample where parental height and weight was additionally adjusted. The tables containing the related results are shown in Appendix 12. However, the characteristics of the children with missing parental height and weight data were not substantially different from the rest of the sample.

3.8 Data entry and cleaning

All returned questionnaires were checked for missing data and ineligible writing. Once the data were collected and checked, they were coded using a predefined coding frame. Each questionnaire was hand checked before coding for any obvious interviewer error.

Data cleaning

The following data cleaning procedures were carried out:

1. Data cleaning through logical checks: once the questionnaires were returned, the questionnaire data were checked for each question for any implausible answers.
2. To ensure the accuracy of entered data, 10% of questionnaires were randomly selected and checked and there was no error in data entry.

Storage and preparation of collected data for analysis

Data collected on paper files were transported from Bangladesh to London in a sealed package and stored in a securely locked filing cabinet at UCL. Electronic data were stored on password-protected computers.

Analytical framework for the outcome variables

The analytical framework has been developed based on the conceptual framework for the study (described previously, see Figure 2-2) that was adapted from the framework developed by Sheiham (2006) and Alkarimi (2013). The framework below depicts the hypothesised pathways. Dental

caries and sepsis might be associated with HAZ, WAZ and BAZ scores via different pathways. Dental caries might have a negative effect on overall OHRQoL of children. Particularly when caries leads to dental pain, eating difficulty, reduced appetite and Sleep disturbance that might have impact on the anthropometric outcomes.

The model also takes into account the demographic and socio economic variables, study setting and markers of early childhood health and nutritional status that might be potential confounders. The analytical framework for the three outcome variables (HAZ, WAZ and BAZ scores) is illustrated in Figure 3-8

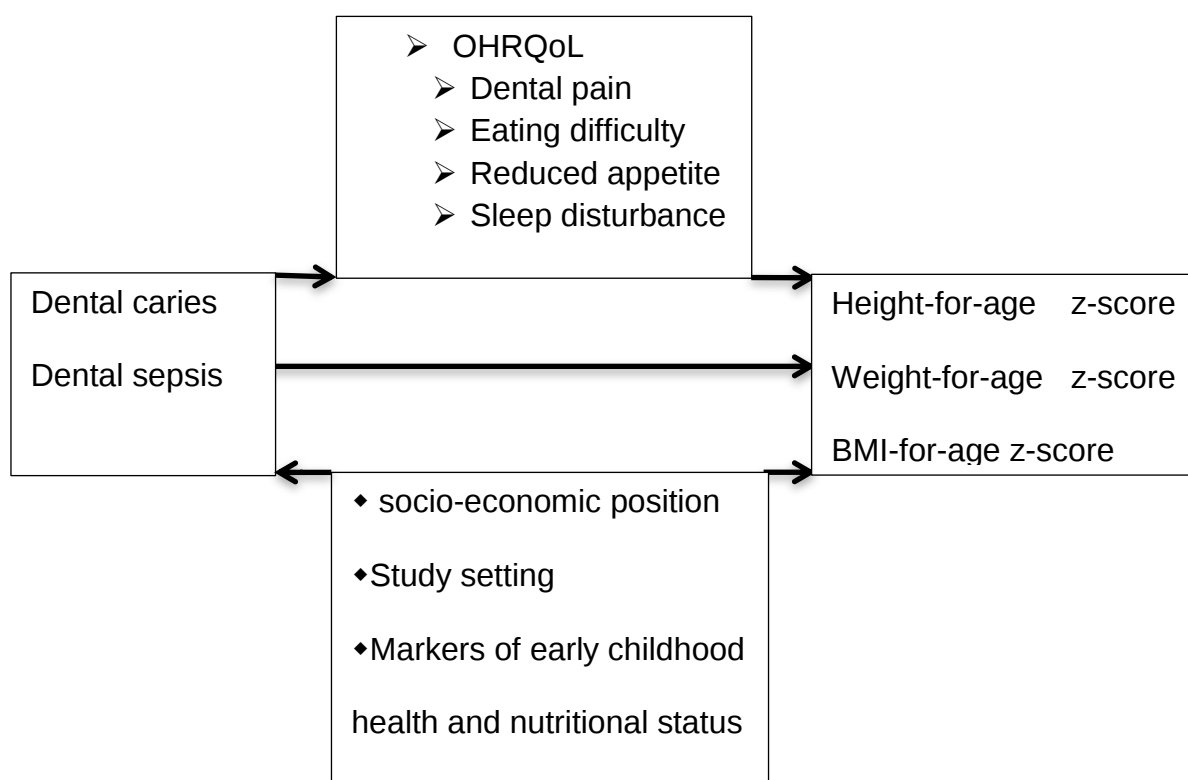


Figure 3-8 Analytical framework of the study

3.9 Data analysis plan

The data analysis plan for objectives 2-4 is summarized below. The details of the methodology and data analysis plan for the first objective (testing the validity and reliability of the Bengali version of SOHO-5) has been described separately in Appendix 10. All data were analysed using STATA version 13.0 (StataCorp. 2013).

Data analysis plan for objectives 2-4

Initially, descriptive analyses were run and then the bivariate associations between the main outcomes and exposures and their association with the covariates were analysed. Finally, linear regression analysis methods were used in order to assess the associations of interest.

3.9.1 Descriptive statistics

The distribution of the main outcome variables (HAZ, WAZ and BAZ scores) and exposures (dental caries and dental sepsis) were examined. The frequency distributions of all covariates were assessed for the whole sample and also by setting (separately for the hospital and school sample).

3.9.2 Bivariate analyses

3.9.2.1 *Association between outcome variables and clinical exposures and covariates*

To assess whether there were statistically significant differences in the mean of the three outcome variables among the four dental caries and

between two dental sepsis groups, one-way analysis of variance (ANOVA) and t-tests were carried out respectively, as the outcome variables were normally distributed (see Figure 3-3).

The associations between outcome variables and covariates were explored through t-tests (for variables with two categories) and one-way ANOVA (for variables with more than two categories).

3.9.2.2 Association of main exposures with covariates

The associations between exposures (dental caries and dental sepsis) and covariates were tested using chi-square tests and chi-square test for trend as appropriate.

Before constructing the multiple linear regression models, the correlations between all variables were examined via Pearson's correlation tests and presented as a correlation matrix (see Appendix 13), which allows for assessment of multicollinearity.

3.9.3 Regression modelling strategy

Covariates adjusted for in the final regression models

Socio-economic variables: In the regression analyses, maternal educational level and monthly family income were used as socio-economic indicators. Maternal occupation and income sufficiency were not significantly associated with the anthropometric outcomes in the bivariate analysis and were therefore not included. Paternal education was highly correlated with maternal education (Pearson's correlation coefficient of 0.76, $p < 0.001$), and therefore not included in the final models to avoid multicollinearity. In addition, models were adjusted for the setting (hospital versus school sample).

Of the markers of early childhood health and nutritional status, birth weight and history of any past illness (childhood diseases) were adjusted for in the regression models. Premature birth and breast-feeding were not significantly associated with the anthropometric outcomes (p -values higher than 0.05) in the bivariate analysis and were therefore not included.

Potential mediators: The dichotomized form of the SOHO-5, dental pain, dental problem related eating difficulty, reduced appetite, and sleep disturbance were adjusted for in the regression analyses. A summary of measures that were included in the regression models is shown in Table 3.3.

Table 3.3 Summary of measures used for the regression modelling

Outcome variables	Exposures	Potential mediators	Covariates
1. Height adjusted for age z-scores (HAZ) (continuous) 2. Weight adjusted for age z-scores (WAZ) (continuous) 3. BMI adjusted for age z-scores (BAZ) (continuous)	1. Dental caries (dmft+DMFT) (categorical: 4 groups) 2. Dental sepsis (pufa+PUFA) (categorical: 2 groups)	1. SOHO-5: any oral impact (dichotomized variable) 2. Dental pain (dichotomized variable) 3. Eating difficulty (dichotomized variable) 4. Reduced appetite (dichotomized variable) 5. Sleep disturbance (dichotomized variable)	1. Socio-economic variables: Maternal education (categorical: 4 groups) Family income (categorical: 4 groups) 2. Setting (binary variable) 3. Early childhood Health and nutritional status: Birth-weight (categorical: 3 groups) Childhood diseases (binary variable)

Analysis sample for regression models

The regression modelling was conducted as complete case analyses. Of the total 788 participants, 8% (n=63) did not return the parental self-completion questionnaire. Among the 725 completed parental questionnaires, 10 had missing data on covariates. The variables with

missing data were: 'child's birth weight' (n=8), 'childhood diseases' (n=2), and sleep disturbance (n=2). Therefore the final analysis sample included 715 complete cases.

The analysis plan for each objective is described below:

3.9.4 Linear regression models

Bivariate and multiple linear regression models to examine the association of dental caries and dental sepsis with HAZ, WAZ and BAZ scores, which was the second objective of the study.

Linear regression analysis was used to assess the association between the exposure (dental caries and sepsis) and outcome variables (HAZ, WAZ and BAZ scores). For each outcome variable, two separate sets of models were run, one for dental caries as the exposure and one for dental sepsis. The models were sequentially adjusted for the covariates: socio-economic factors (maternal education and family income); setting; markers of early childhood health and nutritional status (birth weight and childhood diseases). The following four models were built to test the associations, fitted for each outcome with each exposure.

- Model 1: unadjusted model 'exposure + outcome'.
- Model 2: Model 1 adjusted for 'maternal education + family income'.
- Model 3: Model 2 and additionally adjusted for 'setting'.
- Model 4: Model 3 and additionally adjusted for 'birth weight + childhood diseases'.

Multiple linear regression models to examine the potential role of OHRQoL in the association of dental caries and sepsis with HAZ, WAZ and BAZ score, which was the third objective of the study.

A potential mediator variable is commonly defined as a variable that accounts at least partly for the association between an exposure and an outcome variable in the form of a causal chain (Baron & Kenny 1986). When this variable is controlled, the previously significant association between exposure and outcome is no longer statistically significant or the magnitude of the association greatly reduced. However, it has been argued that testing of mediation is not valid for cross-sectional data, especially when it comes to make causal inferences (Green et al. 2010). Hence this study was restricted to exploring the role of potential mediators in the association between exposures and outcomes through multiple linear regression analyses, without inferring causality.

To test the role of OHRQoL, Model 4 was additionally adjusted for OHRQoL (dichotomized SOHO-5) (Model 5).

- Model 5: Model 4, additionally adjusted for SOHO-5.

Multiple linear regression models to examine the role of dental pain, eating difficulty, reduced appetite and sleep disturbance on the association of dental caries and sepsis with HAZ, WAZ and BAZ scores, which was the fourth objective of the study.

To assess the role of the above measures, instead of adjusting for overall OHRQoL, Model 4 was sequentially adjusted for experience of dental pain (Model 6), secondly for eating difficulty (Model 7), thirdly for reduced appetite (Model 8) and finally for sleep disturbance (Model 9). The order of entering the potential mediators was based upon the consideration of more proximal to distal effects of dental caries and sepsis. The following sets of models were tested:

- Model 6: Model 4 + 'dental pain'.
- Model 7: Model 6 + 'eating difficulty'.
- Model 8: Model 7 + 'reduced appetite'.
- Model 9: Model 8 + 'sleep disturbance'.

The results were expressed as regression coefficients with 95% Confidence Intervals (CI). A p-value of <0.05 was considered significant in all statistical tests.

Sensitivity analysis adjusted for parental height and weight

As mentioned in section 3.7.4.5, a supplementary analysis on a subsample was conducted that included adjustment for parental height and weight as covariates. The tables containing the results for this subsample analysis are shown in Appendix 12 and the results are described in section 5.5.

Chapter 4 Results – Psychometric properties of the Bengali version of SOHO-5

4. Results - Psychometric properties of the Bengali version of SOHO-5 questionnaire

This chapter presents the psychometric properties of the Bengali version of the SOHO-5 questionnaire to address the first objective of the study. In terms of the psychometric properties of Bengali version of SOHO-5, validity (face, content and construct validity) and reliability (internal consistency and test- retest reliability) of the measure were assessed.

The terms ‘face and content validity’ are technical descriptions of the judgement that the scale looks reasonable (Streiner et al. 2014). The assessment of face and content validity was conducted by a panel of experts to check whether the Bengali version of SOHO-5 scale was measuring what it is supposed to measure. The detailed method of the assessment of face and content validity is described in Appendix 10. The results confirmed good face and content validity of the questionnaire.

4.1 Construct validity

Construct validity (convergent and discriminant validity) was assessed using Kruskal Wallis (K Wallis) and Wilcoxon rank-sum tests. The results of the tests are presented in Table 4.1 and Table 4.2.

4.1.1 Convergent validity

Convergent validity was assessed by examining the associations between the SOHO-5 and other subjective oral health status measures. Children's SOHO-5 scores were significantly associated with self-reported current dental pain, any experience of dental pain, satisfaction with oral health status and presence of cavities in teeth (Table 4.1). Children who reported dental pain, being dissatisfied with oral condition, and having hole in teeth had higher SOHO-5 scores (indicating worse quality of life). More specifically, children who reported severe current dental pain had significantly higher SOHO-5 scores than their counterparts who did not have current dental pain (mean score of 5.07 (95% CI 4.49, 5.64) versus mean score of 0.60 (95% CI 0.49, 0.72), $p < 0.001$). A similar pattern of association was found for children who ever had any experience of dental pain. Furthermore, children who were very satisfied with their teeth had significantly lower SOHO-5 scores compared to children who were not satisfied with their teeth (mean score of 0.70 (95% CI 0.55, 0.85) versus mean score of 3.42 (95% CI 2.89, 3.95), $p < 0.001$). Similarly, those who did not report any dental cavities had significantly lower SOHO-5 scores than those who reported cavities (mean score of 0.44 (95% CI 0.33, 0.56) versus mean score of 3.05 (95% CI 2.78, 3.32), $p < 0.001$).

Table 4.1 Children's SOHO-5 scores, by subjective indicators of oral health.

	Median score (25-75 percentile)	Mean score (95% CI)	p-value
Current dental pain ¹			
No	0 (0-1)	0.60 (0.49, 0.72)	<0.001
A little	2 (1-3)	2.70 (2.43, 2.98)	
A lot	4 (3-7)	5.07 (4.49, 5.64)	
Ever had experience of dental pain ¹			
No	0 (0-0)	0.36 (0.23, 0.48)	<0.001
A little	2 (1-3)	2.14 (1.91, 2.37)	
A lot	3 (1-6)	4.24 (3.82, 4.67)	
Satisfaction with oral health ¹			
Not satisfied	3 (1-6)	3.42 (2.89, 3.95)	<0.001
A little satisfied	2 (1-4)	2.50 (2.22, 2.78)	
Very satisfied	0 (0-1)	0.70 (0.55, 0.85)	
Presence of dental cavities ²			
No cavity	0 (0-0)	0.44 (0.33, 0.56)	<0.001
have cavity	2 (1-4)	3.05 (2.78, 3.32)	

¹K Wallis test ²Wilcoxon rank-sum test

4.1.2 Discriminant validity

There were clear and significant differences in the SOHO-5 scores between different clinical dental caries and dental sepsis groups. There was statistically significant increase in mean SOHO-5 score with each level increase in severity of caries (Table 4.2). The mean SOHO-5 score was 0.06 (95% CI 0.00, 0.12) for children with no caries, increasing gradually up to 3.50 (95% CI 3.02, 3.99) for the severe caries group (dmft+DMFT>5). Children who had been diagnosed with dental sepsis (pufa+PUFA>0) had significantly higher SOHO-5 scores than children without dental sepsis (mean score of 3.42 (95% CI 3.10, 3.74) versus mean score of 0.88 (95% CI 0.74, 1.02), $p<0.001$).

Table 4.2 Children's SOHO-5 scores, by dental caries and dental sepsis groups.

Dental status	Child- SOHO-5 Median (25-75 percentile)	Child SOHO-5 Mean (95% CI)	p-value
Dental caries¹			
dmft+DMFT= 0	0 (0-0)	0.06 (0.00, 0.12)	<0.001
dmft+DMFT= 1-3	1 (0-2)	1.57 (1.28, 1.86)	
dmft+DMFT= 4-5	2 (1-3)	2.57 (2.26, 2.88)	
dmft+DMFT= >5	2 (2-5)	3.50 (3.02, 3.99)	
Dental sepsis²			
pufa+PUFA=0	0 (0-1)	0.88 (0.74, 1.02)	<0.001
pufa+PUFA >0	3 (2-5)	3.42 (3.09, 3.74)	

¹ K Wallis test, ² Wilcoxon rank-sum test

4.2 Reliability analysis

4.2.1 Internal consistency

The internal consistency of the SOHO-5 instrument was tested through inter-item and item total correlations. The results are presented in Tables 4.3 and 4.4. The inter-item correlations ranged between 0.18 and 0.53 and the mean inter-item correlation was 0.35 (Table 4.3).

Table 4.3 Internal consistency of SOHO-5: inter-item correlation matrix

	Eating	Drinking	Speaking	Playing	Avoid smiling for pain	Avoid smiling for appearance	Sleeping
Eating	1						
Drinking	0.22	1					
Speaking	0.37	0.18	1				
Playing	0.33	0.26	0.53	1			
Avoid smiling for pain	0.43	0.31	0.52	0.50	1		
Avoid smiling for appearance	0.25	0.24	0.31	0.30	0.29	1	
Sleeping	0.52	0.25	0.46	0.43	0.49	0.23	1
The mean inter-item correlation: 0.35 (P<0.001, Pearson's correlation coefficient)							

Item-total correlations ranged between 0.33 and 0.40. In relation to the Cronbach's alpha statistics, the measure had a standardized item alpha of 0.79 (Table 4.4).

Table 4.4 Internal consistency reliability of children's OHRQoL: Item total correlation coefficients and Cronbach's Alpha

Items	Item total correlation	Cronbach's Alpha if item deleted
Eating	0.35	0.77
Drinking	0.40	0.80
Speaking	0.34	0.75
Playing	0.34	0.75
Avoid smiling for pain	0.33	0.74
Avoid smiling for appearance	0.39	0.79
Sleeping	0.34	0.75
Standardized item alpha: 0.79		

The results indicate good internal consistency of the instrument as all inter-item correlations were positive and all item-total correlations were above the 0.20 arbitrary threshold of good performance. In addition, none of the correlations was high enough to indicate redundancy of any item. The measure had a standardized Cronbach's alpha above the arbitrary threshold of 0.70. The value of Cronbach's alpha was lower when any of the items was deleted.

4.2.2 Test-retest reliability

Test-retest reliability or external reliability was assessed by the consistency of the reporting of SOHO-5 questionnaire.

A test-retest reliability analysis was carried out on twenty children who were interviewed for a second time by measuring the degree of agreement between two measurements. Cohen's Kappa test (for the total SOHO-5 scores) was measured to test the degree of agreement. In this study, the weighted Kappa statistic was 0.85, which indicated excellent reproducibility.

To conclude, this study provided evidence about promising psychometric properties of the Bengali version of SOHO-5. All the associations between subjective measures with the SOHO-5 scores were in the expected directions. The questionnaire also demonstrates the ability to discriminate between different caries and sepsis groups. The test results of internal consistency and test-retest reliability were also promising.

Chapter 5 Results - Main study

5. Results – Main study

Chapter five addresses the main research aim, which was to investigate the association between dental caries and anthropometric outcomes. The chapter starts with a description of the study sample, followed by the results of the bivariate analyses and linear regression analyses.

5.1 Description of the study sample

In total, 788 children participated in the study. Of the total study participants, 30% were recruited in the hospital setting and 70% were recruited from the schools. The details of recruited participants and response rates are shown in Figure 5-1.

5.1.1 Response rate for the school sample

In the schools, a total of 560 parent-child pairs were invited to participate and all parents returned the signed consent form. Nine children were absent on the day of the examination, taking the school sample to 551 children who took part in the interview, oral examinations and had their height and weight measured. Of those 551 children, 62 did not return the parental questionnaire. The response rate for the parental questionnaires in the schools was 88.7%.

5.1.2 Response rate for the hospital sample

In the hospital sample, a total of 245 children were invited to take part in the study. Of them, 237 parents agreed and signed the consent form (response rate = 96.7%). Among the consenting parents, only one parent did not complete the parental questionnaire, which takes the response rate for the parental questionnaires in the hospital sample to 99.6%.

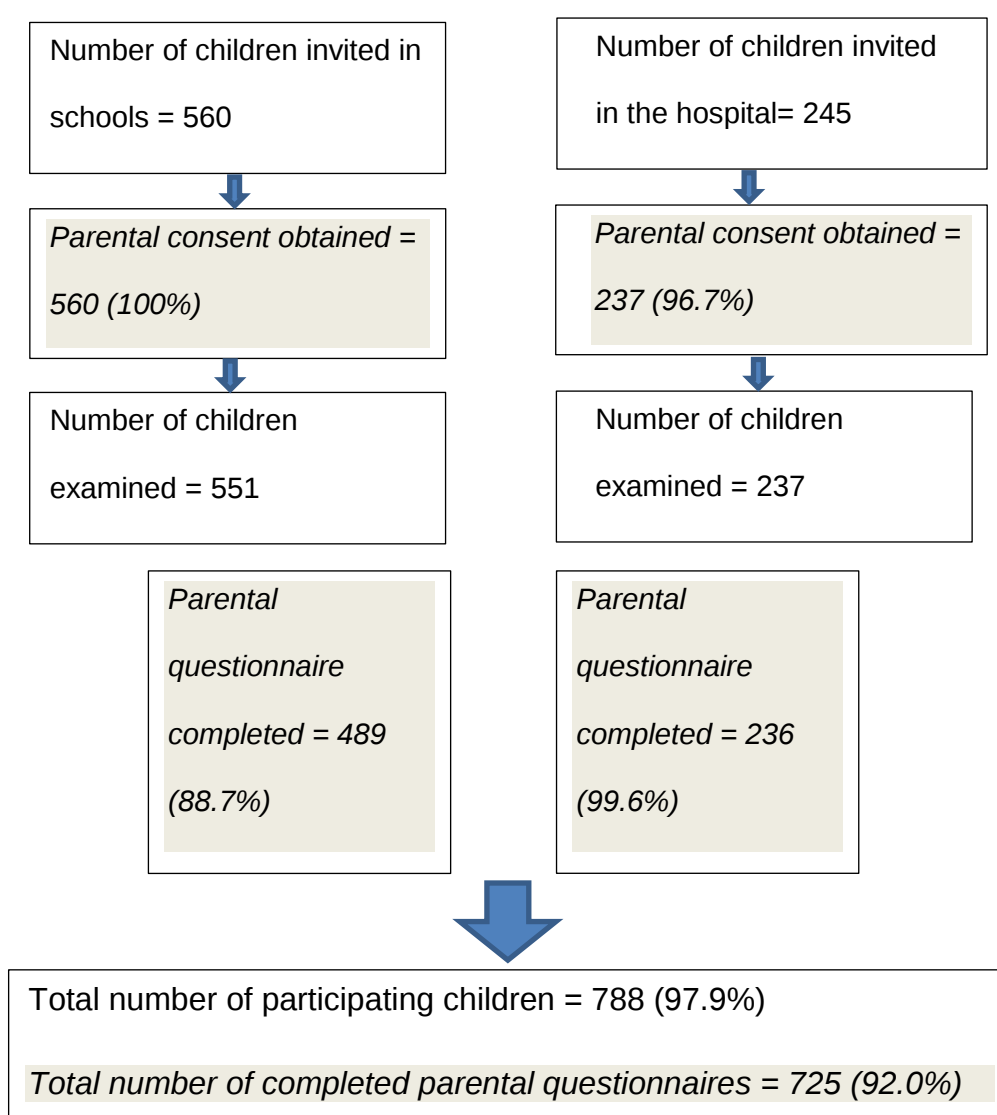


Figure 5-1 Flow chart of study participants

Overall, a total of 725 parents (92%) completed the parental questionnaire. Missing data are described in the methodology chapter (See section 3.9.3). Table 5.1 summarizes the distribution of key sample characteristics by setting. Among the 788 participating children, 388 (49.2%) were boys and 400 (50.8%) were girls. The children were aged 5-9 years with a mean age of 7.12 years (95% CI 7.05-7.19). Of the total 725 participating parents, 62.7% were mothers, 34.1% were fathers and 3.2% were other guardians. In terms of socio-economic variables, 4.8% of fathers and 3.7% of mothers were illiterate, while 37.5% of fathers and 20.3% of mothers had tertiary level of education. Of the total sample, 56.0% of fathers were in service (any kind of official job) while 83.4% of mothers were involved in non-paid household activity (house wife). Nearly half of the sample (47.0%) had a gross family income of 8,000 to 20,000 Taka per month (1GBP=100 Taka) and 66.2% of parents considered that their income was moderately sufficient for their family. Socio-demographic characteristics were similar for both settings in terms of income. However, a higher percentage of the parents in the school sample had a 'tertiary level of education' compared to the hospital sample and more fathers were in businesses. In terms of reported early childhood health and nutritional status, 18.0% of children were born prematurely and 9.5% with low birth weight. Most children had been breast-fed (92.0%) with a mean breast-feeding duration of 23 months. Of the total sample, 17.3% had a history of childhood diseases and 20.7% had a history of being underweight at any point during the first four years of their lives. Parents of the school children reported higher percentage of history of premature birth than parents of

the hospital sample (24.8% versus 3.8%, respectively) and the child being underweight in first four years of their life (24.6% versus 12.6%, respectively).

Table 5.1 Socio-demographic and early childhood characteristics of study sample, by setting (max. N=788)

Variables	Categories	Hospital setting n (%)	School setting n (%)	Total n (%)
Sex	Boys	113 (47.7)	257 (49.9)	388 (49.2)
	Girls	124 (52.3)	276 (50.9)	400 (50.8)
Paternal education level	No education	13 (5.1)	22 (4.5)	35 (4.8)
	Primary education	60 (25.4)	65 (13.3)	125 (17.2)
	Secondary	38 (16.1)	93 (19.0)	131 (18.1)
	Higher secondary	50 (21.2)	112 (22.9)	162 (22.3)
	Graduation/higher	75 (31.8)	197 (40.3)	272 (37.5)
Maternal education level	No education	12 (5.1)	15 (3.1)	27 (3.7)
	Primary education	80 (33.9)	64 (13.1)	144 (19.9)
	Secondary	62 (26.3)	159 (32.5)	221 (30.5)
	Higher secondary	43 (18.2)	143 (29.2)	186 (25.7)
	Graduation/higher	39 (16.5)	108 (22.1)	147 (20.3)
Paternal occupation	Service	131 (55.5)	275 (56.2)	406 (56.0)
	Business	54 (22.9)	157 (32.1)	211 (29.1)
	Labour	46 (19.5)	43 (8.8)	89 (12.3)
	Household activity	0	3 (0.6)	3 (0.4)
	Other	5 (2.1)	11 (2.2)	16 (2.2)

Variables	Categories	Hospital setting n (%)	School setting n (%)	Total n (%)
Maternal occupation	Service	17 (7.2)	64 (13.1)	81 (11.2)
	Business	5 (2.1)	3 (0.6)	8 (1.1)
	Labour	11 (4.7)	7 (1.4)	18 (2.5)
	Household activity	200 (84.7)	405 (82.8)	605 (83.4)
	Other	3 (1.3)	10 (2.0)	13 (1.8)
Household family income (Taka/month)	< 8 thousand	34 (14.4)	71 (14.5)	105 (14.5)
	8-20 thousand	117 (49.6)	224 (45.8)	341 (47.0)
	>20-30 thousand	50 (21.2)	116 (23.7)	166 (22.9)
	>30 thousand	35 (14.8)	78 (15.9)	113 (15.6)
Income sufficiency	Well sufficient	47 (19.9)	85 (17.4)	132 (18.2)
	Moderately sufficient	141 (59.7)	339 (69.3)	480 (66.2)
	Not sufficient	48 (20.3)	65 (13.3)	113 (15.6)
Premature birth	Yes	9 (3.8)	121 (24.8)	130 (18.0)
Birth weight	Low weight	10 (4.3)	58 (12.0)	68 (9.5)
	Normal weight	223 (95.3)	357 (73.9)	580 (80.8)
	Over weight	1 (0.4)	68 (14.1)	69 (9.6)
Breast feeding	Yes	212 (91.4)	451 (92.2)	663 (92.0)
Childhood diseases in first two years of life	Yes	48 (20.5)	77 (15.7)	125 (17.3)
Underweight in first four years of life	Yes	29 (12.6)	120 (24.6)	149 (20.7)

5.1.3 Anthropometric outcomes

Histograms for the three main outcome variables: height-for-age (HAZ), weight-for-age (WAZ) and BMI-for-age (BAZ) z-scores have already been presented in Chapter three, section 3.7.1. The mean (95% CI) values of HAZ, WAZ and BAZ of the participant children were -0.01 (-0.11, 0.08), -0.17 (-0.28, -0.06) and -0.28 (-0.39, -0.17) respectively (Table 5.2). Among the total sample, the mean height was 1.21 (95% CI 1.21, 1.22) metres, mean weight was 23.46 (95% CI 23.01, 23.90) kg and mean BMI was 16.02 (95% CI 15.23, 16.81) kg/m² (not shown in the Table). The hospital sample had lower mean z-scores than the school sample.

Table 5.2 Mean z-scores of anthropometric outcomes: WAZ, HAZ and BAZ of study sample, by setting (max. N=788)

Anthropometric outcomes	HAZ	WAZ	BAZ
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Hospital setting (n=237)	-0.67 (-0.82, -0.52)	-0.98 (-1.15, -0.81)	-0.84 (-0.99, -0.69)
School setting (n=551)	0.27(-0.82, -0.52)	-0.03 (-0.17, 0.11)	-0.03 (-0.17, 0.11)
Total sample (n=788)	-0.01 (-0.11, 0.08)	-0.17 (-0.28, -0.06)	-0.28 (-0.39, -0.17)

z-scores are in relation to WHO 2007 child growth reference standards

5.1.4 Prevalence of clinical exposures: dental caries and dental sepsis

The prevalence of the exposures (dental caries and sepsis) is presented in Table 5.3. The majority of the children (73.2%) had experience of dental caries (dmft+DMFT>0) with mean dmft+DMFT score of 2.84 (95% CI 2.64, 3.03) (median of 2). Dental caries was more prevalent in deciduous teeth (72.6%) than in permanent teeth (3.5%). Active decay (d component) was predominant in the sample, constituting 70.8% of the dmft indicator. On the other hand, 35.8% of children had dental sepsis experience (pufa+PUFA score>0), where majority of them (31.6%) had pulpal involvement in deciduous teeth (p component). When the caries distribution was considered by setting, as expected, dental caries and sepsis were more prevalent among the hospital sample than the school sample. In the hospital sample, a total of 93.2% children had dental caries experience compared to 64.6% for the school sample.

Table 5.3 Frequency of clinical exposures: dental caries and dental sepsis of study sample, by setting (max. N=788)

Dental caries and sepsis	Hospital sample n (%) Mean (95% CI)	School sample n (%) Mean (95% CI)	Total sample n (%) Mean (95% CI)	Total Median (25-75 Percentile)
dmft>0	219 (92.4) 4.46 (4.06, 4.85)	352 (64.0) 2.07 (1.88, 2.26)	571 (72.6) 2.79 (2.59, 2.98)	2 (0-4)
Decay (d)>0	218 (92.0) 4.05 (3.68, 4.43)	339 (61.6) 1.80 (1.63, 1.98)	557 (70.8) 2.48 (2.30, 2.66)	2 (0-4)
Missing (m)>0	36 (15.2) 0.26 (0.17, 0.36)	71 (12.9) 0.21 (0.15, 0.26)	107 (13.6) 0.22 (0.18, 0.27)	0 (0-0)
Filled (f)>0	22 (9.3) 0.14 (0.07, 0.20)	25 (4.5) 0.06 (0.03, 0.08)	47 (6.0) 0.08 (0.05, 0.11)	0 (0-0)
DMFT>0	12 (5.1) 0.08 (0.03, 0.13)	16 (2.9) 0.04 (0.02, 0.06)	28 (3.5) 0.05 (0.03-0.07)	0 (0-0)
Decay (D)>0	10 (4.2) 0.06 (0.02, 0.11)	14 (2.5) 0.03 (0.01, 0.05)	24 (3.0) 0.04 (0.02-0.06)	0 (0-0)
dmft+DMFT>0	221 (93.2) 4.5 (4.14, 4.94)	356 (64.6) 2.11 (1.91, 2.30)	577 (73.2) 2.84 (2.64, 3.03)	2 (0-4)
d+D>0	220 (92.8) 4.12 (3.74, 4.49)	343 (62.3) 1.83 (1.66, 2.01)	563 (71.4) 2.51 (2.34-2.70)	2 (0-4)
pufa >0	140 (59.1) 1.53 (1.27, 1.78)	140 (25.4) 0.51 (1.27, 1.78)	280 (35.5) 0.82 (0.71, 0.92)	0 (0-1)
Involvement of Pulp (p) >0	109 (46.0) 1.11 (0.88, 1.35)	140 (25.4) 0.49 (0.40, 0.59)	249 (31.6) 0.68 (0.58, 0.78)	0 (0-1)

Dental caries and sepsis	Hospital sample n (%) Mean (95% CI)	School sample n (%) Mean (95% CI)	Total sample n (%) Mean (95% CI)	Total Median (25-75 Percentile)
Ulceration (u)>0	24 (10.1) 1.73 (0.09, 0.25)	4 (0.7) 0.01 (-0.00, 0.02)	28 (3.5) 0.06 (0.03, 0.08)	0 (0-0)
Fistula (f) >0	13 (5.5) 0.06 (0.03, 0.09)	0	13 (1.6) 0.02 (0.01, 0.03)	0 (0-0)
Abscess (a) >0	34 (14.4) 0.18 (0.11, 0.24)	2 (0.4) 0.00 (-0.00, 0.01)	36 (4.6) 0.06 (0.04, 0.08)	0 (0-0)
pufa+PUFA >0	142 (59.9) 1.54 (1.29, 1.79)	140 (25.4) 0.51 (0.41, 0.61)	282 (35.8) 0.82 (0.71-0.93)	0 (0-1)

As mentioned in Chapter three (Figure 3-5 and Figure 3-6), for analytical purposes dental caries was classified into four categories and sepsis was classified into two categories. The prevalence for each of these categories is shown in Table 5.4. Overall the majority of children (29.9%) were in the moderate caries group. Moderate and severe caries prevalence was higher among the hospital sample but mild caries was more prevalent among the school sample.

Table 5.4 Dental caries and sepsis groups, by setting and in overall sample (max. N = 788)

Dental caries and sepsis	Hospital sample (N = 551) n(%)	School sample (N = 237) n(%)	Total sample (N = 788) n(%)
Dental caries			
No caries (dmft+DMFT = 0)	16 (6.7)	195 (35.4)	211 (26.8)
Mild (dmft+DMFT = 1-2)	54 (22.8)	148 (28.3)	110 (26.6)
Moderate (dmft+DMFT = 3-5)	88 (37.1)	148 (26.9)	136 (29.9)
Severe (dmft+DMFT = 6-15)	79 (33.3)	52 (9.4)	131 (16.6)
Dental sepsis			
No sepsis (pufa+PUFA = 0)	95 (40.1)	411 (74.6)	506 (64.2)
Having any sepsis (pufa+PUFA = 1-14)	142 (59.9)	140 (25.4)	282 (35.8)

5.1.5 Distribution of potential mediators

5.1.5.1 Oral health related quality of life (OHRQoL)

To measure OHRQoL of children, SOHO-5 was used which revealed that 56.6% of children had at least one negative oral impact on their quality of life (SOHO-5 score > 0). The mean (95% CI) SOHO-5 score was 1.79 (1.62, 1.96) (minimum of 0 to maximum of 14) and the median was 1. A histogram for the SOHO-5 has been shown in Chapter three, section 3.7.3.1 (Figure 3-7).

The prevalence of each item of the SOHO-5 is shown in Table 5.5, which demonstrates that eating difficulty was the most commonly reported impact. More than half of all children in the sample (51.0%) reported any eating difficulty, and 19.4% of the entire sample reported severe eating difficulty. This was followed by sleeping difficulty (28.1%), drinking problem (14.7%), avoid smiling due to oral pain (13.8%) and speaking problem (10.0%).

Parental perceptions about their child's oral impacts were similar to the child's self-reports with 58.5% of parents reporting any negative impact. Overall the correlation coefficient of the total score for the common six items of child and parental reports was 0.74 ($p < 0.001$), showing good agreement. As mentioned in Chapter three, the child reported SOHO-5 was used for further analysis.

**Table 5.5 Frequency of SOHO-5 items and dental pain (child and parent reported)
(max. N = 788)**

SOHO-5 items and dental pain	Children reported severity of difficulty			Child reported any difficulty/dental pain (%) (N=788)	Parent reported any difficulty/dental pain (%) (N=725)
	No (%)	Little (%)	A lot (%)		
SOHO-5 items					
1. Eating problem	49.0	31.6	19.4	51.0	55.0
2. Drinking problem	85.3	10.5	4.2	14.7	NA
3. Speaking problem	90.0	6.8	3.2	10.0	15.9
4. Problem in playing	93.3	4.7	2.0	6.7	12.8
5. Avoiding smiling due to pain	86.1	9.5	4.3	13.8	23.6
6. Avoiding smiling due to appearance	91.4	6.5	2.2	8.6	11.6
7. Difficulty in sleeping	71.9	16.9	11.2	28.1	31.3
8. Effect on confidence	NA	NA	NA	NA	21.7
Dental pain					
Dental pain (ever)	44.9	33.6	21.4	55.1	52.8
Dental pain (current)	58.5	28.2	13.3	41.5	42.9
NA: Not assessed					

5.1.5.2 Dental pain

The prevalence of dental pain is shown in Table 5.5. Of the total sample, 41.5% reported current toothache, while more than half of the sample (55.1%) had any experience of dental pain in their lifetime. Among the whole sample, 33.6% had mild (a little) and 21.4% had severe (a lot) pain. Parental report of the prevalence of toothache was very similar to child's

report. For further bivariate and multiple regression analyses, the child reported variable “any experience of dental pain in the lifetime” was used.

5.1.5.3 Eating difficulty

Apart from the SOHO-5 scale, eating difficulties were also assessed by asking about the child’s eating or chewing ability of three commonly eaten food groups in Bangladesh, the result of which are shown in Table 5.6. Eating difficulty was a common problem with 45.2% of parents reporting that the child had any difficulty with eating due to dental caries. The mean (95% CI) eating difficulty score was 1.86 (1.67, 2.05) (minimum of 0 to maximum of 9). The item based eating difficulty showed that 30.9% of children had mild to severe problems eating rice, home-made ruti and chapatti (common sources of carbohydrate in Bangladesh), 44.4% had problems chewing meat or fish (mainly meat) and 39.7% had problems chewing fresh fruits and vegetables.

5.1.5.4 Poor appetite

On the appetite scale, 44.4% of children had very good to good appetite and 55.6% had average to poor appetite (Table 5.6) with a mean (95% CI) appetite score of 2.62 (2.53, 2.71) and median of 3. In terms of reduced appetite, 18.5% of parents reported that their child’s appetite was reduced due to a dental problem (not shown in the Table).

5.1.5.5 Dental pain related sleep disturbance

32.2% of children had experienced some level of sleep disturbance due to dental pain. Of those children with sleep disturbance, 21.7% had had sleep disturbance once or twice in lifetime, 5.9% had had sleep disturbance once or twice in a year and 4.6% had experienced sleep disturbance once or twice in a month. The participant children had a mean (95% CI) sleep disturbance score of 10.57 (10.31, 10.83) (minimum of 7 to maximum of 30) on the general sleep disturbance scale of children (not shown in the Table).

Table 5.6 Frequency of eating difficulty, appetite, and Sleep disturbance in children (max. N= 725)

Potential mediators	Rice, Rutii/bread n (%)	Meat, fish n (%)	Fruits vegetable n (%)	Total n (%)
Eating difficulty				
No problem	499 (69.0)	402 (55.6)	436 (60.3)	
Mild problem	157 (21.7)	167 (23.1)	154 (21.3)	
Moderate problem	43 (5.9)	78 (10.8)	65 (9.0)	
Severe problem	24 (3.3)	76 (10.5)	68 (9.4)	
Appetite				
Very good appetite				177 (24.4)
Good appetite				145 (20.0)
Average appetite				239 (33.0)
Poor appetite				106 (14.6)
Very poor appetite				58 (8.0)
Sleep disturbance				
Never				490 (67.8)
Once/twice in life				157 (21.7)
Once/twice a year				43 (5.9)
Once/twice a month				33 (4.6)

Prevalence of potential mediators by setting

Table 5.7 presents the prevalence of potential mediators by setting. The prevalence of oral impacts, dental pain, eating difficulty, reduced appetite and sleep disturbance was considerably higher for the hospital sample than the school sample. The potential mediators were used in the bivariate and multiple regression analyses in the form of binary variables (see Chapter three, section 3.9.3, Table 3.3).

Table 5.7 prevalence of potential mediators by setting (max. N=788)

Potential mediators		Hospital setting n (%)	School setting n (%)	Total n (%)
OHRQoL	SOHO-5 score>0	200 (84.4)	246 (44.6)	446 (56.6)
Dental pain	Yes	180 (75.9)	254 (46.1)	434 (55.1)
Eating difficulty	Yes	177 (75.0)	151 (30.9)	328 (45.2)
Reduced appetite	Yes	82 (34.7)	52 (10.6)	134 (18.5)
Sleep disturbance	Yes	103 (44.0)	130 (26.6)	233 (32.2)

The next section of this chapter presents bivariate associations between the outcomes and exposures, and their associations with covariates.

5.2 Anthropometric outcomes, by exposures and covariates

An important issue to consider is the distribution of outcomes by different exposures and covariates.

5.2.1 Anthropometric outcomes, by dental caries and sepsis

In order to assess the bivariate association of HAZ, WAZ and BAZ scores with four caries groups and dichotomized dental sepsis groups, ANOVA and t-tests were conducted respectively. Both tests revealed a negative association between all anthropometric outcomes with dental caries and dental sepsis groups. In addition, the results suggest a dose-response relationship. Children with higher levels of dental caries and sepsis had lower mean HAZ, WAZ and BAZ scores (Figure 5-2 and Figure 5-3).

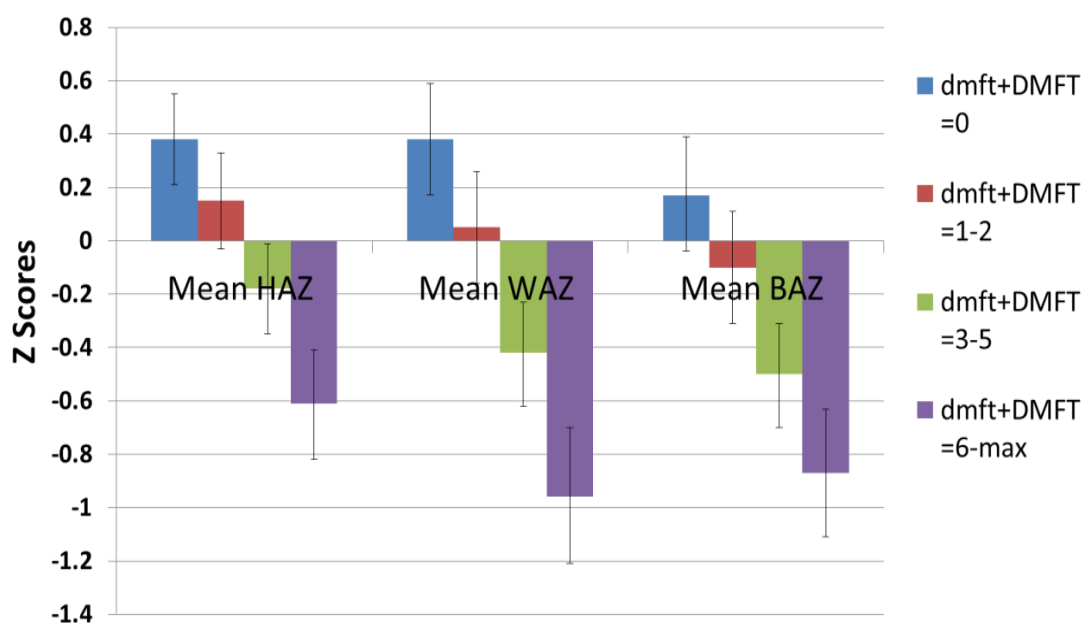


Figure 5-2 Bivariate association of anthropometric outcomes with dental caries groups.

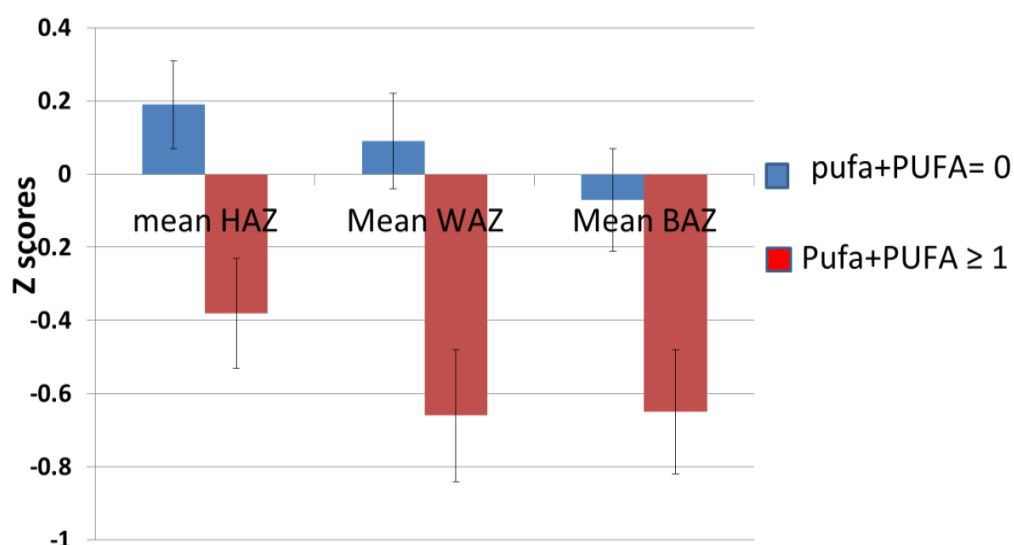


Figure 5-3 Bivariate association of anthropometric outcomes with dental sepsis groups

Table 5.8 shows that all anthropometric measures were negatively associated with dental caries. The mean (95% CI) HAZ score was 0.38 (0.21, 0.55) for the 'no caries' group, which reduced to -0.61 (-0.82, -0.41) for the 'severe caries' group ($p < 0.001$). Following a similar pattern, the mean (95% CI) WAZ score reduced from 0.38 (0.17, 0.59) to -0.96 (-1.21, -0.70) and the mean (95% CI) BAZ score reduced from 0.17 (-0.04, 0.39) to -0.87 (-1.11, -0.63) from the 'no caries' to 'severe caries' groups, respectively ($p < 0.001$). A similar inverse association was found for dental sepsis. The means (95% CI) of HAZ, WAZ and BAZ scores were 0.19 (0.07, 0.30), 0.09 (-0.04, 0.23) and -0.07 (-0.21, 0.07), respectively, in the 'sepsis free' group; compared to means of -0.38 (-0.53, -0.23), -0.66 (-0.84, -0.48) and -0.65 (-0.82, -0.48) in the 'any dental sepsis' group ($p < 0.001$).

Table 5.8 Association between anthropometric outcomes (HAZ, WAZ and BAZ) with clinical exposure groups (max. N=788)

Exposures	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Dental caries groups² (dmft+DMFT)			
0	0.38 0.21, 0.55	0.38 0.17, 0.59	0.17 -0.04, 0.39
1	0.15 -0.03, 0.33	0.05 -0.16, 0.26	-0.10 -0.31, 0.11
2	-0.18 -0.35, -0.01	-0.42 -0.62, 0.23	-0.50 -0.70, -0.31
3	-0.61 -0.82, -0.41	-0.96 -1.21, -0.70	-0.87 -1.11, -0.63
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>
Dental sepsis groups¹ (pufa+PUFA)			
0	0.19 0.07, 0.30	0.09 -0.04, 0.23	-0.07 -0.21, 0.07
1	-0.38 -0.53, -0.23	-0.66 -0.84, -0.48	-0.65 -0.82, -0.48
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>

¹t test ²ANOVA

5.2.2 Anthropometric outcomes by setting and demographic variables

The hospital sample had significantly lower z-scores on all three outcomes (HAZ, WAZ and BAZ scores) than the school sample. A positive association was detected between all anthropometric measures and parental educational categories. Children whose parents had a higher level of education presented with higher mean z-scores on all three outcomes, compared to lower educational categories. Mean BAZ (95% CI) score for children of uneducated mothers was -1.12 (-1.55, -0.68). To

compare, the mean BAZ (95% CI) score was 0.22 (-0.03, 0.48) for children whose mother had tertiary level of education ($p < 0.001$). Similar statistically significant associations were found for father's occupation and family income groups but not for mother's occupation and income sufficiency groups (Table 5.9).

Table 5.9 Association between anthropometric outcomes (HAZ, WAZ and BAZ) with socio-demographic variables (max. N = 788)

Socio-demographic variables	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Sex¹ (N=788)			
Boys	-0.11 -0.24, 0.02	-0.35 -0.52, -0.19	-0.47 -0.64, -0.31
Girls	0.08 -0.05, 0.21	0.04 -0.19, 0.12	-0.09 -0.24, 0.06
<i>p-value</i>	0.042	0.006	<0.001
Setting¹ (N=788)			
Hospital	-0.67 -0.82, -0.52	-0.98 -1.15, -0.81	-0.84 -0.99, -0.69
School	0.27 0.11, 0.08	0.17 0.04, 0.31	-0.03 -0.17, 0.11
<i>p-value</i>	<0.001	<0.001	<0.001
Paternal education² (N=725)			
No education	-1.01 -1.39, -0.59	-1.38 -1.73, -1.02	-1.12 -1.45, -0.79
Primary	-0.59 -0.81, -0.38	-0.96 -1.22, -0.70	-0.91 -1.15, -0.66
Secondary	-0.25 -0.47, -0.04	-0.47 -0.73, -0.21	-0.51 -0.78, -0.24
Higher secondary	0.09 -0.10, -0.30	-0.01 -0.26, 0.24	-0.14 -0.40, 0.11
Tertiary level	0.36 0.20, 0.51	0.28 0.10, 0.46	0.06 -0.13, 0.25
<i>p-value</i>	<0.001	<0.001	<0.001

Socio-demographic variables	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Maternal education ² (N=725)			
No education	-0.77 -1.27, -0.29	-1.24 -1.73, -0.74	-1.12 -1.55, -0.68
Primary	-0.73 -0.93, -0.52	-1.01 -1.25, -0.77	-0.85 -1.08, -0.62
Secondary	-0.12 -0.28, 0.04	-0.34 -0.54, -0.15	-0.44 -0.64, -0.24
Higher secondary	0.24 0.04, 0.43	0.13 -0.10, 0.37	-0.07 -0.28, 0.19
Tertiary level	0.55 0.35, 0.75	0.51 0.27, 0.74	0.22 -0.03, 0.48
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>
Paternal ² occupation (N=725)			
Service	0.16 0.03, 0.29	0.08 -0.13, 0.18	-0.14 -0.30, 0.01
Business	-0.02 -0.20, 0.15	-0.18 -0.39, 0.04	-0.28 -0.50, -0.07
Others	-0.81 -1.02, -0.59	-1.19 -1.45, -0.93	-1.02 -1.26, -0.78
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>
Maternal ¹ occupation			
House wife	-0.02 -0.12, 0.09	-0.17 -0.30, -0.04	-0.26 -0.39, -0.14
Others	-0.14 -0.40, 0.12	-0.48 -0.77, -0.18	-0.61 -0.91, -0.31
<i>p-value</i>	<i>0.383</i>	<i>0.068</i>	<i>0.035</i>
Family income ² (Taka/month) (N=725)			
<8 thousand	-0.49 -0.72, -0.26	-0.82 -1.11, -0.53	-0.79 -1.07, -0.52
8-20 thousand	-0.17 -0.31, -0.03	-0.44 -0.61, -0.28	-0.53 -0.69, -0.37
>20-30 thousand	0.41 0.22, 0.59	0.41 0.17, 0.65	0.19 -0.07, 0.44

Socio-demographic variables	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
>30 thousand	0.13 -0.14, 0.39	0.13 -0.17, 0.42	0.05 -0.22, 0.33
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>
Income ² sufficiency (N=725)			
Well sufficient	-0.07 -0.30, 0.16	0.06 -0.49, 0.06	-0.27 -0.53, -0.01
Moderately sufficient	-0.01 -0.12, 0.11	-0.03 -0.32, -0.03	-0.29 -0.43, -0.14
Insufficient	-0.14 -0.40, 0.12	-0.11 -0.69, -0.11	-0.47 -0.74, -0.20
<i>p-value</i>	<i>0.604</i>	<i>0.402</i>	<i>0.528</i>
¹ t test ² ANOVA			

5.2.3 Anthropometric outcomes by markers of early childhood health and nutritional status

A positive association was detected between all anthropometric measures and reported birth weight. Children who had a history of lower reported birth weight had lower mean z-scores for all three outcomes, compared to the normal and high birth weight groups. A significant association was observed between WAZ and BAZ scores with childhood disease and being underweight in the first four years of life. Children who suffered from any significant childhood diseases and those who had a history of being underweight had lower mean (95% CI) BAZ scores when compared to their counterparts: mean of -0.65 (-0.91, -0.38) versus mean of -0.24 (-0.37, -0.11) and mean of -0.89 (-1.13, -0.66) versus mean of -0.15 (-0.28, -0.02), (respectively) ($p < 0.01$). No significant associations were observed with premature birth and breast-feeding (Table 5.10).

Table 5.10 Anthropometric outcomes (HAZ, WAZ and BAZ) by the marker of early childhood health and nutritional status (max. N=723)

Marker of early childhood health and nutritional status	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Premature Birth ¹ (n=598)			
No	-0.06 -0.18, 0.06	-0.25 -0.39, -0.10	-0.34 -0.48, -0.19
Yes	0.13 -0.10, 0.36	-0.05 -0.32, 0.22	-0.21 -0.49, 0.06
<i>p-value</i>	0.291	0.450	0.743
Birth weight ² (n=717)			
Under weight	-0.11 -0.41, 0.20	-0.56 -0.89, -0.22	-0.78 -1.12, -0.44

Marker of early childhood health and nutritional status	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Normal weight	-0.11 -0.21, 0.00	-0.29 -0.42, -0.16	-0.36 -0.49, -0.24
Over weight	0.54 0.22, 0.87	0.70 0.28, 1.12	0.49 0.05, 0.94
<i>p-value</i>	<i><0.001</i>	<i><0.001</i>	<i><0.001</i>
Breast feeding ¹ (n=721)			
No	-0.29 -0.60, 0.02	-0.50 -0.86, -0.15	-0.52 -0.88, -0.16
Yes	-0.01 -0.12, 0.09	-0.19 -0.31, -0.07	-0.30 -0.42, -0.17
<i>p-value</i>	<i>0.129</i>	<i>0.155</i>	<i>0.305</i>
Childhood diseases ¹ (n=723)			
No	0.01 -0.10, 0.12	-0.13 -0.26, -0.01	-0.24 -0.37, -0.11
Yes	-0.24 -0.48, -0.00	-0.57 -0.85, -0.29	-0.65 -0.91, -0.38
<i>p-value</i>	<i>0.059</i>	<i>0.006</i>	<i>0.009</i>
Being under weight ¹ (n=718)			
No	0.01 -0.11, 0.12	-0.08 -0.22, 0.05	-0.15 -0.28, -0.02
Yes	-0.15 -0.33, 0.02	-0.65 -0.86, -0.44	-0.89 -1.13, -0.66
<i>p-value</i>	<i>0.194</i>	<i><0.001</i>	<i><0.001</i>

¹t test ²ANOVA

('Cannot remember' responses of 'Premature birth' were dropped from analysis.)

5.2.4 Anthropometric outcomes by potential mediators

All three outcomes showed statistically significant associations with the dichotomized groups of potential mediators: SOHO-5, dental pain, eating difficulty, reduced appetite and sleep disturbance when t-test was conducted. The mean z-scores were lower among children who had any difficulty compared to those without any difficulty. For instance, the mean (95% CI) HAZ, WAZ and BAZ scores for children having 'no impact' on OHRQoL were 0.34 (0.20, 0.47), 0.36 (0.19, 0.52), and 0.18 (0.01, 0.35), which reduced to -0.28 (-0.40, -0.16), -0.58 (-0.72, -0.44), and -0.63 (-0.76, -0.49) in 'having any impact' groups (Table 5.11). Similar patterns were observed for the other four potential mediators.

Table 5.11 Anthropometric outcomes (HAZ, WAZ and BAZ) by potential mediators (max. N=788)

Potential mediators	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
OHRQoL (N=788) (Child SOHO-5)			
No impact	0.34 0.20, 0.47	0.36 0.19, 0.52	0.18 0.01, 0.35
Any impact	-0.28 -0.40, -0.16	-0.58 -0.72, -0.44	-0.63 -0.76, -0.49
<i>p-value</i>	<0.001	<0.001	<0.001
Dental pain (N=788)			
No pain	0.25 0.12, 0.39	0.21 0.05, 0.38	0.06 -0.11, 0.23
Had pain	-0.23 -0.35, -0.11	-0.49 -0.64, -0.35	-0.55 -0.69, -0.41
<i>p-value</i>	<0.001	<0.001	<0.001
Eating difficulty (N=725)			
No problem	0.29 0.17, 0.41	0.26 0.11, 0.41	0.08 -0.07, 0.24

Potential mediators	HAZ Mean 95% CI	WAZ Mean 95% CI	BAZ Mean 95% CI
Any problem	-0.42 -0.56, -0.28	-0.76 -0.93, -0.60	-0.76 -0.92, -0.61
<i>p-value</i>	<0.001	<0.001	<0.001
Reduced appetite (N=725)			
No	0.08 -0.03, 0.19	-0.05 -0.18, 0.08	-0.18 -0.31, -0.05
Yes	-0.56 -0.77, -0.35	-0.95 -1.19, -0.72	-0.91 -1.13, -0.70
<i>p-value</i>	<0.001	<0.001	<0.001
Sleep disturbance (N=723)			
No problem	0.10 -0.02, 0.22	-0.03 -0.17, 0.12	-0.17 -0.31, -0.02
Any problem	-0.32 -0.49, -0.16	-0.60 -0.79, -0.41	-0.61 -0.79, -0.43
<i>p-value</i>	<0.001	<0.001	<0.001
t-test			

5.3 Clinical exposures (dental caries and sepsis) by covariates

The associations between exposures and covariates were explored via Chi-square tests.

5.3.1 Dental caries and sepsis by socio-demographic variables

Table 5.12 shows the frequency of caries and sepsis groups by different socio-demographic variables. A negative association was observed between both clinical exposures (dental caries and sepsis) with parental (both maternal and paternal) education groups: higher levels of severe caries and sepsis were associated with lower parental education groups. Of the children whose mothers were uneducated, 37.0% had severe caries, while 18.5% had no caries. In comparison, among children whose mothers had tertiary level of education, only 11.6% had severe caries and 31.3% had no caries. The association was similarly patterned for father's education and was stronger when dental sepsis was considered as exposure. Fewer children (13.0%) had severe caries whose paternal occupation was 'service', compared to 'business' and 'others' occupational groups (22.3% and 22.2% respectively). No statistically significant association was observed between dental caries and sex, maternal occupation, and family income. Similarly, the experience of dental sepsis was also socially patterned and was significantly associated with all the socio-economic variables. Interestingly sepsis was less prevalent in income levels of >20-30 thousand Taka/month and moderate income sufficiency groups.

Table 5.12 Frequency of dental caries and sepsis, by socio-demographic variables (max. N=788)

Socio-demo graphic Variables	Dental caries groups					Sepsis groups		
	n %				p	n %		p
	0	1	2	3		0	1	
Sex (N=788)								
Boy	106 27.3	97 25.0	124 32.0	61 15.7		248 63.9	140 36.1	
Girl	105 26.2	113 28.2	112 28.0	70 17.5		258 64.5	142 35.5	
					0.518			0.865
Paternal education (N=725)								
No education	9 25.7	4 11.4	14 40.0	8 22.9		19 54.3	16 45.7	
Primary	23 18.4	29 23.2	39 31.2	34 27.2		60 48.0	65 52.0	
Secondary	36 27.5	36 27.5	38 29.0	21 16.0		86 65.6	45 34.3	
Higher secondary	44 27.2	37 22.8	51 31.5	30 18.5		103 63.6	59 36.4	
Graduate/ Higher	83 30.5	79 29.0	79 29.0	31 11.4		189 69.5	83 30.5	
					0.017			0.001
Maternal education (N=725)								
No education	5 18.5	3 11.1	9 33.3	10 37.0		11 40.7	16 59.3	
Primary	31 21.5	31 21.5	41 28.5	41 28.5		73 50.7	71 49.3	
Secondary	58 26.2	61 27.6	72 32.6	30 13.6		148 67.0	73 33.0	
Higher secondary	55 29.6	44 23.7	61 32.8	26 14.0		123 66.1	63 33.9	
Graduate/ Higher	46 31.3	46 31.3	38 25.8	17 11.6		102 69.4	45 30.6	
					0.001			0.001
Paternal occupation (N=725)								
Service	114 28.1	118 29.1	121 29.8	53 13.0		274 67.5	132 32.5	

Socio-demo graphic Variables	Dental caries groups					Sepsis groups		
	n					n		
	%					%		
	0	1	2	3	<i>p</i>	0	1	<i>p</i>
Business	54 25.6	47 22.3	63 29.9	47 22.3		129 61.1	82 38.9	
others	27 25.0	20 18.5	37 34.3	24 22.2		54 50.0	54 50.0	
					0.021			0.003
Maternal occupation (N=725)								
House wife	171 27.7	157 25.4	189 30.6	101 16.3		400 64.7	218 35.3	
Others	24 22.4	28 26.2	32 29.9	23 21.5		57 53.3	50 46.7	
					0.497			0.023
Family income (Taka /month) (N=725)								
<8 thousand	31 29.5	21 20.0	35 33.3	18 17.1		61 58.1	44 41.9	
8-20 thousand	76 22.3	91 26.7	112 32.8	62 18.2		203 59.5	138 40.5	
>20-30 thousand	60 36.1	43 25.9	40 24.1	23 13.9		123 74.1	43 25.9	
>30 thousand	28 24.8	30 26.5	34 30.1	21 18.6		70 61.9	43 38.0	
					0.107			0.009
Income sufficiency groups (N=725)								
Well sufficient	32 24.2	34 25.8	32 24.2	34 25.8		75 56.8	57 43.2	
Moderately sufficient	136 28.3	120 25.0	157 32.7	67 14.0		323 67.3	157 32.7	
Not Sufficient	27 23.9	31 27.4	32 28.3	23 20.3		59 52.2	54 47.8	
					0.040			0.003
Chi-square test								

5.3.2 Dental caries and sepsis by markers of early childhood health and nutritional status

Table 5.13 shows that premature birth, birth weight and childhood diseases were statistically significantly associated with dental caries and sepsis. Being underweight in the first four years of life was significantly associated with sepsis but not with dental caries, while breast-feeding was not significantly associated with either of the exposures.

Table 5.13 Frequency of dental caries and sepsis by the marker of early childhood health and nutritional status (max. N=723)

Markers of early childhood health and nutritional status	Dental caries groups					Sepsis groups		
	n %				<i>p</i>	n %		<i>p</i>
	0	1	2	3		0	1	
Premature birth (N=598)								
No	105 22.4	119 25.4	151 32.3	93 19.9		272 58.1	196 41.9	
Yes	48 36.9	32 24.6	32 24.6	18 13.8		93 71.5	37 28.5	
					0.005			0.001
Birth weight (N=717)								
Under weight	25 36.8	14 20.6	20 29.4	9 13.2		48 70.6	20 29.4	
Normal weight	140 24.1	152 26.2	177 30.5	111 19.1		347 59.8	233 40.2	
Over weight	27 39.1	19 27.5	21 30.4	2 2.9		54 78.3	15 21.7	
					0.004			0.004
Breast feed (N=721)								
No	16 27.6	10 17.2	22 37.9	10 17.2		36 62.1	22 37.9	
Yes	179 27.0	174 26.2	197 29.7	113 17.0		420 63.3	243 36.6	
					0.409			0.846

Markers of early childhood health and nutritional status	Dental caries groups					Sepsis groups		
	n					n		
	%					%		
	0	1	2	3		0	1	
					<i>p</i>			<i>p</i>
Childhood diseases (N=723)								
No	172 28.8	152 25.4	181 30.3	93 15.5		388 64.9	210 35.1	
Yes	23 18.4	33 26.4	39 31.2	30 24.0		68 54.4	57 45.6	
					0.036			0.027
Being under Weight (N=718)								
No	151 26.5	152 26.7	166 29.1	100 17.6		349 61.3	220 38.7	
Yes	43 28.9	31 20.8	53 35.6	22 14.8		105 70.5	44 29.5	
					0.263			0.040
Chi-square test								

('Cannot remember' responses of 'Premature birth' were dropped from analysis.)

5.3.3 Distribution of potential mediators by clinical exposure groups

Both simple Chi-square tests and Chi-square tests for trend were conducted to analyse the relationship between dental caries and dental sepsis with dichotomized groups of potential mediators (Table 5.14). All potential mediators showed statistically significant positive associations with dental caries. With each level of increase of dental caries, the prevalence of having any problem (having any oral impact, experience of dental pain, eating difficulty, reduced appetite and sleep disturbance) increased significantly (both tests were highly statistically significant). Similarly, the percentage of having any problem was significantly higher for children with any dental sepsis experience.

Table 5.14 Distribution of potential mediators, by clinical exposure groups

Potential mediators	Dental caries groups					Dental sepsis groups		
			n %				n %	
	0	1	2	3	p^1	0	1	P^2
Experience of dental pain (N=788)								
No	201 95.3	96 45.7	46 19.5	11 8.4	***	325 64.2	29 10.3	***
Yes	10 4.7	114 54.3	190 80.5	120 91.6		181 35.8	253 89.7	
OHRQoL(N=788) (Child SOHO-5)								
0 score	205 97.2	91 43.3	37 15.7	9 6.9	***	320 63.2	22 7.8	***
1-max	6 2.8	119 56.7	199 84.3	122 93.1		186 36.8	260 92.2	
Eating difficulty (N=725)								
No problem	185 94.9	113 61.1	83 37.6	16 12.9	***	343 75.0	54 20.1	***
1-max problem	10 5.1	72 38.9	138 62.4	108 87.1		114 24.9	214 79.8	
Reduced appetite (N=725)								
No	190 97.4	162 87.6	168 76.0	71 57.3	***	418 91.5	173 64.5	***
Yes	5 2.6	23 12.4	53 24.0	53 42.7		39 8.5	95 35.4	
Sleep disturbance (N=723)								
No problem	192 98.5	136 73.9	113 51.4	49 39.5	***	385 84.6	105 39.2	***
Any problem	3 1.5	48 26.1	107 48.6	75 60.5		70 15.4	163 60.8	

*** $p < 0.001$

¹ Chi square test for trend ² Chi square test

Summary of bivariate analyses

Bivariate (unadjusted) analyses demonstrated that dental caries and sepsis were associated with all anthropometric outcomes. Children with higher levels of dental caries and presence of sepsis had lower means of HAZ, WAZ and BAZ scores. Of the covariates, parental education, paternal occupation, birth weight and childhood diseases were significantly associated with both exposures and outcomes. Bivariate analyses also demonstrated highly significant associations of all potential mediators with both outcomes and exposures. The mean z-scores of all outcomes were lower among children who had any negative impact on their OHRQoL, experience of dental pain, eating difficulty, reduced appetite and Sleep disturbance, compared to those without any difficulty. The prevalence of having any difficulties was higher for each higher level of dental caries and sepsis.

5.4 Results of linear regression models

The following sections of this chapter present the results of linear regression models to address objectives two to four of this study, the analytical strategy of which has already been described in the data analysis section of Chapter three. For the convenience of describing the results, the results focused on objective two and three are described together.

5.4.1 Testing the association between dental caries and sepsis and anthropometric outcomes and testing the effect of SOHO-5 on this association.

Bivariate analyses have shown that dental caries and sepsis were associated with all anthropometric outcomes. Linear regression models were used to explore the association adjusting for different covariates. The following models were estimated:

Model 1: unadjusted (crude) model; Model 2: adjusted for socio-economic variables (maternal education and family income); Model 3: additionally adjusted for setting (hospital and schools); and Model 4: additionally adjusted for birth weight and childhood diseases. Model 5: in order to assess the influence of OHRQoL (measured by child reported SOHO-5) on this association, SOHO-5 was additionally adjusted for. To be a potential mediator, it is expected that when this variable is controlled, the previously significant association between exposure and outcome would no longer be statistically significant or the magnitude of the association

would reduce greatly. In the analysis, z-scores for all anthropometric outcome variables were used on a continuous scale.

The results addressing objective two and three, which were to examine the associations between dental caries and sepsis and HAZ, WAZ and BAZ scores (Models 1- 4), and examine the role of OHRQoL on this association (Model 5), are presented in Tables 5.15-5.20.

5.4.1.1 Outcome: height-for-age

Exposure: dental caries

A negative linear association was detected between mean HAZ scores and dental caries (Table 5.15). Model 1 of Table 5.15 shows the results for the crude association, before any adjustments. Compared to the 'no caries' group, the HAZ scores for children in the 'moderate caries' group were on average 0.54 (95% CI -0.79, -0.29) points lower. For the 'severe caries' group the scores were 0.97 points lower (95% CI -1.26, -0.67) compared to the 'no caries' group, which was statistically significant at 0.001 level. There was no statistically significant difference between the 'no caries' and 'mild caries' groups.

This negative association remained highly significant even after adjusting for socio-economic variables (Model 2). However, the magnitude of association attenuated significantly after adjusting for setting in Model 3, where the children in moderate and severe caries group had -0.24 (95% CI -0.49, -0.00) ($p < 0.05$) and -0.41 (95% CI -0.71, -0.12) ($p < 0.01$) points

lower HAZ scores compared to caries free group respectively. Following adjustment for birth weight and early childhood diseases (Model 4) the association became non-significant for 'moderate caries' group and reduced to 0.40 (95% CI -0.69, -0.10) points for 'severe caries' compared to caries free group.

Model 5 additionally adjusted for OHRQoL (measured by SOHO-5). In this model, adjusted for all study variables, oral health related quality of life was not independently associated with HAZ scores. However, after adjusting for SOHO-5, the regression coefficient for the 'severe caries' group was reduced from -0.40 (95% CI -0.69, -0.10) to -0.30 (95% CI -0.66, 0.07) and became non-significant (comparing Model 4 and 5 in Table 5.15). Therefore, there was a 25.0% attenuation of regression coefficient for 'severe caries' group after adjusting for OHRQoL.

Exposure: dental sepsis

Similarly, a strong negative association was observed between HAZ scores and dental sepsis (Table 5.16). Compared to the 'no sepsis' group, the HAZ scores for children in the 'dental sepsis' group were 0.60 (95% CI -0.79, -0.40) points lower which was statistically significant at 0.001 level (Model 1 of Table 5.16). In the adjusted model (Model 4), the regression coefficient reduced to -0.23 (95% CI -0.42, -0.03) but still remained statistically significant ($p < 0.05$).

After adjusting for SOHO-5 the regression coefficient decreased by 34.8%, from -0.23 (95% CI -0.42, -0.03) to -0.15 (95% CI -0.37, 0.07) and became

non-significant (comparing Model 4 and 5 in Table 5.16). As before, SOHO-5 was not independently associated with HAZ scores.

In relation to the covariates; a positive linear association was detected with maternal education throughout the analyses as the adjusted HAZ scores were higher for each higher level of maternal education. Monthly family income of >20-30 thousand Taka was revealed as protective factor. Adjusting for study setting revealed that children from school setting had on average 0.67 (95% CI 0.46, 0.89) points higher HAZ scores compared to children from the hospital setting, considering dental caries as exposure (Model 4 of Table 5.15); and 0.71 (95% CI 0.50, 0.92) points higher HAZ scores compared to hospital setting, considering dental sepsis as exposure (Model 4 of Table 5.16); ($p < 0.001$). Birth weight and childhood diseases did not show any significant associations with HAZ scores. Overall, even though the SOHO-5 measure was not independently associated with height-for-age, the adjustment of SOHO-5 further attenuated the associations between caries and HAZ, as well as sepsis and HAZ. This non significant association between SOHO-5 measure and height-for-age might be an issue of statistical power and the attenuation provides some evidence that OHRQoL might be on the pathway between dental caries / sepsis and height-for-age.

Table 5.15 Results of multiple linear regression models testing the association of dental caries and HAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

HAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.22 (-0.49, 0.04) ^{NS}	-0.21 (-0.46, 0.04) ^{NS}	-0.07 (-0.32, 0.17) ^{NS}	-0.07 (-0.32, 0.17) ^{NS}	-0.01 (-0.29, 0.27) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.54 (-0.79, -0.29) ^{***}	-0.46 (-0.70, -0.22) ^{***}	-0.24 (-0.49, -0.00)*	-0.24 (-0.48, 0.00) ^{NS}	-0.14 (-0.46, 0.17) ^{NS}
	Severe (dmft+DMFT=6-15)	-0.97 (-1.26, -0.67) ^{***}	-0.76 (-1.04, -0.47) ^{***}	-0.41 (-0.71, -0.12) ^{**}	-0.40 (-0.69, -0.10) ^{**}	-0.30 (-0.66, 0.07) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.47 (0.21, 0.72) ^{***}	0.32 (0.06, 0.57)*	0.31 (0.06, 0.57)*	0.31 (0.06, 0.57)*
	Higher secondary		0.74 (0.47, 1.01) ^{***}	0.56 (0.29, 0.83) ^{***}	0.55 (0.28, 0.83) ^{***}	0.55 (0.27, 0.82) ^{***}
	Tertiary		1.02 (0.71, 1.32) ^{***}	0.86 (0.55, 1.16) ^{***}	0.84 (0.54, 1.14) ^{***}	0.83 (0.53, 1.14) ^{***}
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.19 (-0.08, 0.47) ^{NS}	0.22 (-0.04, 0.49) ^{NS}	0.20 (-0.06, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}
	>20-30 thousand		0.47 (0.15, 0.79) ^{**}	0.54 (0.23, 0.86) ^{**}	0.52 (0.21, 0.84) ^{**}	0.52 (0.20, 0.83) ^{**}
	>30 thousand		0.18 (-0.17, 0.53) ^{NS}	0.24 (-0.11, 0.58) ^{NS}	0.23 (-0.11, 0.58) ^{NS}	0.23 (-0.11, 0.58) ^{NS}

Table 5.15 continued

HAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.68 (0.47, 0.89) ^{***}	0.67 (0.46, 0.89) ^{***}	0.65 (0.44, 0.87) ^{***}
Birth weight (ref= normal birth weight)	Low weight				-0.20 (-0.50, 0.11) ^{NS}	-0.20 (-0.51, 0.10) ^{NS}
	High weight				0.20 (-0.11, 0.51) ^{NS}	0.20 (-0.11, 0.51) ^{NS}
Childhood diseases (ref=no)	Any diseases				-0.08 (-0.32, 0.15) ^{NS}	-0.07 (-0.31, 0.16) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.13 (-0.39, 0.13) ^{NS}

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

Table 5.16 Results of multiple linear regression models testing the association of dental sepsis and HAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

HAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Dental sepsis (ref: pufa+PUFA= 0)	Any dental sepsis (pufa+PUFA≥1)	-0.60 (-0.79, -0.40)***	-0.45 (-0.64, -0.26)***	-0.23 (-0.43, -0.04)*	-0.23 (-0.42, -0.03)*	-0.15 (-0.37, 0.07) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.49 (0.23, 0.75)***	0.32 (0.07, 0.58)*	0.32 (0.07, 0.57)*	0.32 (0.07, 0.58)*
	Higher secondary		0.77 (0.50, 1.05)***	0.57 (0.30, 0.84)***	0.56 (0.29, 0.83)***	0.55 (0.28, 0.82)***
	Tertiary		1.07 (0.76, 1.37)***	0.88 (0.58, 1.18)***	0.86 (0.56, 1.16)***	0.85 (0.55, 1.16)***
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.16 (-0.11, 0.44) ^{NS}	0.21 (-0.05, 0.48) ^{NS}	0.19 (-0.07, 0.46) ^{NS}	0.20 (-0.07, 0.47) ^{NS}
	>20-30 thousand		0.43 (0.11, 0.75)**	0.53 (0.21, 0.84)**	0.51 (0.20, 0.82)**	0.50 (0.19, 0.82)**
	>30 thousand		0.13 (-0.22, 0.49) ^{NS}	0.22 (-0.13, 0.56) ^{NS}	0.21 (-0.13, 0.56) ^{NS}	0.22 (-0.12, 0.57) ^{NS}

Table 5.16 continued

HAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.72 (0.52, 0.93) ^{***}	0.71 (0.50, 0.92) ^{***}	0.67 (0.45, 0.89) ^{***}
Birth weight (ref= normal birth weight)	Low weight				-0.20 (-0.51, 0.11) ^{NS}	-0.21 (-0.51, 0.10) ^{NS}
	High weight				0.21 (-0.10, 0.52) ^{NS}	0.21 (-0.10, 0.52) ^{NS}
Childhood diseases (ref=no)	Any diseases				-0.09 (-0.33, 0.14) ^{NS}	-0.08 (-0.31, 0.16) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.16 (-0.38, 0.06) ^{NS}

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

5.4.1.2 Outcome: weight-for-age

Exposure: dental caries

Correspondingly, an inverse linear association was detected between WAZ scores and dental caries groups (Table 5.17). Before any adjustments, compared to the 'no caries' group, the WAZ scores were -0.34 (95% CI -0.65, -0.03), -0.80 (95% CI -1.10, -0.50) and -1.27 (95% -1.62, -0.92) points lower respectively for children in 'mild', 'moderate' and 'severe' caries groups (Model 1 of Table 5.17). After adjusting for potential confounders, the association became non-significant for 'mild caries' group. For children in 'moderate' and 'severe' caries groups WAZ scores were -0.43 (95% CI -0.72, -0.15), and -0.59 (95% CI -0.94, -0.24) points lower compared to the 'no caries' group (respectively) and still remained statistically significant at 0.01 level (Model 4 of Table 5.17).

SOHO-5 showed a significant negative association with WAZ scores when dental caries was considered as the exposure. Children with any oral impact (SOHO-5 score 1-14) had 0.37 (95% CI -0.68, -0.07) points lower WAZ scores compared to children with 'no oral impact' (SOHO-5 score = 0) after adjusting for all other variables ($p < 0.05$) (Model 5 in Table 5.17). Moreover, after adjusting for SOHO-5, the associations between WAZ scores with moderate and severe caries groups were attenuated. The coefficients reduced by 67.4% and 50.8% respectively and became non-significant (comparing Model 4 and 5 in Table 5.17).

Exposure: dental sepsis

Similarly, children having any dental sepsis had on average 0.78 (95% CI -1.02, -0.55) point lower WAZ scores in the crude model (Model 1 of Table 5.18) and 0.33 (95% CI -0.56, -0.10) point lower WAZ scores in the adjusted model (Model 4 of Table 5.18), compared to 'no sepsis' group.

Model 5 of Table 5.18 demonstrated that considering dental sepsis as the exposure, children with any oral impact had 0.41 (95% CI -0.67, -0.15) points lower WAZ scores compared to children with no oral impacts, even after accounting for all other confounders ($p < 0.01$). Furthermore, the coefficient for the association between sepsis and WAZ scores reduced from -0.33 (95% CI -0.56, -0.10) to -0.14 (95% CI -0.40, 0.12) (reduced by 57.6%) and became non-significant after accounting for SOHO-5 (comparing Model 4 and 5 in Table 5.18). Thus OHRQoL could be considered as a potential mediator to explain the negative associations between dental sepsis and weight-for-age.

Other covariates showed a similar pattern of association as before, except for statistically significant association between birth weight and WAZ, where low birth weight was negatively and high birth weight was positively associated with WAZ scores considering both dental caries and sepsis as exposures. Children with history of low birth weight had significantly lower WAZ scores and children who had history of high birth weight had significantly higher WAZ scores compared to normal birth weight children.

Table 5.17 Results of multiple linear regression models testing the association of dental caries and WAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

WAZ	Categories	Model 1	Model 2	Model3	Model 4	Model 5
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.34 (-0.65, -0.03)*	-0.32 (-0.61, -0.02)*	-0.16 (-0.45, 0.13) ^{NS}	-0.16 (-0.45, 0.13) ^{NS}	0.03 (-0.30, 0.35) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.80 (-1.10, -0.50)***	-0.68 (-0.97, -0.40)***	-0.44 (-0.73, -0.15)**	-0.43 (-0.72, -0.15)**	-0.14 (-0.51, 0.22) ^{NS}
	Severe (dmft+DMFT=6-15)	-1.27 (-1.62, -0.92)***	-1.03 (-1.37, -0.69)***	-0.63 (-0.98, -0.27)**	-0.59 (-0.94, -0.24)**	-0.29 (-0.72, 0.13) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.47 (0.16, 0.77)**	0.29 (-0.01, 0.59) ^{NS}	0.28 (-0.02, 0.58) ^{NS}	0.28 (-0.02, 0.58) ^{NS}
	Higher secondary		0.83 (0.51, 1.15)***	0.62 (0.30, 0.94)***	0.60 (0.28, 0.92)***	0.57 (0.26, 0.89)***
	Tertiary		1.08 (0.72, 1.45)***	0.90 (0.54, 1.26)***	0.86 (0.50, 1.21)***	0.84 (0.48, 1.20)***
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.24 (-0.08, 0.57) ^{NS}	0.27 (-0.04, 0.59) ^{NS}	0.23 (-0.08, 0.54) ^{NS}	0.23 (-0.08, 0.54) ^{NS}
	>20-30 thousand		0.73 (0.35, 1.12)***	0.82 (0.45, 1.19)***	0.78 (0.41, 1.15)***	0.76 (0.39, 1.13)***
	>30 thousand		0.47 (0.05, 0.89)*	0.53 (0.12, 0.94)*	0.53 (0.12, 0.93)*	0.53 (0.13, 0.93)*

Table 5.17 continued

WAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.79 (0.54, 1.04)***	0.78 (0.52, 1.03)***	0.73 (0.47, 0.98)***
Birth weight (ref= normal birth weight)	Low weight				-0.54 (-0.90, -0.18)**	-0.55 (-0.91, -0.19)**
	High weight				0.43 (0.07, 0.79)*	0.43 (0.07, 0.79)*
Childhood diseases (ref=no)	Any diseases				-0.22 (-0.50, 0.05) ^{NS}	-0.19 (-0.47, 0.08) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.37 (-0.68, -0.07)*

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

Table 5.18 Results of multiple linear regression models testing the association of dental sepsis and WAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

WAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Dental sepsis (ref: pufa+PUFA=0)	Any dental sepsis (pufa+PUFA=1-14)	-0.78 (-1.02, -0.55)***	-0.61 (-0.83, -0.38)***	-0.35 (-0.58, -0.11)**	-0.33 (-0.56, -0.10)**	-0.14 (-0.40, 0.12) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.49 (0.19, 0.80)**	0.29 (-0.00, 0.59) ^{NS}	0.28 (-0.02, 0.58) ^{NS}	0.29 (-0.00, 0.59) ^{NS}
	Higher secondary		0.87 (0.54, 1.19)***	0.62 (0.30, 0.94)***	0.60 (0.28, 0.92)***	0.58 (0.27, 0.90)***
	Tertiary		1.15 (0.79, 1.51)***	0.93 (0.57, 1.29)***	0.88 (0.52, 1.23)***	0.86 (0.51, 1.22)***
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.20 (-0.12, 0.53) ^{NS}	0.26 (-0.06, 0.57) ^{NS}	0.21 (-0.10, 0.53) ^{NS}	0.23 (-0.08, 0.54) ^{NS}
	>20-30 thousand		0.69 (0.31, 1.08)***	0.81 (0.43, 1.18)***	0.77 (0.40, 1.14)***	0.75 (0.38, 1.11)***
	>30 thousand		0.41 (-0.01, 0.83) ^{NS}	0.50 (0.09, 0.91)*	0.50 (0.09, 0.91)*	0.52 (0.11, 0.92)*

Table 5.18 continued

WAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.86 (0.61, 1.10)***	0.84 (0.59, 1.09)***	0.74 (0.49, 1.00)***
Birth weight (ref= normal birth weight)	Low weight				-0.54 (-0.90, -0.18)**	-0.56 (-0.92, -0.20)*
	High weight				0.44 (0.07, 0.80)*	0.44 (0.07, 0.80)*
Childhood diseases (ref=no)	Any diseases				-0.24 (-0.51, 0.04) ^{NS}	-0.19 (-0.47, 0.08) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.41 (-0.67, -0.15)**

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

5.4.1.3 Outcome: BMI-for-age

Exposure: dental caries

As expected, a negative linear association was observed between BAZ scores and dental caries (Table 5.19). BAZ scores were -0.68 (95% CI -0.98, -0.38) points lower for 'moderate caries' and -0.96 (95% CI -1.31, -0.61) point lower for 'severe caries' groups, compared to the no caries group, which was statistically significant at <0.001 level. No statistical difference was observed between 'mild caries' and 'no caries' groups. The magnitude of association reduced to -0.43 (95% CI -0.72, -0.13) and -0.50 (95% -0.87, -0.13) for moderate and severe caries groups (respectively) in the adjusted model but remained significant at 0.01 level (Model 4 of Table 5.19).

OHRQoL (SOHO-5) was negatively associated with BAZ scores. When dental caries was considered as exposure, children having any negative oral impact had 0.43 (95% CI -0.75, -0.11) lower BAZ scores compared to children without any negative oral impact, after considering all covariates ($p < 0.01$) (Model 5 in Table 5.19). Additionally, after adjusting for SOHO-5, the coefficients for moderate and severe dental caries groups were reduced by 76.8% and 68.0% respectively and became non-significant (comparing Model 4 and 5 in Table 5.19).

Exposure: dental sepsis

Similarly, a negative association was observed between BAZ scores and dental sepsis (Table 5.20). Children with any dental sepsis had 0.29 (95% CI -0.53, -0.05) point lower BAZ scores than 'no dental sepsis' group ($p < 0.05$) after adjusting for potential confounders (Model 4 of Table 5.20).

Children with any oral impact had 0.46 (95% CI -0.73, -0.19) point lower BAZ scores compared to children with no oral impact, after accounting for all other covariates (Model 5 in Table 5.20) ($p < 0.01$). Furthermore, the coefficient for dental sepsis was reduced from -0.29 (95% CI -0.53, -0.05) to -0.07 (95% CI -0.34, 0.19) (reduced by 75.9%) after accounting for SOHO-5 and became non-significant (comparing Model 4 and 5 in Table 5.20). Therefore, as it was hypothesized, OHRQoL could be considered as a potential mediator to explain the negative association between dental caries / sepsis, and BMI-for-age.

The covariates showed similar patterns of associations as before, with only exception for maternal education, where BAZ scores for 'secondary education' group were not significantly different from the 'no education' group.

Table 5.19 Results of multiple linear regression models testing the association of dental caries and BAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

BAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.28 (-0.60, 0.03) ^{NS}	-0.26 (-0.57, 0.04) ^{NS}	-0.16 (-0.46, 0.15) ^{NS}	-0.16 (-0.46, 0.14) ^{NS}	0.05 (-0.29, 0.39) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.68 (-0.98, -0.38) ^{***}	-0.59 (-0.89, -0.30) ^{***}	-0.43 (-0.73, -0.13) ^{**}	-0.43 (-0.72, -0.13) ^{**}	-0.10 (-0.48, 0.29) ^{NS}
	Severe (dmft+DMFT=6-15)	-0.96 (-1.31, -0.61) ^{***}	-0.80 (-1.15, -0.46) ^{***}	-0.54 (-0.91, -0.17) ^{**}	-0.50 (-0.87, -0.13) ^{**}	-0.16 (-0.61, 0.28) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.24 (-0.07, 0.56) ^{NS}	0.13 (-0.18, 0.44) ^{NS}	0.11 (-0.19, 0.43) ^{NS}	0.12 (-0.19, 0.42) ^{NS}
	Higher secondary		0.54 (0.21, 0.87) ^{**}	0.40 (0.07, 0.74) [*]	0.38 (0.05, 0.71) [*]	0.35 (0.02, 0.68) [*]
	Tertiary		0.67 (0.29, 1.04) ^{**}	0.55 (0.17, 0.92) ^{**}	0.50 (0.12, 0.87) ^{**}	0.48 (0.11, 0.85) [*]
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.19 (-0.15, 0.52) ^{NS}	0.21 (-0.12, 0.54) ^{NS}	0.16 (-0.17, 0.48) ^{NS}	0.16 (-0.17, 0.48) ^{NS}
	>20-30 thousand		0.65 (0.26, 1.04) ^{**}	0.71 (0.32, 1.10) ^{***}	0.66 (0.28, 1.05) ^{**}	0.64 (0.25, 1.02) ^{**}
	>30 thousand		0.54 (0.11, 0.98) [*]	0.59 (0.16, 1.01) ^{**}	0.58 (0.16, 1.00) ^{**}	0.59 (0.17, 1.01) ^{**}

Table 5.19 continued

BAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.51 (0.25, 0.77)***	0.51 (0.24, 0.77)***	0.45 (0.18, 0.71)**
Birth weight (ref= normal birth weight)	Low weight				-0.63 (-1.00, -0.25)**	-0.64 (-1.02, -0.27)**
	High weight				0.44 (0.07, 0.83)*	0.45 (0.07, 0.83)*
Childhood diseases (ref=no)	Any diseases				-0.25 (-0.53, 0.04) ^{NS}	-0.21 (-0.50, 0.07) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.43 (-0.75, -0.11)**

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

Table 5.20 Results of multiple linear regression models testing the association of dental sepsis and BAZ and the role of SOHO-5 on this association: presented as regression coefficient (95% CI) (N= 715)

BAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Dental sepsis (ref: pufa+PUFA=0)	Any dental sepsis (pufa+PUFA≥1)	-0.60 (-0.84, -0.37)***	-0.48 (-0.71, -0.24)**	-0.30 (-0.54, -0.06)*	-0.29 (-0.53, -0.05)*	-0.07 (-0.34, 0.19) ^{NS}
Maternal education (ref= no and primary education)	Secondary		0.26 (-0.05, 0.57) ^{NS}	0.13 (-0.18, 0.44) ^{NS}	0.11 (-0.20, 0.42) ^{NS}	0.12 (-0.18, 0.43) ^{NS}
	Higher secondary		0.56 (0.23, 0.89)**	0.40 (0.06, 0.73)*	0.37 (0.04, 0.70)*	0.35 (0.03, 0.68)*
	Tertiary		0.71 (0.34, 1.09)***	0.57 (0.19, 0.94)**	0.51 (0.14, 0.88)**	0.49 (0.13, 0.86)**
Monthly family income (ref= <8000 Taka)	8-20 thousand		0.16 (-0.18, 0.49) ^{NS}	0.19 (-0.14, 0.52) ^{NS}	0.14 (-0.18, 0.47) ^{NS}	0.16 (-0.16, 0.49) ^{NS}
	>20-30 thousand		0.62 (0.23, 1.02)**	0.70 (0.31, 1.09)***	0.66 (0.27, 1.04)**	0.63 (0.25, 1.01)**
	>30 thousand		0.50 (0.07, 0.93)*	0.56 (0.14, 0.99)*	0.56 (0.14, 0.98)**	0.58 (0.16, 1.00)**

Table 5.20 continued

BAZ	Categories	Model 1	Model 2	Model 3	Model 4	Model 5
Setting (ref=Hospital)	School children			0.58 (0.32, 0.83)***	0.56 (0.30, 0.82)***	0.46 (0.19, 0.72)**
Birth weight (ref= normal birth weight)	Low weight				-0.63 (-1.01, -0.25)**	-0.65 (-1.02, -0.28)**
	High weight				0.45 (0.07, 0.83)*	0.45 (0.07, 0.83)*
Childhood diseases (ref=no)	Any diseases				-0.26 (-0.55, 0.02) ^{NS}	-0.21 (-0.50, 0.07) ^{NS}
SOHO-5 (ref= total score 0)	Score 1-14					-0.46 (-0.73, -0.19)**

Model 1: unadjusted analysis;

Model 2: Model 1 + socio-economic variables (maternal education+ family income);

Model 3: Model 2 + setting;

Model 4: Model 3 + birth weight, childhood disease;

Model 5: Model 4 + SOHO-5

*** p<0.001 **p<0.01 *p<0.05

Summary

The multiple regression analyses demonstrated statistically significant negative linear associations between dental caries and all three outcomes. However, the 'mild caries' group was not statistically different from the 'no caries' group. After the adjustment for all potential confounders, children with moderate and severe levels of caries had lower WAZ and BAZ scores compared to the no caries group. HAZ scores were significantly lower only for 'severe caries' group (demonstrating impact of severe caries on long term child growth indicator: height). As expected, children with dental sepsis had significantly lower HAZ, WAZ and BAZ scores compared to the 'no sepsis' group.

SOHO-5 was found to be negatively associated with WAZ and BAZ scores after accounting for all other variables, while the association with HAZ scores was not statistically significant. Moreover, after adjusting for SOHO-5, the regression coefficients for the associations between dental caries / sepsis and anthropometric outcomes were attenuated and became non-significant. Therefore, the results are consistent with the hypothesis that OHRQoL is on pathway between dental caries and sepsis, and weight-for -age and BMI-for-age.

5.4.2 Testing the effect of dental pain, eating difficulty, reduced appetite and sleep disturbance on the association between dental caries / sepsis, and anthropometric outcomes

This section presents the findings in relation to objective four, which was to examine the specific role of potential mediators in the association between dental caries / sepsis and HAZ, WAZ and BAZ scores. In order to test the changes in the association between exposures and outcomes, these potential mediators were sequentially adjusted for, starting with Model 4 from the previous section (which was adjusted for all potential confounders but not for SOHO-5). The results are presented in Table 5.21-5.26. Model 6 was adjusted for maternal education, family income, setting, birth weight, childhood disease and dental pain. Then eating difficulty, reduced appetite, and sleeping disturbance were sequentially added (Model 7 to Model 9). In these tables, Model 4 is presented again (the same model previously shown in Tables 5.15-5.20) to compare the changes of the regression coefficients conveniently.

5.4.2.1 Outcome: Height-for-age

Exposure: dental caries

Dental pain experience did not show any statistical significant association with HAZ scores when dental caries was considered as exposure, after controlling for all other confounders. However, adjustment for dental pain resulted in attenuation of the association between dental caries and HAZ scores. The coefficient of the association for 'severe caries' group reduced by

15.0%, from -0.40 (95% CI -0.69, -0.10) to -0.34 (95% CI -0.70, 0.01), and became non-significant (comparing Model 4 and 6 of Table 5.21). Eating difficulty was not significantly associated with HAZ scores (Model 7 in Table 5.21). However, adjusting for eating difficulty further attenuated the association between dental caries and HAZ scores when compared to Model 6. The coefficient for severe caries group was reduced to -0.27 (95% CI -0.64, 0.10) (20.6% reduction) and remained non-significant (comparing Model 6 and 7 in Table 5.21). Following additional adjustment for reduced appetite (Model 8) and sleep disturbance (Model 9), the coefficients did not change further. None of these potential mediators showed any significant association with HAZ when other confounders were taken into account.

Exposure: dental sepsis

Similarly, when dental sepsis was considered as an exposure, no statistical significant association was observed between dental pain and HAZ scores. Nevertheless, after the adjustment process, the coefficient for the association between dental sepsis and HAZ scores reduced by 26.1%, from -0.23 (95% CI -0.42, -0.03) to -0.17 (95% CI -0.39, 0.05), and became non-significant (comparing Model 4 and 6 of Table 5.22). Likewise, 'eating difficulty' was not significantly associated with HAZ scores (Model 7 in 5.22). However, adjusting for eating difficulty further attenuated the association between dental caries and HAZ scores when compared to Model 6. As before, neither reduced appetite nor sleep disturbance was associated with HAZ scores, nor did they attenuate the coefficient of association between sepsis and height-for-age.

Table 5.21 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental caries and HAZ: presented as Regression coefficient (95% CI)(N= 715)

HAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.07 (-0.32, 0.17) ^{NS}	-0.04 (-0.31, 0.23) ^{NS}	-0.02 (-0.29, 0.25) ^{NS}	-0.02 (-0.29, 0.25) ^{NS}	-0.02 (-0.30, 0.25) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.24 (-0.48, 0.00) ^{NS}	-0.19 (-0.49, 0.11) ^{NS}	-0.15 (-0.46, 0.16) ^{NS}	-0.15 (-0.46, 0.16) ^{NS}	-0.15 (-0.46, 0.16) ^{NS}
	Severe (dmft+DMFT=6-max)	-0.40 (-0.69, -0.10) ^{**}	-0.34 (-0.70, 0.01) ^{NS}	-0.27 (-0.64, 0.10) ^{NS}	-0.26 (-0.64, 0.11) ^{NS}	-0.27 (-0.64, 0.10) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.31 (0.06, 0.57) [*]	0.31 (0.06, 0.56) [*]	0.31 (0.06, 0.57) [*]	0.31 (0.06, 0.57) [*]	0.32 (0.06, 0.57) [*]
	Higher secondary	0.55 (0.28, 0.83) ^{***}	0.55 (0.28, 0.82) ^{***}	0.56 (0.29, 0.83) ^{***}	0.55 (0.28, 0.83) ^{***}	0.56 (0.28, 0.83) ^{***}
	Tertiary	0.84 (0.54, 1.14) ^{***}	0.84 (0.53, 1.14) ^{***}	0.83 (0.53, 1.13) ^{***}	0.82 (0.52, 1.13) ^{***}	0.82 (0.52, 1.13) ^{***}
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.20 (-0.06, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}
	>20-30 thousand	0.52 (0.21, 0.84) ^{**}	0.52 (0.21, 0.84) ^{**}	0.51 (0.19, 0.82) ^{**}	0.51 (0.20, 0.82) ^{**}	0.51 (0.20, 0.83) ^{**}
	>30 thousand	0.23 (-0.11, 0.58) ^{NS}	0.23 (-0.11, 0.58) ^{NS}	0.22 (-0.12, 0.57) ^{NS}	0.23 (-0.12, 0.57) ^{NS}	0.23 (-0.12, 0.57) ^{NS}

Table 5.21 continued

HAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Setting (ref=Hospital)	School children	0.67 (0.46, 0.89) ^{***}	0.67 (0.46, 0.89) ^{***}	0.63 (0.41, 0.86) ^{***}	0.63 (0.41, 0.85) ^{***}	0.62 (0.40, 0.85) ^{***}
Birth weight (ref= normal birth weight)	Low weight	-0.20 (-0.50, 0.11) ^{NS}	-0.20 (-0.51, 0.11) ^{NS}	-0.21 (-0.51, 0.10) ^{NS}	-0.20 (-0.51, 0.10) ^{NS}	-0.20 (-0.51, 0.10) ^{NS}
	High weight	0.20 (-0.11, 0.51) ^{NS}	0.20 (-0.11, 0.51) ^{NS}	0.19 (-0.12, 0.50) ^{NS}	0.19 (-0.12, 0.50) ^{NS}	0.19 (-0.12, 0.50) ^{NS}
Childhood diseases (ref=no)	Any diseases	-0.08 (-0.32, 0.15) ^{NS}	-0.08 (-0.31, 0.16) ^{NS}	-0.07(-0.30, 0.16) ^{NS}	-0.06 (-0.30, 0.17) ^{NS}	-0.06 (-0.30, 0.17) ^{NS}
Dental pain (ref= no)	Dental pain		-0.07 (-0.31, 0.17) ^{NS}	-0.02 (-0.27, 0.23) ^{NS}	-0.01 (-0.26, 0.24) ^{NS}	-0.02 (-0.29, 0.24) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score1-9			-0.16 (-0.40, 0.07) ^{NS}	-0.15 (-0.40, 0.09) ^{NS}	-0.16 (-0.41, 0.09) ^{NS}
Reduced appetite (ref= no)	Reduced appetite				-0.06 (-0.32, 0.20) ^{NS}	-0.07 (-0.34, 0.20) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.04 (-0.21, 0.28) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetite; Model 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

Table 5.22 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and HAZ: presented as Regression coefficient (95% CI)(N= 715)

HAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental sepsis (ref: pufa+PUFA= 0)	Any dental sepsis (pufa+PUFA≥1)	-0.23 (-0.42, -0.03)*	-0.17 (-0.39, 0.05) ^{NS}	-0.12 (-0.35, 0.11) ^{NS}	-0.11 (-0.34, 0.12) ^{NS}	-0.12 (-0.35, 0.11) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.32 (0.07, 0.57)*	0.32 (0.07, 0.57)*	0.32 (0.07, 0.58)*	0.32 (0.07, 0.57)*	0.32 (0.07, 0.58)*
	Higher secondary	0.56 (0.29, 0.83)***	0.56 (0.29, 0.83)***	0.57 (0.30, 0.84)***	0.56 (0.29, 0.83)***	0.56 (0.29, 0.84)***
	Tertiary	0.86 (0.56, 1.16)***	0.85 (0.55, 1.16)***	0.84 (0.54, 1.15)***	0.84 (0.53, 1.14)***	0.84 (0.54, 1.14)***
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.19 (-0.07, 0.46) ^{NS}	0.20 (-0.07, 0.47) ^{NS}	0.20 (-0.07, 0.46) ^{NS}	0.20 (-0.07, 0.47) ^{NS}	0.20 (-0.06, 0.47) ^{NS}
	>20-30 thousand	0.51 (0.20, 0.82)**	0.51 (0.19, 0.82)**	0.50 (0.18, 0.81)**	0.50 (0.19, 0.81)**	0.50 (0.19, 0.82)**
	>30 thousand	0.21 (-0.13, 0.56) ^{NS}	0.22 (-0.13, 0.56) ^{NS}	0.21 (-0.13, 0.55) ^{NS}	0.22 (-0.13, 0.56) ^{NS}	0.22 (-0.13, 0.56) ^{NS}
Setting (ref=Hospital)	School children	0.71 (0.50, 0.92)***	0.70 (0.48, 0.91)***	0.65 (0.43, 0.87)***	0.65 (0.42, 0.87)***	0.64 (0.42, 0.86)***

Table 5.22 continued

HAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Birth weight (ref= normal birth weight)	Low weight	-0.20 (-0.51, 0.11) ^{NS}	-0.21 (-0.51, 0.10) ^{NS}	-0.21 (-0.52, 0.09) ^{NS}	-0.21 (-0.52, 0.10) ^{NS}	-0.21 (-0.52, 0.10) ^{NS}
	High weight	0.21 (-0.10, 0.52) ^{NS}	0.20 (-0.11, 0.51) ^{NS}	0.19 (-0.12, 0.50) ^{NS}	0.19 (-0.12, 0.50) ^{NS}	0.19 (-0.12, 0.50) ^{NS}
Childhood diseases (ref=no)	Any diseases	-0.09 (-0.33, 0.14) ^{NS}	-0.08 (-0.32, 0.15) ^{NS}	-0.07 (-0.31, 0.16) ^{NS}	-0.06 (-0.30, 0.17) ^{NS}	-0.06 (-0.30, 0.17) ^{NS}
Dental pain (ref= no)	Dental pain		-0.12 (-0.33, 0.09) ^{NS}	-0.05 (-0.28, 0.17) ^{NS}	-0.05 (-0.28, 0.18) ^{NS}	-0.06 (-0.30, 0.18) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score=1-9			-0.18 (-0.42, -0.05) ^{NS}	-0.17 (-0.41, 0.07) ^{NS}	-0.18 (-0.43, 0.07) ^{NS}
Reduced appetite (ref= no)	Reduced appetite				-0.07 (-0.32, 0.19) ^{NS}	-0.08 (-0.34, 0.19) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.04 (-0.21, 0.29) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetite; Model 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

5.4.2.2 Outcome: weight-for-age

Exposure: dental caries

Dental pain experience did not show any statistical significant association with WAZ scores when dental caries was considered as exposure, after controlling for all other confounders. However, adjustment for dental pain attenuated the association between dental caries and WAZ scores. In the dental pain adjusted analysis the coefficient for 'moderate caries' group was reduced by 20.9%, from -0.43 (95% CI -0.72, -0.15) to -0.34 (95% CI -0.70, 0.01), and became non-significant. For 'severe caries' group the coefficient reduced by 16.9%, from -0.59 (95% CI -0.94, -0.24) to -0.49 (95% CI -0.91, -0.07), but remained significant at 0.05 level (comparing Model 4 and 6 in Table 5.23).

On the other hand, when 'eating difficulty' was additionally adjusted for, it showed a significant negative association with WAZ scores (Model 7 in Table 5.23). Children with any eating difficulty had 0.38 (95% CI -0.66, -0.10) points lower WAZ scores compared to children with no eating difficulty ($p < 0.01$). Adjustment for 'eating difficulty' also led to a significant attenuation of the association between dental caries and WAZ scores. The coefficients were attenuated by 29.4% for 'moderate caries' group to -0.24 (95% CI -0.60, 0.12) and by 34.7% for 'severe caries' group to -0.32 (95% CI -0.76, 0.11), and became non-significant (comparing Model 6 and 7 in Table 5.23). The additional adjustment for 'reduced appetite' and 'sleep disturbance' did not lead to further attenuation.

Exposure: dental sepsis

Similarly, when dental sepsis was considered as an exposure, no statistical significant association was observed between dental pain and WAZ scores. Yet, the coefficient for the association between dental sepsis and WAZ scores reduced by 30.3%, from -0.33 (95% CI -0.56, -0.10) to -0.22 (95% CI -0.48, 0.04) and became non-significant after the adjustment for dental pain (comparing Model 4 and 6 in Table 5.24).

As before, 'eating difficulty' showed significant negative association with WAZ scores considering dental sepsis as an exposure. Children with any eating difficulty had 0.42 (95% CI -0.70, -0.14) points lower WAZ scores compared to children with no eating difficulty ($p < 0.01$) (Model 7 in Table 5.24). Also the coefficient of association of dental sepsis and WAZ scores was attenuated to -0.11 (95% CI -0.38, 0.16) points (reduced by 50.0%) and remained non-significant (comparing Model 6 and 7 in Table 5.24).

Similar to HAZ, 'reduced appetite' (Model 8) and 'sleep disturbance' (Model 9) did not show any significant association with WAZ scores and their inclusion did not lead to any further significant attenuation in the association of both dental caries and sepsis with WAZ scores. Moreover, among all potential mediators only eating difficulty showed significant negative association with WAZ scores throughout the analyses process.

Table 5.23 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental caries and WAZ: presented as Regression coefficient (95% CI)(N= 715)

WAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.16 (-0.45, 0.13) ^{NS}	-0.10 (-0.42, 0.22) ^{NS}	-0.05 (-0.37, 0.27) ^{NS}	-0.05 (-0.37, 0.27) ^{NS}	-0.05 (-0.37, 0.27) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.43 (-0.72, -0.15) ^{**}	-0.34 (-0.70, 0.01) ^{NS}	-0.24 (-0.60, 0.12) ^{NS}	-0.24 (-0.60, 0.12) ^{NS}	-0.25 (-0.61, 0.11) ^{NS}
	Severe (dmft+DMFT=6-max)	-0.59 (-0.94, -0.24) ^{**}	-0.49 (-0.91, -0.07) [*]	-0.32 (-0.76, 0.11) ^{NS}	-0.31 (-0.74, 0.13) ^{NS}	-0.32 (-0.76, 0.11) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.28 (-0.02, 0.58) ^{NS}	0.28 (-0.02, 0.58) ^{NS}	0.28 (-0.01, 0.58) ^{NS}	0.28 (-0.02, 0.58) ^{NS}	0.29 (-0.01, 0.59) ^{NS}
	Higher secondary	0.60 (0.28, 0.92) ^{***}	0.60 (0.28, 0.91) ^{***}	0.61 (0.29, 0.93) ^{***}	0.60 (0.28, 0.92) ^{***}	0.61 (0.29, 0.93) ^{***}
	Tertiary	0.86 (0.50, 1.21) ^{***}	0.85 (0.49, 1.21) ^{***}	0.83 (0.48, 1.19) ^{***}	0.82 (0.46, 1.18) ^{***}	0.83 (0.47, 1.18) ^{***}
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.23 (-0.08, 0.54) ^{NS}	0.23 (-0.08, 0.55) ^{NS}	0.22 (-0.09, 0.54) ^{NS}	0.23 (-0.08, 0.54) ^{NS}	0.23 (-0.08, 0.54) ^{NS}
	>20-30 thousand	0.78 (0.41, 1.15) ^{***}	0.78 (0.41, 1.15) ^{***}	0.74 (0.38, 1.11) ^{***}	0.75 (0.38, 1.12) ^{***}	0.75 (0.39, 1.12) ^{***}
	>30 thousand	0.53 (0.12, 0.93) [*]	0.52 (0.12, 0.93) [*]	0.50 (0.10, 0.91) [*]	0.51 (0.11, 0.92) [*]	0.51 (0.11, 0.92) [*]

Table 5.23 continued

WAZ	Categories	Model 3	Model 6	Model 7	Model 8	Model 9
Setting (ref=Hospital)	School children	0.78 (0.52, 1.03)***	0.77 (0.52, 1.03)***	0.69 (0.43, 0.95)***	0.68 (0.42, 0.94)***	0.66 (0.40, 0.92)***
Birth weight (ref= normal birth weight)	Low weight	-0.54 (-0.90, -0.18)**	-0.54 (-0.90, -0.18)**	-0.56 (-0.92, -0.20)**	-0.55 (-0.91, -0.19)**	-0.55 (-0.91, -0.19)**
	High weight	0.43 (0.07, 0.79)*	0.42 (0.06, 0.78)*	0.40 (0.04, 0.76)*	0.40 (0.04, 0.77)*	0.40 (0.04, 0.77)*
Childhood diseases (ref=no)	Any diseases	-0.22 (-0.50, 0.05) ^{NS}	-0.21 (-0.49, 0.06) ^{NS}	-0.19 (-0.47, 0.08) ^{NS}	-0.18 (-0.46, 0.10) ^{NS}	-0.18 (-0.45, 0.10) ^{NS}
Dental pain (ref= no)	Dental pain		-0.12 (-0.40, 0.16) ^{NS}	-0.00 (-0.30, 0.29) ^{NS}	0.00 (-0.29, 0.30) ^{NS}	-0.03 (-0.34, 0.27) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score1-9			-0.38 (-0.66, -0.10)**	-0.36 (-0.64, -0.07)*	-0.38 (-0.67, -0.09)*
Reduced appetite (ref= no)	Reduced appetite				-0.14 (-0.44, 0.16) ^{NS}	-0.17 (-0.48, 0.14) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.12 (-0.17, 0.40) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetite; Model 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

Table 5.24 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and WAZ: presented as Regression coefficient (95% CI)(N= 715)

WAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental sepsis (ref: pufa+PUFA= 0)	Any dental sepsis (pufa+PUFA≥1)	-0.33 (-0.56, -0.10)**	-0.22 (-0.48, 0.04) ^{NS}	-0.11 (-0.38, 0.16) ^{NS}	-0.09 (-0.37, 0.17) ^{NS}	-0.11 (-0.39, 0.16) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.28 (-0.02, 0.58) ^{NS}	0.28 (-0.01, 0.58) ^{NS}	0.29 (-0.00, 0.58) ^{NS}	0.28 (-0.01, 0.58) ^{NS}	0.29 (-0.00, 0.59) ^{NS}
	Higher secondary	0.60 (0.28, 0.92)***	0.60 (0.28, 0.92)***	0.61 (0.30, 0.93)***	0.60 (0.28, 0.92)***	0.61 (0.29, 0.93)***
	Tertiary	0.88 (0.52, 1.23)***	0.87 (0.51, 1.22)***	0.85 (0.49, 1.20)***	0.83 (0.48, 1.19)***	0.83 (0.48, 1.19)***
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.21 (-0.10, 0.53) ^{NS}	0.23 (-0.09, 0.54) ^{NS}	0.22 (-0.09, 0.53) ^{NS}	0.23 (-0.09, 0.54) ^{NS}	0.23 (-0.08, 0.54) ^{NS}
	>20-30 thousand	0.77 (0.40, 1.14)***	0.76 (0.39, 1.13)***	0.74 (0.37, 1.10)***	0.74 (0.38, 1.11)***	0.75 (0.38, 1.11)***
	>30 thousand	0.50 (0.09, 0.91)*	0.50 (0.10, 0.91)*	0.49 (0.09, 0.89)*	0.50 (0.10, 0.91)*	0.50 (0.10, 0.91)*

Table 5.24 continued

WAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Setting (ref=Hospital)	School children	0.84 (0.59, 1.09)***	0.81 (0.56, 1.06)***	0.71 (0.46, 0.97)***	0.70 (0.44, 0.96)***	0.69 (0.42, 0.95)***
Birth weight (ref= normal birth weight)	Low weight	-0.54 (-0.90, -0.18)**	-0.55 (-0.91, -0.19)**	-0.57 (-0.93, -0.21)**	-0.56 (-0.92, -0.20)**	-0.56 (-0.92, -0.20)**
	High weight	0.44 (0.07, 0.80)*	0.42 (0.06, 0.78)*	0.40 (0.04, 0.76)*	0.40 (0.04, 0.76)*	0.40 (0.04, 0.76)*
Childhood diseases (ref=no)	Any diseases	-0.24 (-0.51, 0.04) ^{NS}	-0.22 (-0.49, 0.06) ^{NS}	-0.19 (-0.47, 0.08) ^{NS}	-0.18 (-0.46, 0.10) ^{NS}	-0.18 (-0.45, 0.10) ^{NS}
Dental pain (ref= no)	Dental pain		-0.22 (-0.47, 0.03) ^{NS}	-0.08 (-0.34, 0.19) ^{NS}	-0.07 (-0.34, 0.19) ^{NS}	-0.10 (-0.38, 0.18) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score1-9			-0.42 (-0.70, -0.14)**	-0.39 (-0.68, -0.10)**	-0.41 (-0.70, -0.12)**
Reduced appetite (ref= no)	Reduced appetite				-0.15 (-0.45, 0.15) ^{NS}	-0.18 (-0.49, 0.13) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.11 (-0.18, 0.40) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetiteModel 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

5.4.2.3 Outcome: BMI-for-age

Exposure: dental caries

Dental pain experience was not significantly associated with BAZ scores after controlling for all other confounders. The inclusion of dental pain led to some attenuation of the association between caries and BAZ scores (Model 6 of Table 5.25). After adjusting for dental pain, the coefficient for the 'moderate caries' group slightly reduced from -0.43 (95% CI -0.72, -0.13) to -0.32 (95% CI -0.69, 0.05) (25.6% reduction), and for the 'severe caries' group it reduced from -0.50 (95% CI -0.87, -0.13) to -0.39 (95% CI -0.83, 0.05) (22.0% reduction) and became non-significant (comparing Model 4 and 6 of Table 5.25).

Eating difficulty showed a significant negative association with BAZ scores. Children who had any eating difficulty had 0.40 (95% CI -0.69, -0.11) points lower BAZ scores compared to 'no eating difficulty' group ($P < 0.01$) (Model 7 in Table 5.25). In addition, adjustment for eating difficulty caused further attenuation of the associations between dental caries and BAZ scores (comparing Model 6 and 7 in Table 5.25).

Exposure: dental sepsis

A similar pattern was observed when dental sepsis was considered as exposure. Dental pain experience did not show any statistical significant association with BAZ scores, after controlling for all other confounders (Model 6 of Table 5.26). Adjustment for dental pain resulted in some attenuation of the association between dental sepsis and BAZ scores, which reduced from -0.29 (95% CI -0.53, -0.05) to -0.17 (95% CI -0.44, 0.10) (41.4% reduction) and became non-significant (comparing Model 4 and 6 of Table 5.26).

Eating difficulty again showed significant negative association with BAZ scores. Children who had any eating difficulty had 0.43 (95% CI -0.72, -0.14) points lower BAZ scores compared to 'no eating difficulty' group ($p < 0.01$), (Model 7 in Table 5.26). Moreover, the coefficient of association between dental sepsis and BAZ scores attenuated further after adjustment for eating difficulty (comparing Model 6 and 7 in Table 5.26).

Additional adjustment for 'reduced appetite' (Model 8) and 'sleep disturbance' (Model 9) (Table 5.25 and Table 5.26) did not lead to further changes in the association between dental caries / sepsis, and BAZ scores. Neither was significantly associated with BMI-for-age.

Table 5.25 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental caries and BAZ: presented as Regression coefficient (95% CI)(N= 715)

BAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental caries (ref: dmft+DMFT=0)	Mild caries (dmft+DMFT=1-2)	-0.16 (-0.46, 0.14) ^{NS}	-0.09 (-0.43, 0.24) ^{NS}	-0.04 (-0.37, 0.29) ^{NS}	-0.04 (-0.38, 0.29) ^{NS}	-0.05 (-0.38, 0.29) ^{NS}
	Moderate (dmft+DMFT=3-5)	-0.43 (-0.72, -0.13) ^{**}	-0.32 (-0.69, 0.05) ^{NS}	-0.22 (-0.59, 0.16) ^{NS}	-0.21 (-0.59, 0.16) ^{NS}	-0.23 (-0.61, 0.15) ^{NS}
	Severe (dmft+DMFT=6-max)	-0.50 (-0.87, -0.13) ^{**}	-0.39 (-0.83, 0.05) ^{NS}	-0.22 (-0.67, 0.23) ^{NS}	-0.20 (-0.66, 0.25) ^{NS}	-0.22 (-0.67, 0.23) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.11 (-0.19, 0.43) ^{NS}	0.11 (-0.20, 0.42) ^{NS}	0.12 (-0.19, 0.43) ^{NS}	0.11 (-0.19, 0.42) ^{NS}	0.13 (-0.18, 0.44) ^{NS}
	Higher secondary	0.38 (0.05, 0.71) [*]	0.38 (0.04, 0.71) [*]	0.39 (0.06, 0.72) [*]	0.38 (0.05, 0.71) [*]	0.39 (0.06, 0.72) [*]
	Tertiary	0.50 (0.12, 0.87) ^{**}	0.49 (0.12, 0.86) [*]	0.47 (0.10, 0.84) [*]	0.46 (0.09, 0.83) [*]	0.46 (0.09, 0.84) [*]
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.16 (-0.17, 0.48) ^{NS}	0.16 (-0.17, 0.49) ^{NS}	0.15 (-0.17, 0.48) ^{NS}	0.15 (-0.17, 0.48) ^{NS}	0.16 (-0.17, 0.48) ^{NS}
	>20-30 thousand	0.66 (0.28, 1.05) ^{**}	0.66 (0.27, 1.04) ^{**}	0.62 (0.24, 1.01) ^{**}	0.63 (0.25, 1.01) ^{**}	0.64 (0.25, 1.02) ^{**}
	>30 thousand	0.58 (0.16, 1.00) ^{**}	0.58 (0.16, 1.00) ^{**}	0.56 (0.14, 0.98) ^{**}	0.57 (0.15, 0.99) ^{**}	0.57 (0.15, 0.99) ^{**}

Table 5.25 continued

BAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Setting (ref=Hospital)	School children	0.51 (0.24, 0.77)***	0.50 (0.24, 0.77)***	0.41 (0.14, 0.68)**	0.40 (0.13, 0.67)**	0.38 (0.10, 0.65)**
Birth weight (ref= normal birth weight)	Low weight	-0.63 (-1.00, -0.25)**	-0.63 (-1.01, -0.26)**	-0.65 (-1.03, -0.28)**	-0.64 (-1.02, -0.27)**	-0.64 (-1.01, -0.26)**
	High weight	0.44 (0.07, 0.83)*	0.44 (0.06, 0.82)*	0.42 (0.04, 0.80)*	0.42 (0.04, 0.80)*	0.42 (0.04, 0.80)*
Childhood diseases (ref=no)	Any diseases	-0.25 (-0.53, 0.04) ^{NS}	-0.24 (-0.53, 0.05) ^{NS}	-0.22 (-0.50, 0.07) ^{NS}	-0.20 (-0.49, 0.08) ^{NS}	-0.20 (-0.49, 0.09) ^{NS}
Dental pain (ref= no)	Dental pain		-0.14 (-0.43, 0.16) ^{NS}	-0.02 (-0.32, 0.29) ^{NS}	-0.01 (-0.31, 0.30) ^{NS}	-0.05 (-0.37, 0.26) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score1-9			-0.40 (-0.69, -0.11)**	-0.37 (-0.67, -0.07)*	-0.40 (-0.71, -0.10)*
Reduced appetite (ref= no)	Reduced appetite				-0.15 (-0.46, 0.17) ^{NS}	-0.19 (-0.52, 0.13) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.16 (-0.14, 0.46) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetite; Model 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

Table 5.26 Results of multiple linear regression models testing the role of dental pain, eating difficulty, reduced appetite and Sleep disturbance on the association of dental sepsis and BAZ: presented as Regression coefficient (95% CI)(N= 715)

BAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Dental sepsis (ref: pufa+PUFA= 0)	Any dental sepsis (pufa+PUFA≥1)	-0.29 (-0.53, -0.05)*	-0.17 (-0.44, 0.10) ^{NS}	-0.05 (-0.33, 0.23) ^{NS}	-0.09 (-0.37, 0.17) ^{NS}	-0.06 (-0.35, 0.22) ^{NS}
Maternal education (ref= no and primary education)	Secondary	0.11 (-0.20, 0.42) ^{NS}	0.11 (-0.19, 0.42) ^{NS}	0.12 (-0.18, 0.43) ^{NS}	0.28 (-0.01, 0.58) ^{NS}	0.13 (-0.18, 0.44) ^{NS}
	Higher secondary	0.37 (0.04, 0.70)*	0.37 (0.04, 0.70)*	0.39 (0.06, 0.72)*	0.60 (0.28, 0.92)***	0.39 (0.05, 0.72)*
	Tertiary	0.51 (0.14, 0.88)**	0.50 (0.13, 0.87)**	0.48 (0.11, 0.84)*	0.83 (0.48, 1.19)***	0.47 (0.10, 0.84)*
Monthly family income (ref= <8000 Taka)	8-20 thousand	0.14 (-0.18, 0.47) ^{NS}	0.16 (-0.17, 0.48) ^{NS}	0.15 (-0.17, 0.48) ^{NS}	0.23 (-0.09, 0.54) ^{NS}	0.16 (-0.16, 0.49) ^{NS}
	>20-30 thousand	0.66 (0.27, 1.04)**	0.65 (0.27, 1.03)**	0.63 (0.24, 1.01)**	0.74 (0.38, 1.11)***	0.64 (0.25, 1.02)**
	>30 thousand	0.56 (0.14, 0.98)**	0.56 (0.14, 0.99)**	0.55 (0.13, 0.97)*	0.50 (0.10, 0.91)*	0.56 (0.14, 0.98)**

Table 5.26 continued

BAZ	Categories	Model 4	Model 6	Model 7	Model 8	Model 9
Setting (ref=Hospital)	School children	0.56 (0.30, 0.82) ^{***}	0.54 (0.28, 0.80) ^{***}	0.43 (0.17, 0.70) ^{**}	0.70 (0.44, 0.96) ^{***}	0.40 (0.13, 0.67) ^{**}
Birth weight (ref= normal birth weight)	Low weight	-0.63 (-1.01, -0.25) ^{**}	-0.64 (-1.02, -0.27) ^{**}	-0.66 (-1.03, -0.28) ^{**}	-0.56 (-0.92, -0.20) ^{**}	-0.65 (-1.02, -0.27) ^{**}
	High weight	0.45 (0.07, 0.83) [*]	0.43 (0.05, 0.81) [*]	0.41 (0.03, 0.79) [*]	0.40 (0.04, 0.76) [*]	0.41 (0.04, 0.79) [*]
Childhood diseases (ref=no)	Any diseases	-0.26 (-0.55, 0.02) ^{NS}	-0.24 (-0.53, 0.04) ^{NS}	-0.22 (-0.50, 0.07) ^{NS}	-0.18 (-0.46, 0.10) ^{NS}	-0.20 (-0.49, 0.09) ^{NS}
Dental pain (ref= no)	Dental pain		-0.24 (-0.50, 0.02) ^{NS}	-0.09 (-0.37, 0.19) ^{NS}	-0.07 (-0.34, 0.19) ^{NS}	-0.12 (-0.42, 0.17) ^{NS}
Eating difficulty (ref= score 0)	Eating difficulty score 1-9			-0.43 (-0.72, -0.14) ^{**}	-0.39 (-0.68, -0.10) ^{**}	-0.43 (-0.73, -0.13) ^{**}
Reduced appetite (ref= no)	Reduced appetite				-0.15 (-0.45, 0.15) ^{NS}	-0.19 (-0.52, 0.13) ^{NS}
Sleep disturbance (ref=no)	Sleep disturbance					0.15 (-0.15, 0.45) ^{NS}

Model 4: unadjusted analysis+ socio-economic variables (maternal education+ family income) + setting+ birth weight + childhood diseases

Model 6: Model 4 + dental pain; Model 7: Model 6 + eating difficulty; Model 8: Model 7 + reduced appetite; Model 9: Model 8 + Sleep disturbance

*** p<0.001 **p<0.01 *p<0.05

Summary

In these analyses, sequentially adjusted models showed that 'dental pain', 'reduced appetite' and 'sleep disturbance' were not significantly associated with HAZ, WAZ and BAZ scores. In contrast, 'eating difficulty' remained significantly and inversely associated with WAZ and BAZ scores throughout the adjustment process, but not with HAZ scores. Therefore, eating difficulty could be considered on the pathway of the inverse association between dental caries / sepsis, and WAZ and BAZ scores. Though dental pain experience was not significantly associated with any of the anthropometric outcomes, additional adjustment of dental pain showed some attenuation on association between dental caries / sepsis and all anthropometric outcomes. Additional adjustment of eating difficulty led to further attenuation of the associations. While inclusion of 'reduced appetite' and 'sleep disturbance' did not lead to any further change of the coefficients. As the adjustment for 'dental pain' and 'eating difficulty' made significant attenuation of the coefficients for the associations; therefore, the results revealed that these two variables could explain part of the negative association between caries / sepsis and all three anthropometric outcomes (HAZ, WAZ, and BAZ).

5.5 Sensitivity analyses

A sub-sample analysis was conducted on the 371 respondents with complete data on both parental height and weight measures. The analysis strategy of this smaller sub-sample analysis was that for each exposure, a model similar to Model 4 (adjusted for all confounders) was run (estimated as Model H1, W1, B1 separately for three outcomes: HAZ, WAZ and BAZ, respectively), then the models were additionally adjusted for parental height and weight (estimated as Model H2, W2, B2) (for HAZ, WAZ and BAZ, respectively). Finally, H1 versus H2, W1 versus W2 and B1 versus B2 Models were compared for each outcome. The results are presented in additional tables in Appendix 12 (Table A1 and Table A2), where Table A 1 presents the results considering dental caries as an exposure and Table A 2 presents the results considering dental sepsis as an exposure.

The results demonstrate that parental weight, but not height, was significantly associated with all three outcomes. However, the adjustment for parental height and weight did not lead to any significant change in the association between dental caries and HAZ and BAZ, with only exception for WAZ. The regression coefficient of severe caries and WAZ attenuated from -0.63 (95% CI -1.16, -0.10) to -0.48 (95% CI -0.98, 0.02) and became non-significant (comparing Model W1 and W2 in Table A 1). A similar pattern was found when dental sepsis was considered as exposure. Additional adjustment for parental height and weight only led to a slight attenuation in the association between dental sepsis and HAZ and BAZ, without changing the level of significance. However, the regression coefficient of association between

dental sepsis and WAZ decreased from -0.43 (95% CI -0.78, -0.08) to -0.30 (95% CI -0.64, 0.03) and became non-significant (comparing Model W1 and W2 in Table A 2).

Among different potential confounders, maternal education of higher secondary and tertiary level showed positive association with HAZ and WAZ but not with BAZ scores. Similarly, school children had higher HAZ and WAZ scores compared to hospital sample. While low birth weight showed significant negative association with WAZ and BAZ scores but not with HAZ scores.

Thus the result demonstrated that parental weight was significantly associated with child's height, weight and BMI after adjusting for all confounders. Moreover, adjusting for parental weight attenuated the associations between caries / sepsis, and child's weight-for-age. However, the result was obtained from data of 371 participants; hence the power to demonstrate statistical significance was greatly reduced.

Chapter summary

The aim of this chapter was to examine the associations between dental caries / sepsis and anthropometric measures while accounting for possible confounding factors, namely maternal education, family income, study setting, birth weight, and childhood diseases. The results demonstrated that compared to children with no caries, those with severe caries had on average lower height-for-age ($p < 0.01$); and children with both moderate and severe caries levels had significantly lower weight-for-age and BMI-for-age. However, there was no statistically significant difference between the 'no caries' and 'mild caries' groups for all three outcomes. Dental sepsis was also negatively associated with all three anthropometric outcomes.

This chapter also examined the role of OHRQoL, which was measured by SOHO-5, as an underlying factor of these negative associations. The results revealed that although the adjustment of SOHO-5 led to significant attenuation of associations between both clinical exposures (caries, sepsis) and anthropometric outcomes, SOHO-5 showed significant negative association only with WAZ and BAZ scores but not with HAZ scores, which is considered as a marker of long term growth. This indicates that OHRQoL influenced the associations with body weight and BMI, rather than with height.

This chapter also explored the specific role of 'dental pain', 'eating difficulty', 'reduced appetite' and 'sleep disturbance'. These variables were considered in the analyses as potential mediators. Of these variables, only 'dental pain'

and 'eating difficulty' led to significant attenuation of the association between clinical exposures and anthropometric outcomes. Moreover, only 'eating difficulty' was significantly inversely associated with WAZ and BAZ in the fully adjusted models, and explained a substantial part of the negative associations between caries / sepsis and WAZ / BAZ scores. However, eating difficulty was not associated with HAZ scores. This indicates that eating difficulty partly explains relationships between dental caries / sepsis, and weight-for-age and BMI-for-age.

Chapter 6 Discussion

6. Discussion

The aim of this thesis was to assess the associations between dental caries and anthropometric measures amongst 5-9-year-old Bangladeshi children and to examine the possible factors underlying these associations. The overall working hypothesis was that dental caries and sepsis would be inversely associated with children's age adjusted height, weight and BMI. As the possible underlying mechanism of this inverse association, it was hypothesized that dental caries and sepsis would result in impaired or compromised OHRQoL, particularly in relation to dental pain, eating difficulty, reduced appetite and Sleep disturbance, which in turn would negatively affect child growth.

The main findings of the thesis are summarized in this chapter and discussed in the light of the existing literature. Additionally, this chapter includes the strengths and limitations of this study, and implication for further research and policies.

6.1 Overview of key findings

This study found that in the school sample the prevalence of dental caries was 64.6% and mean dmft+DMFT was 2.11 (95% CI 1.91, 2.30). As the prevalence of dental caries for children of Bangladesh is unknown, this study finding made an important contribution towards the collection of dental epidemiological data in the country, although it was not a representative sample of children in Bangladesh.

6.1.1 Association between dental caries and anthropometric outcomes

Multiple linear regressions showed that dental caries was negatively associated with height-for-age, weight-for-age and BMI-for-age after adjusting for maternal education and family income; setting; birth weight and childhood diseases. Compared to the caries-free children, those with 'severe caries' had statistically significant lower height-for-age z-scores and those with moderate and severe caries had significantly lower weight-for-age and BMI-for-age z-scores. However, no significant difference was observed between children with mild caries and those without caries. Similarly, children who had dental sepsis had significantly lower height-for-age, weight-for-age and BMI-for-age compared to the children with no dental sepsis.

6.1.2 Testing the relative role of potential mediators

6.1.2.1 Exploring the role of OHRQoL

OHRQoL partly explained the inverse associations between dental caries / sepsis and anthropometric outcomes as adjustment of OHRQoL showed attenuation of the magnitude of the associations between dental caries / sepsis and all anthropometric outcomes and all associations became non-significant after the adjustment of OHRQoL. However, OHRQoL showed significant association with weight-for-age and BMI-for-age but not with height-for-age.

6.1.2.2 Exploring the role of specific factors

When the specific role of dental pain, eating difficulty, reduced appetite and sleep disturbance was investigated by sequential adjustment of these variables while adjusting for all confounders (but not for SOHO-5), it revealed the following:

Dental pain: With the adjustment of dental pain the coefficients for the associations between caries / sepsis and height-for-age, weight-for-age and BMI-for-age were reduced and became statistically non-significant in most cases, apart from association between severe caries and weight-for-age. However, dental pain did not show significant association with the outcome variables.

Eating difficulty: When eating difficulty was additionally adjusted, the coefficients for the associations between dental caries and all outcomes attenuated further and the remaining significant association between severe caries and weight-for-age became non-significant. However, eating difficulty showed significant association with weight-for-age and BMI-for-age but not with height-for-age.

Reduced appetite and sleep disturbance: Taking these factors into account did not further attenuate associations between dental caries / sepsis and the outcomes.

To sum up, dental caries and sepsis were negatively associated with all anthropometric measures amongst 5-9-year-old Bangladeshi children. That

means children who had higher levels of caries and sepsis had lower height-for-age, weight-for-age and BMI-for-age compared to caries and sepsis free children, which was consistent with the second hypothesis. The findings suggested that the possible explanation underlying these inverse associations was via negative impact of dental caries and sepsis on children's OHRQoL, particularly via dental pain and eating difficulty. Moreover, poor OHRQoL, particularly eating difficulty might have more impact on child's weight and BMI as these two potential mediators showed significant associations with weight-for-age and BMI-for-age z-scores but not with height-for-age z-score in the fully adjusted model.

6.2 Final proposed frame work of the association

The final proposed framework of association between dental caries / sepsis and height-for-age, weight-for-age, BMI-for-age has been illustrated in Figure 6-1.

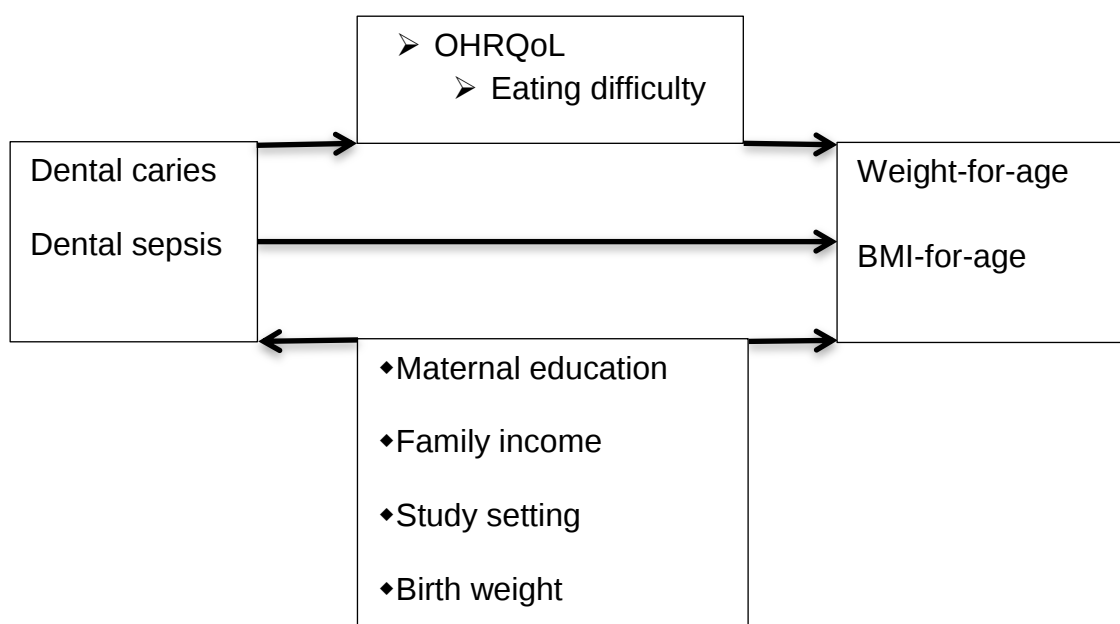


Figure 6-1 Final proposed framework of association

Dental caries and sepsis were inversely associated with all anthropometric outcomes (height-for-age, weight-for-age and BMI-for-age) in the study population. However, the proposed underlying mechanism of this association showed that dental caries and sepsis is associated with poor OHRQoL, especially in terms of experiencing eating difficulty, which in turn are negatively associated with children's weight-for-age and BMI-for-age.

6.3 Comparisons with previous research

As highlighted in Chapter two, the evidence for the association between dental caries and anthropometric outcomes is inconsistent. The present study was conducted in a population where 73.2% of children had experience of dental caries, and 35.8% had experience of dental sepsis, with a mean dmft+DMFT score of 2.84 (SD 2.80) (median 2). Mean (SD) height-for-age, weight-for-age and BMI for age z-scores were -0.01 (1.33), -0.17 (1.60), and -0.28 (1.59) respectively and higher level of dental caries and having dental sepsis were significantly related to lower height-for-age, weight-for-age and BMI-for-age.

6.3.1 Comparison with studies reporting similar findings

6.3.1.1 Comparison with studies reporting associations between dental caries with height and/or weight

Several studies have reported that children with higher caries levels were more likely to be shorter in height and lighter in weight than children without caries or with lower caries level, which was in accordance with the findings from this study (Miller et al., 1982; Acs et al., 1992; Ayhan et al., 1996; Gemert-Schriks et al. 2011; Mishu et al., 2013; Alkarimi et al., 2014). Most of the hospital based studies on samples with higher caries levels showed similar negative association (Miller et al. 1982; Acs et al. 1992; Vania et al. 2011).

The current study used z-scores for height, weight and BMI based on WHO growth reference data for 5-19 years (WHO 2007) and considered all

anthropometric measures on a continuous scale, which was similar to the study conducted in a school setting in Saudi Arabia (Alkarimi et al. 2014). However, despite the similarity of methodology and overall findings, some minor differences in the results were observed. For instance, Alkarimi et al (2014) reported an inverse-graded association between all anthropometric outcomes and caries levels in 6-8-year-old Saudi children; i.e. children at each higher level of caries had significantly lower height and weight than those with lower caries levels. However, the current study did not find a significant difference between the 'mild caries' and 'no caries' groups. Moreover, a previous study conducted in Bangladesh with 1,699 children of 6-12-year-old from deprived rural and slum urban areas reported an inverse association when both caries and height / weight were considered on continuous scales. However, after categorization of stunting (<-2 height-for-age z-score) and underweight (<-2 weight-for-age z-score), it was observed that children with at least one decayed tooth were significantly more likely to be underweight (odds ratio = 1.5), but no association was found with stunting (Mishu et al. 2013). This present study categorized caries into three severity groups and considered the presence of dental sepsis separately, thus was able to draw more specific conclusions on the impact of different severity levels of dental caries and presence of dental sepsis on child's height and weight.

Although some cross sectional studies reported a similar pattern of association, those studies explained the association with regard to malnutrition (lower height and weight) as a risk factor for higher levels of dental caries (Alvarez et al. 1990; Abolfotouh et al. 2000; Oliveira et al. 2008;

Koksal et al. 2011). Nevertheless, there were also some methodological issues that need to be considered. Similar to this study, Koksal et al. (2011) used the WHO 2007 growth reference for children's anthropometric measurements, but Oliveira et al. (2008) used the WHO 2005 child growth reference. However, although Oliveira et al. (2008) conducted multilevel linear regression to investigate the effect of nutritional, socio-economic, and demographic factors on dental caries; Koksal et al. (2011) only conducted bi-variate tests to find correlations without adjusting for any confounders. On the other hand, Alvarez et al. (1990) considered the National Centre for Health Statistics growth tables as the standard and Abolfotouh et al (2000) compared weight and height values with the local growth standards in Saudi Arabia, hence making direct comparison difficult.

The evidence for an association between caries and underweight was also indirectly supported by studies of 'catch-up growth' following comprehensive dental treatment. In these studies, children who had early childhood caries were dentally rehabilitated or treated and dental treatment was followed by greater weight gain (Acs et al. 1998; Acs et al. 1999; Mohammadi et al. 2009; Monse et al. 2012). Though these studies tested whether dental treatment was associated with weight gain, their findings indirectly support the present study results of negative association between dental caries/ sepsis and child's weight.

6.3.1.2 Comparison with studies reporting associations between dental caries and BMI

As mentioned in Chapter two, some prior studies also reported a similar pattern of a negative association between caries and BMI (Cameron et al. 2006; Ngoenwiwatkul & Leela-adisorn 2009; Benzian et al. 2011; Vania et al. 2011; Mohammadi et al. 2012; Goodson et al. 2013). However, some of the studies only conducted descriptive analyses and showed the result as cross tabulations, without adjusting for any potential confounding factors (Vania et al. 2011; Mohammadi et al. 2012). The inverse relationship of BMI and caries was in accord with a Thai study (Narksawat et al. 2009), though nutritional status was calculated in that study according to weight for height in Thai children and categorized into five groups. The result was also in line with three recent cross-sectional studies in China with school aged children (Liang et al. 2016; Peng et al. 2016; Yang et al. 2015). However, those studies used the BMI classification based on Chinese child growth standards and the first two studies only used the prevalence of caries as a dichotomized variable. Similarly, the inverse association was in agreement with several recent studies that have already been discussed in the literature review chapter (Bansal et al. 2016; Chauhan et al. 2016; Chopra et al. 2015; Bafti et al. 2015; Bhayat et al. 2016; Farsi et al. 2016; Ferraz et al. 2016; Markovic et al. 2015). Nevertheless, as described before, in contrast to the present study, most of the studies used different categorization of BMI that made direct comparison difficult. Moreover, these studies observed the association considering BMI status as an exposure to explain the prevalence of dental caries in children.

As mentioned earlier, several cross sectional and some longitudinal studies considered malnutrition as a risk factor for developing dental caries and a systematic review by Psoter et al. (2005) supports this contention. Infact, the evidence demonstrated that under nourished children are more susceptible to develop caries. Furthermore, this disadvantaged group had limited opportunity to receive dental treatment as a result of which they are more likely to suffer from the consequences of untreated caries; thereby their growth might be affected.

However, correlation does not imply causation (Iacobucci 2008) and the temporality issues cannot be explained from cross-sectional observational studies. Majority of the studies analysed in the literature review were cross-sectional in design and failed to utilise methods to strengthen causal inference. Still, the previously mentioned cross-sectional studies are considered to strengthen the hypothesis of the current study.

6.3.2 Comparing studies with dis-similar pattern of association between dental caries and anthropometric measures.

As mentioned in the literature review chapter, five reviews focused on the relationship between caries and obesity in children and reported inconsistent findings on the direction of association (Kantovitz et al. 2006; Hooley et al. 2012; Silva et al. 2013; Hayden et al. 2013; Li et al. 2015). In a review of Hayden et al.'s (2013) systematic review, Hooley (2014) confirmed that along with the influence of individual level socio-economic status, there is also an influence of country level variables (described in the paper as 'industrialization of the country'), since most of the studies that reported

positive associations were from high-income countries (Hooley 2014). Given the consideration of the dissimilarity of country and study population, this thesis did not attempt to replicate the findings of studies conducted in high-income countries. Therefore, the following section will focus on studies conducted in LMICs.

Positive association: While most of the studies in LMICs reported inverse relationships between caries and anthropometric measures, three studies in India (Sakeenabi et al. 2012; Honne et al. 2012; Bhoomika et al. 2013) reported a positive association between dental caries and BMI, which is contradictory to the present study finding. Bhoomika et al. (2013) reported a positive correlation between BMI and severe early childhood caries in 3-6-year-old children, but the study was very selective in their sample selection and only conducted basic statistical analyses. Sakeenabi et al. (2012) and Honne et al (2012) conducted logistic regression analysis and adjusted for various confounders, and reported the prevalence of caries in three BMI groups: normal weight, overweight and obese, but without considering underweight as a distinct group. Similarly, Yao et al. (2014) in their study in China considered healthy and underweight together as their reference group, making it more difficult to detect a relationship between dental caries and underweight. On the other hand, in some populations the relationship is U-shaped. Chopra et al. (2015) in their study in India found that both under and overweight children had higher caries levels than children with normal BMI.

Other studies reporting a positive association between dental caries and higher BMI from Iran (Shahraki et al. 2013; Bagherian & Sadeghi 2013) also

have similar limitations. The study by Bagherian & Sadeghi (2013) reported a positive association from the result of multiple regressions considering BMI-for-age. However, this study adjusted only for age and sex in their analysis but not for any other socio-economic factors. Moreover, that study used 'standardized percentile curves of body-mass index for children and adolescents', thus limiting its comparability to other studies using other child growth standards. On the other hand, despite of a larger sample size of 1,213 Iranian children, Shahraki et al. (2013) only conducted basic statistical analyses.

No association: Some studies reported no significant association between dental caries and children's BMI. However, most of these studies aimed to find an association between caries and obesity. Kumar et al. (2016) aimed to determine the association of BMI with dental caries and the influence of socio-economic status in 11-14-year-old Indian schoolchildren and reported that the association of BMI with dental caries varied by socio-economic status: overweight children of high socio-economic status were at lower risk of experiencing dental caries (Kumar et al. 2017). Despite the potential effect of socio-economic factors, Kottayi et al. (2016) in their study with 12-14-year-old children did not adjust for any confounding factors. Also, the authors considered overweight and normal-weight children, but did not assess underweight as a separate group. Similarly, Edalat et al. (2014) in their study among Iranian children of 3-6 years only showed cross tabulations. Another study by Alves et al. (2013) conducted among 12-year-old Brazilian children, considered caries as a count variable and conducted Poisson regression with adjustment for socio-economic variables, and reported no significant

association. However, they merged underweight and normal weight children together in their analysis. Similarly, another study in the Philippines with 1,962 representative samples of children could not draw a conclusion on the specific association between dental caries and weight status after accounting for socio-economic factors (Heinrich-Weltzien et al. 2013). However, in contrast to the previous categorization, this study categorized their sample as 'non-underweight' and 'underweight' groups. Similar to this study, maternal education was reported to be a protecting factor by several other studies (Nicolau et al. 2003; Oliveira et al. 2008). Therefore, controlling for socio-economic confounding factors and age group of the study children (as most of the non-association studies included children from higher age group) appears to have an important effect on the observed associations.

To sum up, several methodological issues need to be considered. Most of the reported studies used different categorization of BMI and the use of different cut-off points or non-standardized BMI cut off points influenced the study findings and made study comparisons difficult. Difference in measurement of caries prevalence and severity also has impact on the associations, as non-cavitated caries are more likely to be symptom free, but the advanced lesions are more likely to be associated with pain and other negative consequences, hence negatively associated with child's weight (Ferraz et al. 2014). The differences in patterns of association could be due to biases in the study population (studies conducted in a specific area or single school) and due to failure to consider individual level socio-economic factors. Moreover, the inconsistency of association is even more prominent among studies from countries of different income level. Therefore, the above-

mentioned explanations need to be considered to clarify the inconsistent pattern of associations. The following section provides insights to explain the negative pattern of associations considering the negative effect of dental caries on child's OHRQoL.

6.4 Underlying factors of a negative association between dental caries and anthropometric outcomes

In a cross sectional study Goodson et al. (2013) concluded that

“An inverse obesity-dental decay relationship contradicts the obesity-sugar and the obesity-dental decay relationship hypotheses” (Goodson et al. 2013).

That study recommended that the current lack of clarity of the underlying reasons of this inverse relationship warranted further investigation. In line with this, the current study provides some evidence for the potential pathways between dental caries / sepsis and poor height, weight and BMI of children. The third and fourth hypotheses of this study were to examine the role of OHRQoL, specifically the role of experience of dental pain, eating difficulty, reduced appetite, and sleep disturbance to explain the association between dental caries / sepsis and anthropometric measures. The present study demonstrated that OHRQoL, especially dental pain and eating difficulty has influence on the negative association.

Comparing studies assessing the effect of potential mediators to explain negative association between dental caries / sepsis and anthropometric outcomes

OHRQoL is often a neglected aspect to consider for children in the LMICs. Most of the studies referred in the literature review chapter only focused on association between dental caries and poor OHRQoL, but did not consider OHRQoL to explain the negative association between caries and child's anthropometric measures. This study provided some evidence that poor OHRQoL might be on the pathway between dental caries / sepsis and children's weight and BMI.

Evidence from intervention study aiming to investigate the effect of treatment of dental caries on improving OHRQoL and weight gain indirectly supports this finding. So far only one RCT using SOHO-5 scale formally attempted to test the hypothesis that treatment of severe caries would significantly improve children's weight via the improvement of their OHRQoL and demonstrated that after extraction of severely decayed teeth in underweight Filipino children, levels of oral health related impacts were associated with rate of weight gain (Duijster et al. 2013).

This current study not only investigated the potential impact of overall OHRQoL but also some specific factors to explain the inverse association. The association between dental pain and child growth has only been hypothesized theoretically as a direct impact (through an increase of glucocorticoid production) or indirect impact (via functional impact,

specifically on eating or chewing, drinking, sleeping) by several studies (Acs et al. 1992; Ayhan et al. 1996; Sheiham 2006). Similarly, the alteration of diet, induced by dental caries and dental pain related chewing difficulty and reduced appetite was hypothesized to cause nutritional deficiency to explain weight loss associated with severe caries. Also sleep disturbance was theoretically considered to negatively affect child growth via inhibition of growth hormone release (Acs et al. 1992; Sheiham 2006; Vania et al. 2011). However, none these hypotheses has been thoroughly investigated.

This study showed that the negative associations between dental caries / sepsis, and anthropometric outcomes were attenuated after adjustment of dental pain and eating difficulty, however, reduced appetite and sleep disturbance did not contribute additionally. Therefore, dental pain and eating difficulty partly explained this negative association. Additionally, the study exhibited that children with any oral impact had on average 0.41 points lower (i. e. 41% SD) weight-for-age / BMI-for-age z-scores, compared to children having no oral impact. Among specific potential mediators, compared to children with no eating difficulty, children with any eating difficulty had on average 0.40 points lower (i.e. 40% SD) weight-for-age / BMI-for-age z-scores.

Another RCT by Alkarimi et al (2012) assessing the impact of treatment of severe dental caries on children's weight, height and subjective health related outcomes showed that treating severe dental caries significantly reduced dental pain, dental sepsis, dissatisfaction with teeth and smile, and poor appetite. However, that study did not show any improvement in height

and weight, possibly due to the short follow up period. Another interventional study in India reported that treatment of severe early childhood caries improved body weight and quality of life in preschool children from low socio-economic status. However, that study had a small sample size (50 children in test group and 50 in control group) and did not attempt to test the improvement of OHRQoL to explain weight gain (Gaur & Nayak 2011). Nonetheless, overall these findings indirectly support the present study's results.

6.5 Strengths and limitations of this study

6.5.1 Strengths

Study novelty

Many studies have investigated the negative association of dental caries and anthropometric measures of children or negative impact of caries on child's OHRQoL. However, unlike this study, no other cross-sectional study took the approach to explain the negative association by adjusting for OHRQoL, and specific factors like dental pain, eating difficulty, poor appetite and sleep disturbance. Moreover, probably this was the first study assessing OHRQoL of children in Bangladesh by using Bengali translated and validated SOHO-5 questionnaire.

Methodological strengths

The study has the following methodological strengths:

1. The study was conducted with a fairly large sample size of children and parent pairs. The sample size calculation was conducted to have an adequate power to establish differences of height, weight and BMI-z-scores among different caries groups. The sample size calculation accounted for non-response. In addition, the high response rate achieved is among the strengths of this study. Achieving this high response rate was possible due to effective communication linkage with hospital and school authorities, especially with the outdoor duty doctors and class teachers and the offer of the complementary incentive of toothbrush and paste for the children. It was

not easy to reach the large hospital and school sample due to political unrest during the pilot study and severe monsoon rainfall during the main data collection period. The study team worked very hard for smooth completion of data collection following the timeline diligently, without any serious obstructions; which is considered as an obvious strength of the study.

2. This study collected comprehensive sets of data that included clinical (anthropometric and dental caries data) and subjective oral health outcomes. This study provides important insights of association between caries and child's anthropometric measures by analysing both clinical and subjective oral health outcomes data.

3. Another strong point of this study was seeking information from both children and parental sources. Dental pain and SOHO-5 questionnaire was administered for both children and parents and after assessing their agreement, the children's self-reported scores were used for the analysis. Family socio-economic status, history of early childhood health and nutritional status, details on eating difficulty, sleep disturbance and appetite related information was also gathered from parental questionnaire. Thus, the present analyses exploited different information from different informants, both children and parents.

4. One problem with many studies on assessing subjective oral health measures, specially studies from LMICs, were lack of standardized and reliable questionnaire to capture subjective oral impacts of the population. In this study, different scales and questionnaires were adopted from

internationally validated questionnaires (appetite scale, sleep disturbance scale of children and SOHO-5). An innovative approach was considered to measure the score of eating difficulty of different food groups. Assessment of validity and test-retest reliability of Bengali version of SOHO-5 questionnaires was conducted and the questionnaires were administered through a trained and experienced survey team.

5. All the clinical measurements used throughout this research were standardised and reliable. WHO protocol for clinical examination (WHO 2013) was followed meticulously and clinical dental examination was conducted by a survey team who were trained and calibrated to avoid any measurement bias. In addition, the outcomes were objectively measured and similar standard was maintained in measuring anthropometric outcomes.

5. A categorisation of caries (based on caries tertiles of this study population) was used in this study that went beyond the usually applied binary caries variable (yes/no) used in most studies. In addition, consideration of clinical consequences of untreated dental caries (PUFA/pufa index) provides further insight of this association.

6. Several studies as mentioned in literature review did not consider the socio-economic and other related factors in their analysis. The present study considered the association after taking into account of a range of socio-economic and early childhood variables and adjusted those variables in the data analysis and observed significant inverse association even after adjusting for those confounding factors.

6.5.2 Limitations of the study

The study had several limitations that need to be acknowledged.

1. Cross sectional study design

Ideally a proper measure of child growth (e.g. height, weight increase) would better explain the hypothesis of this study. Nonetheless, due to the cross-sectional study design, it was not possible to capture child growth. Moreover, no cause effect relationship was determined from this study, as the data of both exposure and outcome were simultaneously assessed at one point of time (Bowling 2014). However, a longitudinal study design was beyond the scope of this project. Hence the results of the study can be interpreted in the context of association and obviously correlation does not imply causation (Iacobucci 2008). The possibility of reverse causation is particularly inflated in the case of assessing association of child nutrition or growth indicators such as height and weight with dental caries, as described earlier. An attempt to reduce the effect of early childhood health status was made by adjusting the related variables in the analyses.

Additionally, proper testing of mediation was not possible due to the cross-sectional data. In fact, presence of a non-zero correlation could also be due to a third variable that is associated with both of the exposures and outcomes. Thus this study hypothesized some potential confounders and potential mediating factors that were adjusted in the analyses. However, testing for mediation from cross-sectional data are often criticized (Iacobucci 2008). Hence this study only indicated the potential mediating factors to

explain the association rather than running a proper mediation analysis to calculate the direct and indirect effect of these factors.

The standard methods of identifying causality are to conduct experimental or longitudinal observational study. However, considering the complexity and methodological issues (Alkarimi et al. 2012), It was not possible to run an experimental or longitudinal study within the time frame, scope and context of the present study.

2. The sample for this study is not a true representative sample of Bangladeshi children though every possible effort was taken for the random selection of multiple schools in the vicinity of the hospital, within the scope of the study. However, the main aim of this study was to explore the association between dental caries and height, weight and BMI of children, not to survey a representative sample and produce population estimates; and the study sample is not representative of all children of the same age living in Bangladesh.

3. This cross-sectional association might have a selection effect (selection bias). The inclusion of children from higher socio-economic class might have impact on the direction of the association as their BMI and caries burden might be different than the current study sample. As the caries level was unknown in the population level and it was important to test the study hypotheses in a study sample with range of caries (no caries to high levels of caries); thus this study considered both hospital and school sample.

3. There was limited ability to adjust for missing data on parental weight / height (item non-response). These variables were not adjusted in the main analysis and a separate sub sample analysis was conducted adjusting for these variables.

4. There were some limitations regarding 'Questionnaire design'.

Question on parental occupation: In the questionnaire parental occupation categories were not hierarchical though it was adapted from demographic and health survey of Bangladesh. Use of hierarchical occupation categories might have added value in data interpretation.

Question on eating difficulty and sleep disturbance: the use of more sensitive scale to measure eating and sleeping difficulty might explain its impact on the association more explicitly. For instance, the use of details of the eating pattern of the children (e.g. use of food diary) might be helpful to explore the impact of current eating difficulty on their nutritional intake. Similarly, use of the part of 'sleep disturbance scale of children' might not have been sensitive enough in this study population and there might be recall bias in reporting of sleep disturbance. It might be under represented as sleep disturbance was mostly reported by those having a current toothache and they might not report their past episode of sleep disturbance. Also the sleep disturbance might be associated with many external environmental factors that also needed to be considered.

Other issues: There might be an issue of acquiescence bias and social desirability bias with the reported data. Due to the dynamic nature of caries

and sepsis, acute painful pulpitis may become asymptomatic necrotic pulp with lapse of time, which makes detection of dental pain difficult. Thus dental pain could be underestimated in this study due to recall bias. Moreover, subjective oral health and early childhood health status data were based on self-report and therefore subject to recall bias. Although several demographic and socio-economic data were collected and were adjusted in the analyses, there might be some other potential confounders (such as health care access) that were not assessed.

6.6 Recommendations

6.6.1 Implications for future research

Experimental or longitudinal population based study designs are indicated to assess the associations between dental caries and child growth. However, in the context of lower middle-income countries with scarcity of resources, this would be challenging. Thus, some practical approaches have been recommended.

6.6.1.1 Modification of future observational study design

Most of the previous hospital based studies only included samples with high disease burden. On the other hand, some community-based studies were very selective on their school selection. Future observational studies should assess the association in randomly selected samples using internationally comparable measure of caries and height, weight and BMI and should account for possible confounding variables. To strengthen the evidence, specific dental problem related validated scales should be used. Bio-chemical tests to investigate the association of caries and the biomarkers of anaemia and other micronutrient deficiency could also be conducted. Testing the effect of dental infection induced inflammatory mediators or dental pain related glucocorticoid on child growth and the association of micro nutrient deficiency and anemia with dental caries would be interesting.

6.6.1.2 Interventional study for prevention and early treatment of caries

Rather than only exploring the caries-growth association, now is the time to take effective action to prevent dental caries and provide early treatment for children; especially in the countries like Bangladesh. Therefore, the future studies should address these issues and interventional studies should be conducted to find out cost effective measures for caries prevention and treatment for children.

6.6.2 Policy implications

This study has some important public health implications as it has provided some evidence of a negative association of dental caries and height, weight and BMI of children. Since dental caries prevalence is increasing in LMICs thus oral health should be acknowledged as an important agenda and reducing the prevalence of caries and ensuring early treatment should be a priority in health policy to reduce the further suffering of children. Oral health is fundamental to overall health, wellbeing and quality of life (Petersen et al. 2005). Despite this, oral health has always been given low priority in health system of LMICs, for instance, oral health issues were not even mentioned in the health policy of Bangladesh (MOHFW 2014). Therefore, there is a need to revive the current health policy and the following suggestions are made:

Incorporating evidence based approaches on oral health promotion and caries prevention strategies

Policy makers need to be aware of the health research and evidence based policy and practice. Existing evidence on impacts of dental caries on children's health outcomes need to be acknowledged. The policy makers could adapt the existing evidence based approaches in oral health promotion, such as 'Delivering Better Oral Health' (Public Health England 2014). Government initiatives and private sectors should use both individual and community based approaches to reduce the caries burden among children. Initiatives could be adapted from other approaches. For example, Public Health England in 2016 launched the children's oral health improvement programme board (COHIPB) with the ambition of *'every child grows up free from tooth decay as part of having the best start in life'* (PHE 2016), and a community based oral health care programme like 'Childsmile' project is successfully running in Scotland (Childsmile 2017). Despite the huge difference in availability of resources and context between high income countries and lower middle-income countries, the basic principles of these programmes could be adopted. The country specific approach should be considered within the restraint of resources. There is a need to integrate oral health into general health. For children this could be introduced through school programmes like 'Fit for school' (Monse et al. 2013); this approach is also recommended by WHO (Jürgensen & Petersen 2013).

The policy makers should also follow the evidence based approaches on prevention strategies of dental caries such as reduction of sugar

consumption (WHO 2015) and use of Fluoride (Petersen & Lennon 2004; Petersen & Phantumvanit 2012). Oral health promotion and prevention strategies should be adequately emphasized as they prove to be affordable and sustainable (Parkash et al. 2006).

Increase oral health care access

This study demonstrated that there was no statistically significant difference between the 'no caries' and 'mild caries' groups. Other studies also showed that early treatment of dental caries reduces the chance of dental sepsis (Pine et al. 2006; Alkarimi et al. 2012). Therefore, treatment of caries at early stage would reduce its adverse effects. The children of LMICs suffer more with malnutrition which is considered as a risk factor for the development of dental caries. Also due to the food transition over time and availability of sugary foods and drinks, caries prevalence has increased in children of LMICs (Lagerweij & van Loveren 2015). In addition to that, due to lack of oral health awareness, very limited access to dental health care and less availability of treatment facilities, most of the decay remains untreated (Petersen 2003; Van Palenstein-Helderman et al. 2015) and thus children are more likely to suffer a lot with the consequences of untreated dental caries, which might be associated negatively with their growth. Thus these countries should try to implement 'Universal Health Coverage plan' to provide accessible and affordable oral health care to all.

6.7 Concluding remarks

This study set out to examine whether dental caries is associated with height, weight and BMI of the children and investigated the factors underlying this association. The thesis showed a significant negative association between dental caries and sepsis and height-for-age, weight-for-age and BMI-for-age in the study population of 5-9-year-old children in Bangladesh. This study is one of the limited numbers of studies which provided evidence that poor OHRQoL is one of the associated factors explaining the inverse associations particularly via dental pain and eating difficulty. More specifically, OHRQoL particularly eating difficulty was found as important factor to explain the negative associations between dental caries /sepsis and weight-for-age and BMI-for-age. The findings of present study highlight the need for prevention of dental caries and ensure early diagnosis and treatment of dental caries for all children.

References

References

- AAPD, 2008. Definition of early childhood caries (ECC). *American Academy of Pediatric Dentistry*, p.1. Available at: http://www.aapd.org/assets/1/7/D_ECC.pdf [Accessed April 18, 2017].
- Abanto, J., Carvalho, T.S., Mendes, F.M., Wanderley, M.T., Bönecker, M. & Raggio, D.P., 2011. Impact of oral diseases and disorders on oral health-related quality of life of preschool children. *Community Dentistry and Oral Epidemiology*, 39(2), pp.105–14.
- Abanto, J., Paiva, S.M., Sheiham, A., Tsakos, G., Mendes, F.M., Cordeschi, T., Vidigal, E.A. & Bonecker, M., 2016. Changes in preschool children's OHRQoL after treatment of dental caries: responsiveness of the B-ECOHIS. *International Journal of Paediatric Dentistry*, 26(4), pp.259–265.
- Abanto, J., Tsakos, G., Ardenghi, T.M., Paiva, S.M., Raggio, D.P., Sheiham, A. & Bönecker, M., 2013. Responsiveness to change for the Brazilian Scale of Oral Health Outcomes for 5-year-old children (SOHO-5). *Health and Quality of Life Outcomes*, 11(1), p.137.
- Abanto, J., Tsakos, G., Paiva, S.M., Raggio, D.P., Celiberti, P. & Bönecker, M., 2014. Agreement between children aged 5-6 years and their mothers in rating child oral health-related quality of life. *International Journal of Paediatric Dentistry*, 24(5), pp.373–9.
- Abolfotouh, M.A., Hassan, K.H., Khattab, M.S., Youssef, R.M., Sadek, A. & El-Sebaiei, M., 2000. Dental caries: experience in relation to wasting and stunted growth among schoolboys in Abha, Saudi Arabia. *Annals of Saudi Medicine*, 20(5–6), pp.360–363.

- Accardo, P., 1982. *Failure to Thrive in Infants and Early Childhood: A Multidisciplinary Team Approach.*, Baltimore: University Park Press.
- Acharya, S. & Tandon, S., 2011. The effect of early childhood caries on the quality of life of children and their parents. *Contemporary Clinical Dentistry*, 2(2), pp.98–101.
- Acquadro, C., 2009. *Linguistic Validation Manual for Patient-reported Outcomes (PRO) Instruments*, Mapi Research Institute.
- Acs, G., Lodolini, G., Kaminsky, S. & Cisneros, G.J., 1992. Effect of nursing caries on body weight in a pediatric population. *Pediatric Dentistry*, 14(5), pp.302–5.
- Acs, G., Lodolini, G., Shulman, R. & Chussid, S., 1998. The effect of dental rehabilitation on the body weight of children with failure to thrive: case reports. *Compendium of Continuing Education in Dentistry (Jamesburg, N.J. : 1995)*, 19(2), pp.161–164.
- Acs, G., Pretzer, S., Foley, M. & Ng, M.W., 2001. Perceived outcomes and parental satisfaction following dental rehabilitation under general anesthesia. *Pediatric Dentistry*, 23(5), pp.419–423.
- Acs, G., Shulman, R., Ng, M.W. & Chussid, S., 1999. The effect of dental rehabilitation on the body weight of children with early childhood caries. *Pediatric Dentistry*, 21(2), pp.109–113.
- Adair, L.S., 1999. Filipino children exhibit catch-Up growth from age 2 to 12 years. *The Journal of Nutrition*, 129(6), pp.1140–8.
- Addo, O.Y., Stein, A.D., Fall, C.H., Gigante, D.P., Guntupalli, A.M., Horta, B.L., Kuzawa, C.W., Lee, N., Norris, S.A., Prabhakaran, P., Richter, L.M., Sachdev, H.S. & Martorell, R., 2013. Maternal height and child growth patterns. *The*

Journal of Pediatrics, 163(2), pp.549–54.

Alkarimi, H.A., Watt, R.G., Pikhart, H., Jawadi, A.H., Sheiham, A. & Tsakos, G., 2012. Impact of treating dental caries on schoolchildren's anthropometric, dental, satisfaction and appetite outcomes: a randomized controlled trial. *BioMed Central Public Health*, 12, p.706.

Alkarimi, H. a, Watt, R.G., Pikhart, H., Sheiham, A. & Tsakos, G., 2014. Dental Caries and Growth in School-Age Children. *Pediatrics*, 133(3), pp.e616–e623.

Alsumait, A., ElSalhy, M., Raine, K., Cor, K., Gokiart, R., Al-Mutawa, S. & Amin, M., 2015. Impact of dental health on children's oral health-related quality of life: a cross-sectional study. *Health and Quality of Life Outcomes*, 13, p.98.

Altman, D.G., 1991. *Practical Statistics for Medical Research* - Douglas G. Altman - Google Books 1st ed., London ;New York: Chapman and Hall.

Alvarez, J.O., Caceda, J., Woolley, T.W., Carley, K.W., Baiocchi, N., Caravedo, L. & Navia, J.M., 1993. A longitudinal study of dental caries in the primary teeth of children who suffered from infant malnutrition. *Journal of Dental Research*, 72(12), pp.1573–1576.

Alvarez, J.O., Eguren, J.C., Caceda, J. & Navia, J.M., 1990. The effect of nutritional status on the age distribution of dental caries in the primary teeth. *Journal of Dental Research*, 69(9), pp.1564–1566.

Alvarez, J.O., Lewis, C.A., Saman, C., Caceda, J., Montalvo, J., Figueroa, M.L., Izquierdo, J., Caravedo, L. & Navia, J.M., 1988. Chronic malnutrition, dental caries, and tooth exfoliation in Peruvian children aged 3-9 years. *The American Journal of Clinical Nutrition*, 48(2), pp.368–372.

Alves, L.S., Susin, C., Dame-Teixeira, N. & Maltz, M., 2013. Overweight and obesity

are not associated with dental caries among 12-year-old South Brazilian schoolchildren. *Community Dentistry and Oral Epidemiology*, 41(3), pp.224–231.

Anderson, H.K., Drummond, B.K. & Thomson, W.M., 2004. Changes in aspects of children's oral-health-related quality of life following dental treatment under general anaesthesia. *International Journal of Paediatric Dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*, 14(5), pp.317–25.

Arora, T., Broglia, E., Thomas, G.N. & Taheri, S., 2014. Associations between specific technologies and adolescent sleep quantity, sleep quality, and parasomnias. *Sleep Medicine*, 15(2), pp.240–7.

Ayhan, H., Suskan, E. & Yildirim, S., 1996. The effect of nursing or rampant caries on height, body weight and head circumference. *The Journal of Clinical Pediatric Dentistry*, 20(3), pp.209–212.

von Baeyer, C.L., Uman, L.S., Chambers, C.T. & Gouthro, A., 2011. Can we screen young children for their ability to provide accurate self-reports of pain? *Pain*, 152(6), pp.1327–33.

Bahti, L.S., Hashemipour, M.A., Poureslami, H. & Hoseinian, Z., 2015. Relationship between Body Mass Index and Tooth Decay in a Population of 3-6-Year-Old Children in Iran. *International Journal of Dentistry*, 2015, p.126530.

Bagherian, A. & Sadeghi, M., 2013. Association between dental caries and age-specific body mass index in preschool children of an Iranian population. *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research*, 24(1), pp.66–70.

- Bagramian, R.A., Garcia-Godoy, F. & Volpe, A., 2009. The global increase in dental caries. A pending public health crisis. *American Journal of Dentistry*, 22, pp.3–8.
- Bangladesh Bureau of Statistics., 2014. Bangladesh population and housing Census 2011. , p.41. Available at: <http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/NationalReports/UnionStatistics.pdf> [Accessed August 3, 2016].
- Bansal, K., Goyal, M. & Dhingra, R., 2016. Association of severe early childhood caries with iron deficiency anemia. *Journal of the Indian Society of Pedodontics and Preventive Dentistry*, 34(1), pp.36–42.
- Barbosa, T. de S., Gavião, M.B.D., Leme, M.S. & Castelo, P.M., 2016. Oral Health-related Quality of Life in Children and Preadolescents with Caries, Malocclusions or Temporomandibular Disorders. *Oral health & Preventive Dentistry*, 14(5), p.389.
- Barbosa, T. de S., Tureli, M.C. de M., Nobre-dos-Santos, M., Puppin-Rontani, R.M. & Gavião, M.B.D., 2013. The relationship between oral conditions, masticatory performance and oral health-related quality of life in children. *Archives of Oral Biology*, 58(9), pp.1070–7.
- Barbosa, T. & Gavião, M., 2008. Oral health-related quality of life in children: Part II. Effects of clinical oral health status. A systematic review. *International Journal of Dental Hygiene*, 6(2), pp.100–107.
- Barbosa, T.S. & Gavião, M.B.D., 2008. Oral health-related quality of life in children: part I. How well do children know themselves? A systematic review. *International Journal of Dental Hygiene*, 6(2), pp.93–99.

- Baron, R.M. & Kenny, D.A., 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), pp.1173–1182.
- BDHS, 2011. Bangladesh Demographic and Health Survey 2011. Available at: dhsprogram.com/pubs/pdf/FR265/FR265.pdf [Accessed March 5, 2014].
- Beaton, D.E., Bombardier, C., Guillemin, F. & Ferraz, M.B., 2000. Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine*, 25(24), pp.3186–91.
- Bennadi, D. & Reddy, C.V.K., 2013. Oral health related quality of life. *Journal of International Society of Preventive and Community Dentistry*, 3(1), pp.1–6.
- Benzian, H., Monse, B., Heinrich-Weltzien, R., Hobdell, M., Mulder, J. & van Palenstein Helderman, W., 2011. Untreated severe dental decay: a neglected determinant of low Body Mass Index in 12-year-old Filipino children. *BioMed Central Public Health*, 11, p.558.
- Bhayat, A., Ahmad, M.S. & Fadel, H.T., 2016. Association between body mass index, diet and dental caries in Grade 6 boys in Medina, Saudi Arabia. *Eastern Mediterranean Health Journal*, 22(9), pp.687–693.
- Bhoomika, W., Ramakrishna, Y. & Munshi, A.K., 2013. Relationship between severe early childhood caries and body mass index. *The Journal of Clinical Pediatric Dentistry*, 37(3), pp.235–242.
- Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. & Uauy, R., 2013. Maternal and child undernutrition and overweight in low-income and middle-

income countries. *Lancet*, 382(9890), pp.427–51.

Boeira, G.F., Correa, M.B., Peres, K.G., Peres, M.A., Santos, I.S., Matijasevich, A., Barros, A.J.D. & Demarco, F.F., 2012. Caries is the main cause for dental pain in childhood: Findings from a birth cohort. *Caries Research*, 46(5), pp.488–495.

Boersma Bart & Jan, M.W., 1997. Catch-up growth. *Endocrine Reviews*, 18(5), pp.646–661.

Bönecker, M., Abanto, J., Tello, G. & Oliveira, L.B., 2012. Impact of dental caries on preschool children's quality of life: an update. *Brazilian Oral Research*, 26(spe1), pp.103–107.

Bonuck, K., Parikh, S. & Bassila, M., 2006. Growth failure and sleep disordered breathing: a review of the literature. *International Journal of Pediatric Otorhinolaryngology*, 70(5), pp.769–78.

Bowling, A., 2014. *Research methods in health: investigating health and health and health services*, Open University Press.

Brook, C., 1982. *Growth assessment in childhood and adolescence*, Oxford; Boston: Blackwell Scientific Publications; St Louis Mo. Blackwell Mosby Book Distributors.

Brown, A. & Al-Khayal, Z., 2006. Validity and reliability of the Arabic translation of the child oral-health-related quality of life questionnaire (CPQ11-14) in Saudi Arabia. *International Journal of Paediatric Dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*, 16(6), pp.405–11.

Brown, K., Peerson, J., Lopez de Romana, G., de Kanashiro, H. & Black, R., 1995. Validity and epidemiology of reported poor appetite among Peruvian infants

from a low-income, periurban community. *American Journal of Clinical Nutrition*, 61(1), pp.26–32.

Bruni, O., Ottaviano, S., Guidetti, V., Romoli, M., Innocenzi, M., Cortesi, F. & Giannotti, F., 1996. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *Journal of Sleep Research*, 5(4), pp.251–61.

Bulletin of WHO, 2015. Bulletin of WHO, Volume 93:2015, Number 9, September 2015. *Online document*, pp.589–664. Available at: <http://www.who.int/bulletin/volumes/93/9/15-020915/en/> [Accessed June 21, 2016].

Cameron, F.L., Weaver, L.T., Wright, C.M. & Welbury, R.R., 2006. Dietary and social characteristics of children with severe tooth decay. *Scottish Medical Journal*, 51(3), pp.26–29.

Cameron, N., 2012. *Human Growth and Development (Google eBook)*, Academic Press.

Cappa, M. & Loche, S., 2003. Evaluation of growth disorders in the paediatric clinic. *Journal of Endocrinological Investigation*, 26(7 Suppl), pp.54–63.

Caulfield, L.E., Richard, S.A., Rivera, J.A., Musgrove, P. & Black., R.E., 2006. *Disease Control Priorities in Developing Countries* 2nd ed., World Bank.

Van Cauter, E. & Plat, L., 1996. Physiology of growth hormone secretion during sleep. *The Journal of Pediatrics*, 128(5), pp.S32–S37.

Chaffee, B.W., Rodrigues, P.H., Kramer, P.F., Vítolo, M.R. & Feldens, C.A., 2017. Oral health-related quality-of-life scores differ by socioeconomic status and caries experience. *Community Dentistry and Oral Epidemiology*, 45(3), pp.216–

Chakravarty, I. & Sinha, R.K., 2002. Prevalence of micronutrient deficiency based on results obtained from the national pilot program on control of micronutrient malnutrition. *Nutrition Reviews*, 60(5 Pt 2), pp.S53-8.

Chakravathy, K.P., Thippeswamy, H.M., Kumar, N. & Chenna, D., 2013. Relationship of body mass index and dental caries with oral health related quality of life among adolescents of Udupi district, South India. *European Archives of Paediatric Dentistry: Official Journal of the European Academy of Paediatric Dentistry*, 14(3), pp.155–9.

Chauhan, A., Nagarajappa, S., Dasar, P.L. & Mishra, P., 2016. Association of body mass index with dental caries among malnourished tribal children of Indore division. *Clujul Medical*, 89(4), pp.542–547.

Chaves, A.M.B., Rosenblatt, A. & Oliveira, O.F.B., 2007. Enamel defects and its relation to life course events in primary dentition of Brazilian children: a longitudinal study. *Community Dental Health*, 24(1), pp.31–36.

Chen, W., Chen, P., Chen, S.C., Shih, W.T. & Hu, H.C., 1998. Lack of association between obesity and dental caries in three-year-old children. *Zhonghua Minguo xiao er ke yi xue hui za zhi [Journal]*. *Zhonghua Minguo xiao er ke yi xue hui*, 39(2), pp.109–111.

Childsmile, 2017. Childsmile-improving the oral health of children in Scotland. Available at: <http://www.child-smile.org.uk/> [Accessed July 19, 2017].

Chiu, S.H., Dimarco, M.A. & Prokop, J.L., 2013. Childhood obesity and dental caries in homeless children. *Journal of Pediatric Health Care: official publication of National Association of Pediatric Nurse Associates & Practitioners*, 27(4),

pp.278–283.

Chopra, A., Rao, N.C., Gupta, N., Vashisth, S. & Lakhanpal, M., 2015. The Predisposing Factors between Dental Caries and Deviations from Normal Weight. *North American Journal of Medical Sciences*, 7(4), pp.151–159.

Clarke, M., Locker, D., Berall, G., Pencharz, P., Kenny, D.J. & Judd, P., 2006. Malnourishment in a population of young children with severe early childhood caries. *Pediatric Dentistry*, 28(3), pp.254–9.

Cogill, B., 2003. *Anthropometric Indicators Measurement Guide*, Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Cole, S.Z. & Lanham, J.S., 2011. Failure to thrive: an update. *American Family Physician*, 83(7), pp.829–834.

Connolly, M.A. & Johnson, J.A., 1999. Measuring quality of life in paediatric patients. *Pharmaco Economics*, 16(6), pp.605–25.

Costello, A.M., 1989. Growth velocity and stunting in rural Nepal. *Archives of Disease in Childhood*, 64(10), pp.1478–1482.

Cowson, R. & Odell, E., 2008. *Essential of oral pathology and oral medicine*. 8th ed., Churchill livingstone.

Cunnion, D.T., Spiro, A., Jones, J. a, Rich, S.E., Papageorgiou, C.P., Tate, A., Casamassimo, P., Hayes, C. & Garcia, R.I., 2010. Pediatric oral health-related quality of life improvement after treatment of early childhood caries: a prospective multisite study. *Journal of Dentistry for Children (Chicago, Ill.)*, 77(1), pp.4–11.

Czerwinski, S.A., Lee, M., Choh, A.C., Wurzbacher, K., Demerath, E.W., Towne, B.

& Siervogel, R.M., 2007. Genetic factors in physical growth and development and their relationship to subsequent health outcomes. *American journal of human biology: the official journal of the Human Biology Council*, 19(5), pp.684–91.

Daher, A., Versloot, J., Leles, C.R. & Costa, L.R., 2014. Screening preschool children with toothache: validation of the Brazilian version of the Dental Discomfort Questionnaire. *Health and Quality of Life Outcomes*, 12(1), p.30.

DDCH, 2017. Dhaka Dental College Hospital. Available at: <http://www.dhakadental.gov.bd/> [Accessed June 6, 2017].

Dean, A., Sullivan, K. & Soe, M., 2015. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version. Available at: www.OpenEpi.com [Accessed January 1, 2015].

Delgado-Angulo, E.K., Hobdell, M.H. & Bernabe, E., 2013. Childhood stunting and caries increment in permanent teeth: a three and a half year longitudinal study in Peru. *International Journal of Paediatric Dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*, 23(2), pp.101–109.

Dewald, J.F., Meijer, A.M., Oort, F.J., Kerkhof, G.A. & Bögels, S.M., 2010. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews*, 14(3), pp.179–89.

Do, L.G. & Spencer, A., 2007. Oral health-related quality of life of children by dental caries and fluorosis experience. *Journal of Public Health Dentistry*, 67(3), pp.132–9.

- Downs, S.H. & Black, N., 1998. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology & Community Health*, 52(6), pp.377–384.
- Duijster, D., Sheiham, A., Hobdell, M.H., Itchon, G. & Monse, B., 2013. Associations between oral health-related impacts and rate of weight gain after extraction of pulpally involved teeth in underweight preschool Filipino children. *BMC Public Health*, 13(1), p.533.
- Easton, J.A., Landgraf, J.M., Casamassimo, P.S., Wilson, S. & Ganzberg, S., 2008. Evaluation of a generic quality of life instrument for early childhood caries-related pain. *Community Dentistry and Oral Epidemiology*, 36(5), pp.434–440.
- Edalat, A., Abbaszadeh, M., Eesvandi, M. & Heidari, A., 2014. The Relationship of Severe Early Childhood Caries and Body Mass Index in a Group of 3- to 6-year-old Children in Shiraz. *Journal of Dentistry*, 15(2), pp.68–73.
- Edelstein, B.L., 2006. The dental caries pandemic and disparities problem. *BMC Oral Health*, 6 Suppl 1(Suppl 1), p.S2.
- Farsi, D.J., Elkhodary, H.M., Merdad, L.A., Farsi, N.M.A., Alaki, S.M., Alamoudi, N.M., Bakhaidar, H.A. & Alolayyan, M.A., 2016. Prevalence of obesity in elementary school children and its association with dental caries. *Saudi Medical Journal*, 37(12), pp.1387–1394.
- Fazili, A., Mir, A., Pandit, B., Bhat, I., Rohul, J. & Shamila, H., 2012. Nutritional Status of School Age Children (5-14 years) in a Rural Health Block of North India (Kashmir) Using WHO Z-Score System. *Online Journal of Health and Allied Sciences*, 11(2).

- Ferraz, E.G., Silva, L.R., Sarmento, V.A., de Jesus Campos, E., de Oliveira, T.F.L., Magalhaes, J.C., Paraguassu, G.M. & Boa-Sorte, N., 2016. Comparison of two visual methods for detecting caries among obese and non-obese children. *Acta Odontologica Scandinavica*, 74(5), pp.405–410.
- Ferraz, N.K.L., Nogueira, L.C., Pinheiro, M.L.P., Marques, L.S., Ramos-Jorge, M.L. & Ramos-Jorge, J., 2014. Clinical consequences of untreated dental caries and toothache in preschool children. *Pediatric Dentistry*, 36(5), pp.389–392.
- Ferreira, M.C., Goursand, D., Bendo, C.B., Ramos-Jorge, M.L., Pordeus, I.A. & Paiva, S.M., 2012. Agreement between adolescents' and their mothers' reports of oral health-related quality of life. *Brazilian Oral Research*, 26(2), pp.112–118.
- Filstrup, S.L., Briskie, D., da Fonseca, M., Lawrence, L., Wandera, A. & Inglehart, M.R., 2003. Early childhood caries and quality of life: child and parent perspectives. *Pediatric Dentistry*, 25(5), pp.431–40.
- Finucane, D., 2012. Rationale for restoration of carious primary teeth: a review. *Journal of the Irish Dental Association*, 58(1), pp.31–42.
- Firmino, R.T., Gomes, M.C., Clementino, M.A., Martins, C.C., Paiva, S.M. & Granville-Garcia, A.F., 2016. Impact of oral health problems on the quality of life of preschool children: a case-control study. *International Journal of Paediatric Dentistry*, 26(4), pp.242–249.
- Floyd, B., 2009. Associations between height, body mass, and frequency of decayed, extracted, and filled deciduous teeth among two cohorts of Taiwanese first graders. *American Journal of Physical Anthropology*, 140(1), pp.113–119.
- Foster Page, L.A. & Thomson, W.M., 2012. Caries prevalence, severity, and 3-year

increment, and their impact upon New Zealand adolescents' oral-health-related quality of life. *Journal of Public Health Dentistry*, 72(4), pp.287–94.

Foster Page, L.A., Thomson, W.M., Ukra, A. & Farella, M., 2013. Factors influencing adolescents' oral health-related quality of life (OHRQoL). *International journal of paediatric dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*, 23(6), pp.415–23.

Freire, M.C.M., Sheiham, A. & Netuveli, G., 2008. Relationship between height and dental caries in adolescents. *Caries Research*, 42(2), pp.134–140.

Fung, M., Wong, M., Lo, E. & Chu, C., 2013. Early Childhood Caries: A Literature Review. *Journal of Oral Hygiene & Health*, 1(1).

Galobardes, B., Shaw, M., Lawlor, D.A., Lynch, J.W. & Davey Smith, G., 2006. Indicators of socioeconomic position (part 1). *Journal of Epidemiology and Community Health*, 60(1), pp.7–12.

Gaur, S. & Nayak, R., 2011. Underweight in low socioeconomic status preschool children with severe early childhood caries. *Journal of the Indian Society of Pedodontics and Preventive Dentistry*, 29(4), pp.305–9.

van Gemert-Schriks, M.C.M., van Amerongen, E.W., Aartman, I.H.A., Wennink, J.M.B., Ten Cate, J.M. & de Soet, J.J., 2011. The influence of dental caries on body growth in prepubertal children. *Clinical Oral Investigations*, 15(2), pp.141–149.

Gherunpong, S., Tsakos, G. & Sheiham, A., 2004. Developing and evaluating an oral health-related quality of life index for children; the CHILD-OIDP. *Community Dental Health*, 21(2), pp.161–9.

Gibson, A.T., Carney, S., Cavazzoni, E. & Wales, J.K., 2000. Neonatal and post-

natal growth. *Hormone Research*, 53(Suppl. 1), pp.42–9.

Gilchrist, F., Rodd, H., Deery, C. & Marshman, Z., 2014. Assessment of the quality of measures of child oral health-related quality of life. *BMC Oral Health*, 14(1), p.40.

Goes, P.S.A., Watt, R., Hardy, R.G. & Sheiham, A., 2007. The prevalence and severity of dental pain in 14-15 year old Brazilian schoolchildren. *Community Dental Health*, 24(4), pp.217–24.

Gomes, M.C., Pinto-Sarmiento, T.C. de A., Costa, E.M.M. de B., Martins, C.C., Granville-Garcia, A.F. & Paiva, S.M., 2014. Impact of oral health conditions on the quality of life of preschool children and their families: a cross-sectional study. *Health and Quality of Life Outcomes*, 12, p.55.

Goodson, J.M., Tavares, M., Wang, X., Niederman, R., Cugini, M., Hasturk, H., Barake, R., Alsmadi, O., Al-Mutawa, S., Ariga, J., Soparkar, P., Behbehani, J. & Behbehani, K., 2013. Obesity and dental decay: inference on the role of dietary sugar. *PloS One*, 8(10), p.e74461.

Gradella, C.M.F., Bernabe, E., Bonecker, M. & Oliveira, L.B., 2011. Caries prevalence and severity, and quality of life in Brazilian 2- to 4-year-old children. *Community Dentistry and Oral Epidemiology*, 39(6), pp.498–504.

Granville-Garcia, A.F., Gomes, M.C., Dantas, L.R., Dantas, L.R., da Silva, B.R.C., Perazzo, M. de F. & Siqueira, M.B.L.D., 2016. Parental influence on children's answers to an oral-health-related quality of life questionnaire. *Brazilian Oral Research*, 30.

Green, D.P., Ha, S.E. & Bullock, J.G., 2010. Enough Already about “Black Box” Experiments: Studying Mediation Is More Difficult than Most Scholars Suppose.

The Annals of the American Academy of Political and Social Science, 628(1), pp.200–208.

Guillemin, F., Bombardier, C. & Beaton, D., 1993. Cross-cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. *Journal of Clinical Epidemiology*, 46(12), pp.1417–32.

Gururatana, O., Baker, S.R. & Robinson, P.G., 2014. Determinants of children's oral-health-related quality of life over time. *Community Dentistry and Oral Epidemiology*, 42(3), pp.206–215.

Hahn, C.-L., Best, A.M. & Tew, J.G., 2000. Cytokine Induction by *Streptococcus mutans* and Pulpal Pathogenesis. *Infection and Immunity*, 68(12), pp.6785–6789.

Harris, R., Nicoll, A.D., Adair, P.M., Pine, C.M. & Harris, R. V., 2004. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dental Health*, 21, pp.71–85.

Harvey, D., 1995. *Community child health and paediatrics*, Oxford; Boston: Butterworth-Heinemann.

Hayden, C., Bowler, J.O., Chambers, S., Freeman, R., Humphris, G., Richards, D. & Cecil, J.E., 2013. Obesity and dental caries in children: a systematic review and meta-analysis. *Community Dentistry and Oral Epidemiology*, 41(4), pp.289–308.

Heinrich-Weltzien, R., Monse, B., Benzian, H., Heinrich, J. & Kromeyer-Hauschild, K., 2013. Association of dental caries and weight status in 6- to 7-year-old Filipino children. *Clinical Oral Investigations*, 17(6), pp.1515–1523.

Helderman, W.H., Joarder, M.A. & Begum, A., 1996. Prevalence and severity of

- periodontal diseases and dental caries in Bangladesh. *International Dental Journal*, 46(2), pp.76–81.
- Hilasaca-Mamani, M., Barbosa, T. de S., Fegadolli, C. & Castelo, P.M., 2016. Validity and reliability of the quality of masticatory function questionnaire applied in Brazilian adolescents. *CoDAS*, 28(2), pp.149–154.
- Hindmarsh, P. C. & Brook, C.G.D., 1988. Hormonal control of infant growth in the first year. *perinatal Practice*, 5, pp.195–210.
- Hindmarsh, P., Smith, P.J., Brook, C.G.D. & Matthews, D.R., 1987. The relationship between height velocity and growth hormone secretion in short prepubertal children. *Clinical Endocrinology*, 27(5), pp.581–591.
- Honne, T., Pentapati, K., Kumar, N. & Acharya, S., 2012. Relationship between obesity/overweight status, sugar consumption and dental caries among adolescents in South India. *International Journal of Dental Hygiene*, 10(4), pp.240–244.
- Hooley, M., 2014. Dental caries is related to obesity in children but the relationship is moderated by socio-economic strata and child age. *Journal of Evidence-Based Dental Practice*, 14(1), pp.16–18.
- Hooley, M., Skouteris, H., Boganin, C., Satur, J. & Kilpatrick, N., 2012. Body mass index and dental caries in children and adolescents: a systematic review of literature published 2004 to 2011. *Systematic Reviews*, 1(1), p.57.
- Huntington, N.L., Spetter, D., Jones, J.A., Rich, S.E., Garcia, R.I. & Spiro, A., 2011. Development and validation of a measure of pediatric oral health-related quality of life: the POQL. *Journal of Public Health Dentistry*, 71(3), pp.185–93.
- Iacobucci, D., 2008. *Mediation analysis* Quantitati., Los Angeles : Sage, ©2008.

- Ismail, A.I., Sohn, W., Tellez, M., Amaya, A., Sen, A., Hasson, H. & Pitts, N.B., 2007. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. *Community Dentistry and Oral Epidemiology*, 35(3), pp.170–8.
- Jamieson, L.M., Sayers, S.M. & Roberts-Thomson, K.F., 2013. Associations between oral health and height in an indigenous Australian birth cohort. *Community dental health*, 30(1), pp.58–64.
- Jernelöv, S., Lekander, M., Almqvist, C., Axelsson, J. & Larsson, H., 2013. Development of atopic disease and disturbed sleep in childhood and adolescence--a longitudinal population-based study. *Clinical and Experimental Allergy: Journal of the British Society for Allergy and Clinical Immunology*, 43(5), pp.552–9.
- Jokovic, A., Locker, D., Stephens, M. & Guyatt, G., 2003. Agreement between mothers and children aged 11-14 years in rating child oral health-related quality of life. *Community Dent Oral Epidemiol*, Oct;31(5), pp.335–43.
- Jokovic, A., Locker, D., Stephens, M., Kenny, D., Tompson, B. & Guyatt, G., 2003. Measuring parental perceptions of child oral health-related quality of life. *Journal of Public Health Dentistry*, 63(2), pp.67–72.
- Jolley, C.D., 2003. Failure to thrive. *Current Problems in Pediatric and Adolescent Health Care*, 33(6), pp.183–206.
- de Jong-Lenters, M., van Dommelen, P., Schuller, A.A. & Verrips, E.H.W., 2015. Body mass index and dental caries in children aged 5 to 8 years attending a dental paediatric referral practice in the Netherlands. *BMC Research Notes*, 8, p.738.

- Jürgensen, N. & Petersen, P.E., 2013. Promoting oral health of children through schools – Results from a WHO global survey 2012. *Community Dental Health*, 30, pp.204–218.
- Kantovitz, K.R., Pascon, F.M., Rontani, R.M.P. & Gavião, M.B.D., 2006. Obesity and dental caries--A systematic review. *Oral Health & Preventive Dentistry*, 4(2), pp.137–144.
- Karlberg, J., Jalil, F. & Lindblad, B.S., 1988. Longitudinal Analysis of Infantile Growth in an Urban Area of Lahore, Pakistan. *Acta Paediatrica*, 77(3), pp.392–401.
- Katona, P. & Katona-Apte, J., 2008. The interaction between nutrition and infection. *Clinical Infectious Diseases: an Official Publication of the Infectious Diseases Society of America*, 46(10), pp.1582–8.
- Kay, E.J., Northstone, K., Ness, A., Duncan, K. & Crean, S.J., 2010. Is there a relationship between birthweight and subsequent growth on the development of dental caries at 5 years of age? A cohort study. *Community Dentistry and Oral Epidemiology*, 38(5), pp.408–414.
- Kelly, Y., Kelly, J. & Sacker, A., 2013. Time for bed: associations with cognitive performance in 7-year-old children: a longitudinal population-based study. *Journal of Epidemiology and Community Health*, 67(11), pp.926–31.
- Killip, S., Mahfoud, Z. & Pearce, K., 2004. What is an intracluster correlation coefficient? Crucial concepts for primary care researchers. *Annals of Family Medicine*, 2(3), pp.204–8.
- Klein, H., Palmer, C.E. & Knutson, J.W., 1938. Studies on Dental Caries: I. Dental Status and Dental Needs of Elementary School Children. *Public Health Reports (1896-1970)*, 53(19), p.751.

- Knapp, R., Gilchrist, F., Rodd, H.D. & Marshman, Z., 2017. Change in children's oral health-related quality of life following dental treatment under general anaesthesia for the management of dental caries: a systematic review. *International Journal of Paediatric Dentistry*, 27(4), pp.302–312.
- Koksal, E., Tekcicek, M., Yalcin, S.S., Tugrul, B., Yalcin, S. & Pekcan, G., 2011. Association between anthropometric measurements and dental caries in Turkish school children. *Central European journal of Public Health*, 19(3), pp.147–151.
- Kottayi, S., Bhat, S.S., Hegde, K.S., Peedikayil, F.C., Chandru, T.P. & Anil, S., 2016. A Cross-sectional Study of the Prevalence of Dental Caries among 12- to 15-year-old Overweight Schoolchildren. *The Journal of Contemporary Dental Practice*, 17(9), pp.750–754.
- Krisdapong, S., Prasertsom, P., Rattananangsim, K. & Sheiham, A., 2013a. Impacts on quality of life related to dental caries in a national representative sample of Thai 12- and 15-year-olds. *Caries Research*, 47(1), pp.9–17.
- Krisdapong, S., Prasertsom, P., Rattananangsim, K. & Sheiham, A., 2013b. Sociodemographic differences in oral health-related quality of life related to dental caries in Thai school children. *Community Dental Health*, 30(2), pp.112–118.
- Krisdapong, S., Somkotra, T. & Kueakulpipat, W., 2014. Disparities in early childhood caries and its impact on oral health-related quality of life of preschool children. *Asia-Pacific Journal of Public Health*, 26(3), pp.285–294.
- Kuh, D. & Wadsworth, M., 1989. Parental Height: Childhood Environment and Subsequent Adult Height in a National Birth Cohort. *International Journal of Epidemiology*, 18(3), pp.663–668.

- Kumar, S., Badiyani, B.K., Kumar, A., Dixit, G., Sharma, P. & Agrawal, S., 2016. Orofacial pain and quality of life in early adolescents in India. *International Journal of Adolescent Medicine and Health*.
- Kumar, S., Kroon, J. & Laloo, R., 2014. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Health and Quality of Life Outcomes*, 12(1), p.41.
- Kumar, S., Kroon, J., Laloo, R., Kulkarni, S. & Johnson, N.W., 2017. Relationship between body mass index and dental caries in children, and the influence of socio-economic status. *International Dental Journal*, 67(2), pp.91–97.
- Lagerweij, M.D. & van Loveren, C., 2015. Declining Caries Trends: Are We Satisfied? *Current oral health reports*, 2(4), pp.212–217.
- Landgraf, J. & Abetz, L., 1996. *Measuring health outcomes in pediatric populations: issues in psychometrics and applications*. B. Spilker, ed., Philadelphia (PA): Lippincott-Raven Publishers,.
- Langhans, W., 1996. Bacterial products and the control of ingestive behavior: clinical implications. *Nutrition (Burbank, Los Angeles County, Calif.)*, 12(5), pp.303–15.
- Leal, S.C., Bronkhorst, E.M., Fan, M. & Frencken, J.E., 2012. Untreated cavitated dentine lesions: impact on children's quality of life. *Caries Research*, 46(2), pp.102–6.
- Lee, G.H.M., McGrath, C., Yiu, C.K.Y. & King, N.M., 2011. Sensitivity and responsiveness of the Chinese ECOHIS to dental treatment under general anaesthesia. *Community Dentistry and Oral Epidemiology*, 39(4), pp.372–7.

- Lemes, M.G.C., Peixoto, M. do R.G., Meneses, I.H.C.F. & Freire, M. do C.M., 2015. Dental pain and associated factors in 2 to 4-year-old children in Goiania. *Brazilian Journal of Epidemiology*, 18(3), pp.630–641.
- Li, C., Xia, B., Wang, Y., Guan, X., Yuan, J. & Ge, L., 2014. Translation and psychometric properties of the Chinese (Mandarin) version of the Child Oral Health Impact Profile-Short Form 19 (COHIP-SF 19) for school-age children. *Health and quality of life outcomes*, 12, p.169.
- Li, L., Wong, H.M., Peng, S. & McGrath, C.P., 2015. Anthropometric Measurements and Dental Caries in Children: A Systematic Review of Longitudinal Studies. *Advances in Nutrition: An International Review Journal*, 6(1), pp.52–63.
- Li, M.Y., Zhi, Q.H., Zhou, Y., Qiu, R.M. & Lin, H.C., 2015. Impact of early childhood caries on oral health-related quality of life of preschool children. *European Journal of Paediatric Dentistry: Official Journal of European Academy of Paediatric Dentistry*, 16(1), pp.65–72.
- Li, S., Malkinson, S., Veronneau, J. & Allison, P.J., 2008. Testing responsiveness to change for the early childhood oral health impact scale (ECOHIS). *Community dentistry and oral epidemiology*, 36(6), pp.542–8.
- Li, Y.J., Gao, Y.H. & Zhang, Y., 2014. The impact of oral health status on the oral health-related quality of life (OHRQoL) of 12-year-olds from children's and parents' perspectives. *Community Dental Health*, 31(4), pp.240–244.
- Liang, J.J., Zhang, Z.Q., Chen, Y.J., Mai, J.C., Ma, J., Yang, W.H. & Jing, J., 2016. Dental caries is negatively correlated with body mass index among 7-9 years old children in Guangzhou, China. *BMC Public Health*, 16, p.638.
- Locker, D., 1989. *An introduction to behavioural science and dentistry.*, London:

Routledge.

Low, W., Tan, S. & Schwartz, S., 1999. The effect of severe caries on the quality of life in young children. *Pediatric Dentistry*, 21(6), pp.325–326.

Lucas, A., Makrides, M., Ziegler, E.E. & S. Karger (Firm), 2010. *Importance of growth for health and development*, Karger.

Malden, P.E., Thomson, W.M., Jokovic, A. & Locker, D., 2008. Changes in parent-assessed oral health-related quality of life among young children following dental treatment under general anaesthetic. *Community Dentistry and Oral Epidemiology*, 36(2), pp.108–17.

Marcenes, W., Kassebaum, N.J., Bernabe, E., Flaxman, A., Naghavi, M., Lopez, A. & Murray, C.J.L., 2013. Global Burden of Oral Conditions in 1990-2010: A Systematic Analysis. *Journal of Dental Research*, 92(7), pp.592–597.

Markovic, D., Ristic-Medic, D., Vucic, V., Mitrovic, G., Nikolic Ivosevic, J., Peric, T. & Karadzic, I., 2015. Association between being overweight and oral health in Serbian schoolchildren. *International Journal of Paediatric Dentistry*, 25(6), pp.409–417.

Marshall, T.A., Eichenberger-Gilmore, J.M., Broffitt, B.A., Warren, J.J. & Levy, S.M., 2007. Dental caries and childhood obesity: roles of diet and socioeconomic status. *Community Dentistry and Oral Epidemiology*, 35(6), pp.449–58.

Martin, R.M., 2002. Association between breast feeding and growth: the Boyd-Orr cohort study. *Archives of Disease in Childhood - Fetal and Neonatal Edition*, 87(3), p.193F–201.

Martins-Júnior, P.A., Ramos-Jorge, J., Paiva, S.M., Marques, L.S. & Ramos-Jorge, M.L., 2012. Validations of the Brazilian version of the Early Childhood Oral

Health Impact Scale (ECOHIS). *Cadernos de Saúde Pública*, 28(2), pp.367–374.

Martins-Júnior, P.A., Vieira-Andrade, R.G., Corrêa-Faria, P., Oliveira-Ferreira, F., Marques, L.S. & Ramos-Jorge, M.L., 2013. Impact of early childhood caries on the oral health-related quality of life of preschool children and their parents. *Caries Research*, 47(3), pp.211–8.

Mashoto, K.O., Astrom, A.N., Skeie, M.S. & Masalu, J.R., 2010. Changes in the quality of life of Tanzanian school children after treatment interventions using the Child-OIDP. *European Journal of Oral Sciences*, 118(6), pp.626–634.

Miller, J., Vaughan-Williams, E., Furlong, R. & Harrison, L., 1982. Dental caries and children's weights. *Journal of Epidemiology & Community Health*, 36(1), pp.49–52.

Mishu, M.P., Hobdell, M., Khan, M.H., Hubbard, R.M. & Sabbah, W., 2013. Relationship between Untreated Dental Caries and Weight and Height of 6- to 12-Year-Old Primary School Children in Bangladesh. *International Journal of Dentistry*, 2013, pp.1–5.

Mohammadi, T., Wright, C.M. & Kay, E.J., 2009. Childhood growth and dental caries. *Community Dental Health*, 26(1), pp.38–42.

Mohammadi, T.M., Hossienian, Z. & Bakhteyar, M., 2012. The association of body mass index with dental caries in an Iranian sample of children. *Journal of Oral Health and Oral Epidemiology*, 1(1), pp.29–35.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. & Group, T.P., 2009. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement (Reprinted from *Annals of Internal Medicine*). *Physical Therapy*,

89(9), pp.873–880.

MOHFW, 2014. National Health Policy. Available at: [file:///ad.ucl.ac.uk/home/rmj/Impm/DesktopSettings/Desktop/Bangladesh-Survey study/NATIONAL HEALTH POLICY 2011, MOHFW.pdf](file:///ad.ucl.ac.uk/home/rmj/Impm/DesktopSettings/Desktop/Bangladesh-Survey%20study/NATIONAL%20HEALTH%20POLICY%202011,%20MOHFW.pdf) [Accessed April 25, 2017].

Monse, B., Benzian, H., Naliponguit, E., Belizario, V., Schratz, A. & van Palenstein Helderman, W., 2013. The Fit for School Health Outcome Study - a longitudinal survey to assess health impacts of an integrated school health programme in the Philippines. *BMC Public Health*, 13, p.256.

Monse, B., Duijster, D., Sheiham, A., Grijalva-Eternod, C.S., van Palenstein Helderman, W. & Hobdell, M.H., 2012. The effects of extraction of pulpally involved primary teeth on weight, height and BMI in underweight Filipino children. A cluster randomized clinical trial. *BMC Public Health*, 12(1), p.725.

Monse, B., Heinrich-Weltzien, R., Benzian, H., Holmgren, C. & van Palenstein Helderman, W., 2010. PUFA--an index of clinical consequences of untreated dental caries. *Community Dentistry and Oral Epidemiology*, 38(1), pp.77–82.

Montero, J., Rosel, E., Barrios, R., Lopez-Valverde, A., Albaladejo, A. & Bravo, M., 2016. Oral health-related quality of life in 6- to 12-year-old schoolchildren in Spain. *International Journal of Paediatric Dentistry*, 26(3), pp.220–230.

Monzavi, R. & Cohen, P., 2002. IGFs and IGFBPs: role in health and disease. *Best Practice & Research Clinical Endocrinology & Metabolism*, 16(3), pp.433–447.

Mota-Veloso, I., Soares, M.E.C., Alencar, B.M., Marques, L.S., Ramos-Jorge, M.L. & Ramos-Jorge, J., 2016. Impact of untreated dental caries and its clinical consequences on the oral health-related quality of life of schoolchildren aged 8-

10 years. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, 25(1), pp.193–199.

Moura-Leite, F.R., Ramos-Jorge, J., Ramos-Jorge, M.L., Paiva, S.M., Vale, M.P. & Pordeus, I.A., 2011. Impact of dental pain on daily living of five-year-old Brazilian preschool children: prevalence and associated factors. *European Archives of Paediatric Dentistry: Official Journal of the European Academy of Paediatric Dentistry*, 12(6), pp.293–297.

Moura-Leite, F.R., Ramos-Jorge, M.L., Bonanato, K., Paiva, S.M., Vale, M.P. & Pordeus, I.A., 2008. Prevalence, intensity and impact of dental pain in 5-year-old preschool children. *Oral health & Preventive Dentistry*, 6(4), pp.295–301.

Moynihan, P. & Petersen, P.E., 2004. Diet, nutrition and the prevention of dental diseases. *Public Health Nutrition*, 7(1A), pp.201–26.

Narksawat, K., Tonmukayakul, U. & Boonthum, A., 2009. Association between nutritional status and dental caries in permanent dentition among primary schoolchildren aged 12-14 years, Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 40(2), pp.338–344.

Nelson, S., Albert, J.M., Geng, C., Curtan, S., Lang, K., Miadich, S., Heima, M., Malik, A., Ferretti, G., Eggertsson, H., Slayton, R.L. & Milgrom, P., 2013. Increased enamel hypoplasia and very low birthweight infants. *Journal of Dental Research*, 92(9), pp.788–794.

Ngoenwiwatkul, Y. & Leela-adisorn, N., 2009. Effects of Dental Caries on Nutritional Status Among First-Grade Primary School Children. *Asia-Pacific Journal of Public Health*, 21(2), pp.177–183.

Nicolau, B., Marcenes, W., Allison, P. & Sheiham, A., 2005. The life course

approach: explaining the association between height and dental caries in Brazilian adolescents. *Community Dentistry and Oral Epidemiology*, 33(2), pp.93–8.

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 Research*, 37(5), pp.319–326.

Nomura, L.H., Bastos, J.L.D. & Peres, M.A., 2004. Dental pain prevalence and association with dental caries and socioeconomic status in schoolchildren, Southern Brazil, 2002. *Brazilian Oral Research*, 18(2), pp.134–140.

Norberg, C., Hallstrom Stalin, U., Matsson, L., Thorngren-Jerneck, K. & Klingberg, G., 2012. Body mass index (BMI) and dental caries in 5-year-old children from southern Sweden. *Community Dentistry and Oral Epidemiology*, 40(4), pp.315–322.

Nützenadel, W., 2011. Failure to thrive in childhood. *Deutsches Ärzteblatt International*, 108, pp.642–9.

Ohayon, M.M., Roberts, R.E., Zulley, J., Smirne, S. & Priest, R.G., 2000. Prevalence and patterns of problematic sleep among older adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*, 39(12), pp.1549–56.

Ohlund, I., Holgerson, P.L., Backman, B., Lind, T., Hernell, O. & Johansson, I., 2007. Diet intake and caries prevalence in four-year-old children living in a low-prevalence country. *Caries Research*, 41(1), pp.26–33.

Oliveira, L.B., Sheiham, A. & Bönecker, M., 2008. Exploring the association of dental caries with social factors and nutritional status in Brazilian preschool

children. *European Journal of Oral Sciences*, 116(1), pp.37–43.

Onis, D., Onyango, A., Borghi, E., Siyam, A., Nishida, C. & Siekmann J., 2007. WHO | Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, 85, pp.660–7.

Online Dhaka, 2014. Schools in Mirpur. Available at: http://www.online-dhaka.com/105_1204_4317_0-schools-in-mirpur-thana-area-dhaka.html. [Accessed January 15, 2014].

Ortiz, F.R., Tomazoni, F., Oliveira, M.D.M., Piovesan, C., Mendes, F. & Ardenghi, T.M., 2014. Toothache, associated factors, and its impact on Oral Health-Related Quality of Life (OHRQoL) in preschool children. *Brazilian Dental Journal*, 25(6), pp.546–553.

Pahel, B.T., Rozier, R.G. & Slade, G.D., 2007. Parental perceptions of children's oral health: the Early Childhood Oral Health Impact Scale (ECOHIS). *Health and Quality of Life Outcomes*, 5(1), p.6.

Van Palenstein-Helderman, W., Hölmgren, C., Monse, B. & Benzian, H., 2015. Caries prevention and control in low and middle income countries. In O. Fejerskov, B. Nyvad, & E. Kidd, eds. *Dental caries: the disease and its clinical management*. JohnWiley&Sons, Ltd., pp. 405–422.

Parkash, H., Mathur, V.P. & Duggal, R., 2006. Dental workforce issues: a global concern. *Journal of Dental Education*, 70(11), pp.22–26.

Parke, R., 2008. *Child psychology : a contemporary view point*, New York: McGraw-Hill Higher Education.

Parsons, T.J., Power, C. & Manor, O., 2001. Fetal and early life growth and body mass index from birth to early adulthood in 1958 British cohort: longitudinal

study. *British Medical Journal*, 323(7325), pp.1331–1335.

Pau, A.K.H., Croucher, R. & Marcenes, W., 2003. Prevalence estimates and associated factors for dental pain: a review. *Oral health & preventive dentistry*, 1(3), pp.209–20.

de Paula, J.S., Sarracini, K.L.M., Meneghim, M.C., Pereira, A.C., Ortega, E.M.M., Martins, N.S. & Mialhe, F.L., 2015. Longitudinal evaluation of the impact of dental caries treatment on oral health-related quality of life among schoolchildren. *European Journal of Oral Sciences*, 123(3), pp.173–178.

Paula, J.S., Meneghim, M.C., Pereira, A.C. & Mialhe, F.L., 2015. Oral health, socio-economic and home environmental factors associated with general and oral-health related quality of life and convergent validity of two instruments. *BMC Oral Health*, 15, p.26.

Peng, R., Li, S., Zhang, H., Zeng, H., Jiang, B., Liu, Y., Yi, X., Xu, M., Zhu, L. & Zhang, Z., 2016. Weight Status Is Associated with Blood Pressure, Vital Capacity, Dental Decay, and Visual Acuity among School-Age Children in Chengdu, China. *Annals of Nutrition & Metabolism*, 69(3–4), pp.237–245.

Peng, S.M., Wong, H.M., King, N.M. & McGrath, C., 2014a. Association between dental caries and adiposity status (general, central, and peripheral adiposity) in 12-year-old children. *Caries research*, 48(1), pp.32–38.

Peng, S.M., Wong, H.M., King, N.M. & McGrath, C., 2014b. Is dental caries experience associated with adiposity status in preschool children?. *International journal of paediatric dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*, 24(2), pp.122–130.

Pentapati, K.C., Acharya, S., Bhat, M., Krishna Rao, S.V. & Singh, S., 2013. Oral

health impact, dental caries, and oral health behaviors among the National Cadets Corps in South India. *Journal of investigative and clinical dentistry*, 4(1), pp.39–43.

Petersen, P. & Phantumvanit, P., 2012. Perspectives in the effective use of fluoride in Asia. *Journal of Dental Research*, 91(2), pp.119–121.

Petersen, P.E., 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 Dentistry and Oral Epidemiology*, 31(s1), pp.3–24.

Petersen, P.E., Bourgeois, D., Ogawa, H., Estupinan-Day, S. & Ndiaye, C., 2005. The global burden of oral diseases and risks to oral health. *Bulletin of the World Health Organization*, 83(9), pp.661–9.

Petersen, P.E. & Lennon, M.A., 2004. Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. *Community Dentistry and Oral epidemiology*, 32(5), pp.319–21.

PHE, 2016. Launch of the Children's Oral Health Improvement Programme Board - News stories - GOV.UK. *News Story*. Available at: <https://www.gov.uk/government/news/launch-of-the-childrens-oral-health-improvement-programme-board> [Accessed April 25, 2017].

Pine, C.M., Harris, R. V, Burnside, G. & Merrett, M.C., 2006. An investigation of the relationship between untreated decayed teeth and dental sepsis in 5-year-old children. *British Dental Journal*, 200(1), pp.45–7.

Pitts, N., Chadwick, B. & Anderson, T., 2015. *Children's Dental Health Survey 2013. Report 2: Dental Disease and Damage in Children: England, Wales and Northern Ireland*,

- Pitts, N. & Ekstrand, K., 2013. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS) - methods for staging of the caries process and enabling dentists to manage caries. *Community Dentistry and Oral Epidemiology*, 41(1), pp.e41–e52.
- Pitts, N.B., Zero, D.T., Marsh, P.D., Ekstrand, K., Weintraub, J.A., Ramos-Gomez, F., Tagami, J., Twetman, S., Tsakos, G. & Ismail, A., 2017. Dental caries. *Nature Reviews*, 3, p.17030.
- Plata-Salamán, C.R., 1996. Anorexia during acute and chronic disease. *Nutrition (Burbank, Los Angeles County, Calif.)*, 12(2), pp.69–78.
- Polnay, L., 2002. *Community Paediatrics* third. L. Polnay, ed., Edinburgh ;New York: Churchill livingstone.
- Psoter, W.J., Reid, B.C. & Katz, R. V, 2005. Malnutrition and dental caries: a review of the literature. *Caries Research*, 39(6), pp.441–7.
- Public Health England, 2014. Delivering better oral health: an evidence-based toolkit for prevention. Available at: <https://www.gov.uk/government/publications/delivering-better-oral-health-an-evidence-based-toolkit-for-prevention>.
- Pulache, J., Abanto, J., Oliveira, L.B., Bönecker, M. & Porras, J.C., 2016. Exploring the association between oral health problems and oral health-related quality of life in Peruvian 11- to 14-year-old children. *International Journal of Paediatric Dentistry*, 26(2), pp.81–90.
- Rabbani, A., Khan, A., Yusuf, S. & Adams, A., 2016. Trends and determinants of inequities in childhood stunting in Bangladesh from 1996/7 to 2014.

International Journal for Equity in Health, 15(1), p.186.

Rajshekar, S.A. & Laxminarayan, N., 2011. Comparison of primary dentition caries experience in pre-term low birth-weight and full-term normal birth-weight children aged one to six years. *Journal of the Indian Society of Pedodontics and Preventive Dentistry*, 29(2), pp.128–134.

Ramos-Jorge, J., Alencar, B.M., Pordeus, I.A., Soares, M.E. da C., Marques, L.S., Ramos-Jorge, M.L. & Paiva, S.M., 2015. Impact of dental caries on quality of life among preschool children: emphasis on the type of tooth and stages of progression. *European Journal of Oral Sciences*, 123(2), pp.88–95.

Ramos-Jorge, J., Pordeus, I.A., Ramos-Jorge, M.L., Marques, L.S. & Paiva, S.M., 2014. Impact of untreated dental caries on quality of life of preschool children: different stages and activity. *Community Dentistry and Oral Epidemiology*, 42(4), pp.311–322.

Rogol, A.D., Clark, P.A. & Roemmich, J.N., 2000. Growth and Pubertal development in children and adolescents: effects of diet and physical activity. *American Journal of Clinical Nutrition*, 72, pp.521–8.

Rogol, A.D., Roemmich, J.N. & Clark, P.A., 2002. Growth at puberty. *The Journal of Adolescent Health : official publication of the Society for Adolescent Medicine*, 31(6 Suppl), pp.192–200.

Rousham, E.K., Roschnik, N., Baylon, M.A.B., Bobrow, E.A., Burkhanova, M., Champion, M.G., Adle-Chua, T., Degefie, T., Hilari, C., Kalengamaliro, H., Kassa, T., Maiga, F., Mahumane, B.J., Mukaka, M., Ouattara, F., Parawan, A.R., Sacko, M., Patterson, D.W., Sobgo, G., et al., 2011. A comparison of the National Center for Health Statistics and new World Health Organization growth references for school-age children and adolescents with the use of data

from 11 low-income countries. *American Journal of Clinical Nutrition*, 94(2), pp.571–577.

Sacramento, P.A., de Castilho, A.R.F., Frassetto, F., Gaviao, M.B.D., Nobre-dos-Santos, M. & Rontani, R.M.P., 2011. One-year clinical evaluation of oral rehabilitation after the loss of multiple primary teeth. *General Dentistry*, 59(3), pp.230–233.

Saigal, S., Stoskopf, B., Streiner, D., Paneth, N., Pinelli, J. & Boyle, M., 2006. Growth trajectories of extremely low birth weight infants from birth to young adulthood: a longitudinal, population-based study. *Pediatric Research*, 60(6), pp.751–8.

Takeenabi, B., Swamy, H.S. & Mohammed, R.N., 2012. Association between obesity, dental caries and socioeconomic status in 6- and 13-year-old school children. *Oral Health & Preventive Dentistry*, 10(3), pp.231–241.

Scarpelli, A.C., Paiva, S.M., Viegas, C.M., Carvalho, A.C., Ferreira, F.M. & Pordeus, I.A., 2013. Oral health-related quality of life among Brazilian preschool children. *Community Dentistry and Oral Epidemiology*, 41(4), pp.336–44.

Schroth, R.J., Levi, J.A., Sellers, E.A., Friel, J., Kliewer, E. & Moffatt, M.E.K., 2013. Vitamin D status of children with severe early childhood caries: a case-control study. *BMC Pediatrics*, 13(1), p.174.

Schroth, R.J., Levi, J., Kliewer, E., Friel, J. & Moffatt, M.E.K., 2013. Association between iron status, iron deficiency anaemia, and severe early childhood caries: a case-control study. *BMC Pediatrics*, 13, p.22.

Schuch, H.S., Dos Santos Costa, F., Torriani, D.D., Demarco, F.F. & Goettems, M.L., 2014. Oral health-related quality of life of schoolchildren: impact of clinical

and psychosocial variables. *International Journal of Paediatric Dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children*.

Sede, M.A. & Ehizele, A.O., 2014. Relationship between obesity and oral diseases. *Nigerian Journal of Clinical Practice*, 17(6), pp.683–690.

Selwitz, R.H., Ismail, A.I. & Pitts, N.B., 2007. Dental caries. *Lancet*, 369(9555), pp.51–9.

Serra-Negra, J.M., Paiva, S.M., Fulgêncio, L.B., Chavez, B.A., Lage, C.F. & Pordeus, I.A., 2014. Environmental factors, sleep duration, and sleep bruxism in Brazilian schoolchildren: a case-control study. *Sleep Medicine*, 15(2), pp.236–9.

Shahraki, T., Shahraki, M. & Omrani Mehr, S., 2013. Association between body mass index and caries frequency among zahedan elementary school children. *International Journal of High Risk Behaviors & Addiction*, 2(3), pp.122–125.

Sharma, A. & Hegde, A.M., 2009. Relationship between body mass index, caries experience and dietary preferences in children. *The Journal of Clinical Pediatric Dentistry*, 34(1), pp.49–52.

Sheiham, A., 2006. Dental caries affects body weight, growth and quality of life in pre-school children. *British Dental Journal*, 201(10), pp.625–6.

Sheiham, A. & Steele, J., 2001. Does the condition of the mouth and teeth affect the ability to eat certain foods, nutrient and dietary intake and nutritional status amongst older people? *Public Health Nutrition*, 4(3), pp.797–803.

Shepherd, M.A., Nadanovsky, P. & Sheiham, A., 1999. Dental public health: The prevalence and impact of dental pain in 8-year-old school children in Harrow,

- England. *British Dental Journal*, 187(1), pp.38–41.
- Silva, A.E.R., Menezes, A.M.B., Demarco, F.F., Vargas-Ferreira, F. & Peres, M.A., 2013. Obesity and dental caries: systematic review. *Revista de Saúde Pública*, 47(4), pp.799–812.
- Simm, P.J. & Werther, G.A., 2005. Child and adolescent growth disorders--an overview. *Australian Family Physician*, 34(9), pp.731–7.
- Simondon, K.B., Simondon, F., Simon, I., Diallo, A., Bénéfice, E., Traissac, P. & Maire, B., 1998. Preschool stunting, age at menarche and adolescent height: a longitudinal study in rural Senegal. *European Journal of Clinical Nutrition*, 52(6), pp.412–8.
- Sischo, L. & Broder, H.L., 2011. Oral health-related quality of life: what, why, how, and future implications. *Journal of Dental Research*, 90(11), pp.1264–70.
- Slade, G.D., 2001. Epidemiology of dental pain and dental caries among children and adolescents. *Community Dental Health*, 18(4), pp.219–27.
- de Soet, J.J., Schriks, M.C.M., Kratz, E., Poland, D.C.W., Dijk, W. van & W.E., van A., 2003. Dental Caries Related to Plasma IgG and Alpha1-Acid Glycoprotein. *Caries Research*, 37, p.:79–84.
- Stanhope, R., Pringle, P.J., Brook, C.G.D., Adams, J. & Jacobs, H.S., 1987. Induction of puberty by pulsatile gonadotropin releasing hormone. *Lancet*, 330(8558), pp.552–555.
- Stanhope, R., Wilks, Z. & Hamill, G., 1994. Failure to grow: lack of food or lack of love? *Professional Care of Mother and Child*, 4(8), pp.234–7.
- StataCorp., 2013. Stata 13 Base Reference Manual.

- Stephensen, C.B., 1999. Burden of Infection on Growth Failure. *Journal of Nutrition*, 129(2), pp.534–538.
- Strading, J., 1990. Effect of adenotonsillectomy on nocturnal hypoxaemia, sleep disturbance, and symptoms in snoring children. *Lancet*, 335(8684), pp.249–253.
- Streiner, D.L., Norman, G.R. & Cairney, J., 2014. *Health Measurement Scales: A practical guide to their development and use* Fifth Edit., Oxford University Press.
- Swinburn, B.A., Caterson, I., Seidell, J.C. & James, W.P.T., 2004. Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutrition*, 7(1A), pp.123–46.
- Tanner, 1981. Catch up growth in man. *British Medical Bulletin*, 37(3), p.233–238.
- Tanner, J.M. & Whitehouse, R.H., 1976. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. *Archives of Disease in Childhood*, 51(3), pp.170–179.
- Theunissen, N.C., Vogels, T.G., Koopman, H.M., Verrips, G.H., Zwinderman, K.A., Verloove-Vanhorick, S.P. & Wit, J.M., 1998. The proxy problem: child report versus parent report in health-related quality of life research. *Quality of Life Research*, 7(5), pp.387–97.
- Thomas, C.W. & Primosch, R.E., 2002. Changes in incremental weight and well-being of children with rampant caries following complete dental rehabilitation. *Pediatric Dentistry*, 24(2), pp.109–113.
- Tickle, M., Blinkhorn, A.S. & Milsom, K.M., 2008. The occurrence of dental pain and extractions over a 3-year period in a cohort of children aged 3-6 years. *Journal*

of Public Health Dentistry, 68(2), pp.63–9.

Tsakos, G., Blair, Y.I., Yusaf, H., Wright, W., Watt, R.G. & Macpherson, L.M.D., 2012. Developing a new self-reported scale of oral health outcomes for 5-year-old children (SOHO-5). *Health and Quality of Life Outcomes*, 10(1), p.62.

Tubert-Jeannin, S., Pegon-Machat, E., Gremeau-Richard, C., Lecuyer, M.-M. & Tsakos, G., 2005. Validation of a French version of the Child-OIDP index. *European Journal of Oral Sciences*, 113(5), pp.355–362.

Tuomi, T., 1989. Pilot study on obesity in caries prediction. *Community Dentistry and Oral Epidemiology*, 17(6), pp.289–291.

UN, 2016. UNdata, country profile, Bangladesh. UN. Available at: <http://data.un.org/CountryProfile.aspx?cname=Bangladesh> [Accessed May 10, 2017].

Vania, A., Parisella, V., Capasso, F., Di Tanna, G.L., Vestri, A., Ferrari, M. & Polimeni, A., 2011. Early childhood caries underweight or overweight, that is the question. *European Journal of Paediatric Dentistry: Official Journal of European Academy of Paediatric Dentistry*, 12(4), pp.231–5.

Versloot, J., Veerkamp, J. & Hoogstraten, J., 2006. Dental Discomfort Questionnaire: assessment of dental discomfort and/or pain in very young children. *Community Dentistry and Oral Epidemiology*, 34, pp.47–52.

Versloot, J., Veerkamp, J.S.J. & Hoogstraten, J., 2005. Dental discomfort questionnaire for young children before and after treatment. *Acta Odontologica Scandinavica*, 63(6), pp.367–370.

Vidmar, S.I., Cole, T.J. & Pan, H., 2013. Standardizing anthropometric measures in children and adolescents with functions for egen: Update. *Stata Journal*, 13(2),

pp.366–378.

Wasantwisut, E., 1997. Nutrition and development: other micronutrients' effect on growth and cognition. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 28 Suppl 2, pp.78–82.

Weightman, A. & Mann, M., 2004. Health Evidence Bulletins Wales: *Project Methodology*, 5(January). Available at: [http://www.hebw.cardiff.ac.uk/projectmethod/Project Methodology 5.pdf](http://www.hebw.cardiff.ac.uk/projectmethod/Project%20Methodology%205.pdf) [Accessed May 23, 2017].

WHO, 2014. Complementary feeding of young children in developing countries. *WHO*. Available at: http://www.who.int/nutrition/publications/infantfeeding/WHO_NUT_98.1/en/ [Accessed April 19, 2017].

WHO, 2013. Oral Health Surveys: Basic Methods | Health, Education, Social Protection News & Notes – RSS Feeds. Available at: <http://hesp-news.org/2013/12/13/oral-health-surveys-basic-methods/> [Accessed September 23, 2014].

WHO, 1995. Physical Status: The Use and Interpretation of Anthropometry - Report of a WHO Expert Committee. Available at: <http://helid.digicollection.org/en/d/Jh0211e/> [Accessed March 31, 2014].

WHO, 2015. Sugars intake for adults and children. , p.49. Available at: http://www.who.int/nutrition/publications/guidelines/sugars_intake/en/ [Accessed March 3, 2017].

WHO, 2007. WHO Growth reference data for 5-19 years. Available at: <http://www.who.int/growthref/en> [Accessed March 31, 2014].

- WHO, 2016. World Health Statistics. *Global Health Observatory data repository*. Available at: WHO 2016 Apps.who.int/gho/data/node.ssdg2-2 [Accessed March 21, 2017].
- Willershausen, B., Haas, G., Krummenauer, F. & Hohenfellner, K., 2004. Relationship between high weight and caries frequency in German elementary school children. *European journal of medical research*, 9(8), pp.400–404.
- Wong, H.M., McGrath, C.P.J., King, N.M. & Lo, E.C.M., 2011. Oral health-related quality of life in Hong Kong preschool children. *Caries Research*, 45(4), pp.370–6.
- Yang, F., Zhang, Y., Yuan, X., Yu, J., Chen, S., Chen, Z., Guo, D., Cai, J., Ma, N. & Guo, E., 2015. Caries experience and its association with weight status among 8-year-old children in Qingdao, China. *Journal of International Society of Preventive & Community Dentistry*, 5(1), pp.52–58.
- Yao, Y., Ren, X., Song, X., He, L., Jin, Y., Chen, Y., Lu, W., Guo, D., Ding, L., Tang, H., Wei, N., Qiu, S. & Li, C., 2014. The relationship between dental caries and obesity among primary school children aged 5 to 14 years. *Nutricion Hospitalaria*, 30(1), pp.60–65.
- 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 and Quality of Life Outcomes*, 4(1), p.38.
- Public engagement project in Bangladesh, Train and engage, UCL. Available at; <https://www.acu.ac.uk/membership/member-communities/engage/articles/train-engage>. [Accessed December 10, 2016].

Appendices

Appendix 1

Table for systematic review

Summary Table of systematic reviews: association of dental caries and BMI in children

Author (year)	Study aim	Study identified	Articles selected	Articles included	'A' grade studies	Main findings	Study conclusions	Study Limitations
Kantovitz et al. (2006)	Review the relationship between obesity and prevalence of dental caries (all age group)	69 studies from 1984-2004	33 Articles	7 papers (5 papers included children)	3 studies on children to provide high level of evidence (modified from Britton (2000)	2 studies- no association 1 study- positive association.	Inconclusive associations: conflicting results regarding the presence of a positive association between obesity and dental caries.	Narrow search criteria, they excluded all studies related to oral health and nutritional deficiency, underweight and amalgamation of multiple age groups.
Hooley (2012)	Review the relationship between BMI and dental caries in children and adolescents	109 studies 2004 to 2011	64 articles assessed in full text	48 studies (23 studies- no, 17 studies- positive, 9 studies- inverse	5 studies following this study specific rating criteria.	2 studies - no; 2 studies- positive; 1 study - inverse relationship. (non-linear association)	Dental caries was related with both high and low BMI. Pattern of association is context specific: Positive associations from high-income and inverse associations from LMICs.	Low number of longitudinal study.

Author (year)	Study aim	Study identified	Articles selected	Articles included	'A' grade studies	Main findings	Study conclusions	Study Limitations
				association)				
Hayden et al. (2013)	Provide evidence to quantify the relationship between obesity and dental caries in children.	212 articles between 1980 and 2010	35 articles	14 articles met selection criteria, included in meta-analysis.	7 studies, 'University of Wales' guide lines were followed for quality assessment.	Overall significant relationship between childhood obesity and dental caries (Effect size=0.104, p=0.049); mainly studies from industrialized countries (Effect size=0.122, p=0.001)	Significant positive relationship between overweight/obesity and dental caries exists only for permanent dentitions when only the studies using standardized BMI assessment were included in meta-analysis and studies involving children from industrialized countries.	Children who were underweight were not included in the study. Assessment of individual level socio-economic status was not considered. Defining countries as industrialized vs newly industrialized.
Silva et al. (2013)	Possible association between obesity and dental	537 articles between 2005 and	28 articles.	28 articles (24 cross-sectional,	13 good quality studies assessed using criteria	6 studies- positive association 1 study- negative	Not sufficient evidence regarding the association between obesity and dental caries.	Excluded studies on individual < 6 years. Only five study analysed

Author (year)	Study aim	Study identified	Articles selected	Articles included	'A' grade studies	Main findings	Study conclusions	Study Limitations
	caries Possible association between obesity and dental caries	2012		3 prospective cohort, 1 case control study)	of 'Downs & Black' (1998): 8 with adjusted analysis.	association 8 study- no association	Meta-analysis was not performed due to the heterogeneity of the study.	data from longitudinal study and very few studies adjusted for other confounders.
Li et al. (2015)	Review the evidence of the association between anthropometric measurements and dental caries over time.	1338 studies	59 potentially effective studies	17 effective longitudinal studies	The quality score ranged from 19.5 to 30.0 according to STROBE criteria.	15 studies- inconsistent findings. 2 studies- inverse association	Evidence of the association between anthropometric measurements and dental caries was conflicting and remains inconclusive. (15 studies: where anthropometric measurements were used to predict caries) (2 studies: dental caries as predictor of anthropometric measures)	Inclusion of only longitudinal studies and studies did not adjusted for potential confounding factors.

Appendix 2

Ethical approval and Permission letters

Ethical approval from the UCL Research Ethics Committee.

UCL RESEARCH ETHICS COMMITTEE
ACADEMIC SERVICES



Professor Richard Watt
Department of Epidemiology and Public Health
1-19 Torrington Place
UCL

24 November 2014

Dear Professor Watt

Notification of Ethical Approval

Project ID 5348/001: Exploring the association between untreated dental caries and oral health related quality of life and anthropometric measures in Bangladeshi children

In my capacity as Chair of the UCL Research Ethics Committee (REC) I am pleased to confirm that your project has been approved by the UCL REC for the duration of the project i.e. until September 2016.

Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form': <http://ethics.grad.ucl.ac.uk/responsibilities.php>
2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

Reporting Non-Serious Adverse Events

For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

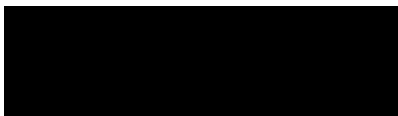
Reporting Serious Adverse Events

The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.

Yours sincerely



Professor John Foreman
Chair of the UCL Research Ethics Committee

Cc:
Masuma Mishu, Applicant
Professor Martin Bobak

Academic Service, 2 Tavilton Street,
University College London Gower Street London WC1E 6BT
Tel: +44 (0)20 3108 4312
Email: ethics@ucl.ac.uk
<http://ethics.grad.ucl.ac.uk/>

Ethical approval from the 'National Research Ethics Committee of Bangladesh' through 'Bangladesh Medical Research Council (BMRC)'.



Ref: BMRC/NREC/2013-2016/879

Date: 16-04-2015

বাংলাদেশ চিকিৎসা গবেষণা পরিষদ Bangladesh Medical Research Council

National Research Ethics Committee

Prof. Richard G Watt
Head
Department of Epidemiology
and Public Health
UCL 1-19 Torrington Place
London WC1 6BT.

Subject: Ethical Clearance

With reference to your application on the above subject, this is to inform you that your Proposal entitled "Exploring the association between untreated dental caries and oral health related quality of life (OHRQoL) and anthropometric measures among 5 to 9 year old Bangladeshi children" has been reviewed and approved by the National Research Ethics Committee (NREC).

You are requested to please note the following ethical guidelines as mentioned at page 2 (overleaf) of this memo-

(Dr. Mahmood-uz-jahan)
Director



**THE ETHICAL GUIDELINES TO BE FOLLOWED
BY THE PRINCIPAL/ CO-INVESTIGATORS**

- ☐ The rights and welfare of individual volunteers are adequately protected.
- ☐ The methods to secure informed consent are fully appropriate and adequately safeguard the rights of the subjects (in the case of minors, consent is obtained from parents or guardians).
- ☐ The Investigator(s) assume the responsibility of notifying the National Research Ethics Committee (NREC) if there is any change in the methodology of the protocol involving a risk to the individual volunteers.
- ☐ To immediately report to the NREC if any evidence of unexpected or adverse reaction is noted in the subjects under study.
- ☐ Project may be supervised by BMRC authority periodically.
- ☐ This approval is subject to Principal Investigator's reading and accepting the BMRC ethical principles and guidelines currently in operation.
- ☐ You are required to submit a report to the BMRC periodically and after completion of the research work.

Permission letters from schools and Dhaka Dental College Hospital



MODEL ACADEMY

(An Ideal Higher Secondary School)

Mirpur-1, Dhaka-1216

E-mail: modelacademy1978@yahoo.com

Website: model.academy.mirpur.dh.bd

Phone: 9001502 / 9009970

School Code: 1334

EIIN No: 108173

Letter No.

Date: 29.09.2014

To whom it may concern

I am giving my consent to collect data and run the study from the 5-9 year old children of Model Academy, for the study named below for PHD project of Masuma Pervin Mishu, PHD student, Department of Epidemiology and Public Health, University College London.

Project Title: Exploring associations between dental caries and anthropometric measures in Bangladeshi children.

Principal Investigator:

Professor Richard G watt, Head of the Department of Epidemiology and Public Health, University College London.

Co-Investigators:

Professor Aubrey Sheiham, emeritus professor, Department of Epidemiology and Public Health, UCL.

Dr. Georgios Tsakos, Senior lecturer, Department of Epidemiology and Public Health UCL. Dr. Anja Heilmann, lecturer, Department of Epidemiology and Public Health, UCL. And Masuma Pervin Mishu, PHD student, Department of Epidemiology and Public Health, UCL.

I wish every success of this study.



Headmaster
Model Academy
Mirpur, Dhaka.

Phone: +88 02-9009970

Mobile: 01711460609.

Suvasish Kumar Biswas
B.Sc (Hons), M.Sc, B.Ed
Headmaster (Incharge)



কল্যাণপুর গার্লস স্কুল ও কলেজ Kallyanpur Girls' School & College

মিরপুর, ঢাকা-১২০৭

EIIN : ১০৮২১৮

স্কুল কোড : ১৩২৫

কলেজ কোড : ১২৮২

বি.এম কোড : ৫০০৭৪

☎ : ৯০০২১১৩

স্মারক নং :

তারিখ : ২০.০৩.১৭

প্রেরক : অধ্যক্ষ/সম্পাদক

কল্যাণপুর গার্লস স্কুল ও কলেজ

To whom it may concern

I am giving my consent to collect data and run the study from the 5-9 year old children of Kallyanpur Girls' School and College, for the study named below for PhD project of MasumaPervinMishu, PhD student, Department of Epidemiology and Public Health, University College London.

Project Title: **Exploring associations between dental caries and anthropometric measures in Bangladeshi children.**

Principal Investigator:

Professor Richard G watt, Head of the department of Epidemiology and Public Health, University College London.

Co-Investigators:

Professor AubrySheiham, emeritus professor, Department of Epidemiology and Public Health, UCL.

Dr. GeorgiosTsakos, Senior lecturer, Department of Epidemiology and Public Health, UCL.

Dr. AnjaHeilmann, lecturer, Department of Epidemiology and Public Health, UCL. and MasumaPervinMishu, PhD student, Department of Epidemiology and Public Health, UCL.

I wish every success of this study.

Principal
Kallyanpur Girls' School and College
Phone: +88 02 9002113
Email: kgsepr@gmail.com



To whom it may concern

I am giving my consent to collect data and run the study from the 5-9 year old children of Bashiruddin Primary School, for the study named below for PhD project of Masuma Pervin Mishu, PhD student, Department of Epidemiology and Public Health, University College London.

Project Title: Exploring associations between dental caries and anthropometric measures in Bangladeshi children.

Principal Investigator:

Professor Richard G watt, Head of the department of Epidemiology and Public Health, University College London.

Co-Investigators:

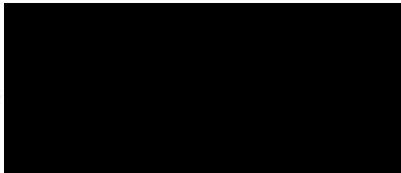
Professor Aubrey Sheiham, emeritus professor, Department of Epidemiology and Public Health, UCL.

Dr. Georgios Tsakos, Senior lecturer, Department of Epidemiology and Public Health, UCL.

Dr. Anja Heilmann, lecturer, Department of Epidemiology and Public Health, UCL. and

Masuma Pervin Mishu, PhD student, Department of Epidemiology and Public Health, UCL.

I wish every success of this study.



(Afroza Sultana)

Head teacher

Bashiruddin Primary school

School code:01

EMI: 310010211

Mirpur, Dhaka-1216

Phone: 01552383260

Date- 29.9.2014



ঢাকা ডেন্টাল কলেজ ও হাসপাতাল
DHAKA DENTAL COLLEGE & HOSPITAL

Mirpur-14, Dhaka-1206, Bangladesh.

Tel: No. 8055487, 8050878, Fax 8050061, E-mail : ddchgovbd@yahoo.com

DO No:DDCH /2014/৭৬১

Date: 26/08/14

TO WHOM IT MAY CONCERN

I am giving my consent to collect data from the Children coming for dental treatment in the children department of Dhaka Dental College Hospital and to use necessary facilities to run the data collection procedure, for the study named below for Ph.D project of Masuma Pervin Mishu, Ph.D student, Department of Epidemiology and Public Health, UCL.

Project Title : Exploring the associations between dental caries and anthropometric measures in Bangladeshi children.

Principal Investigator :

Professor Richard G watt, Head of the Department of Epidemiology and Public Health, University College London.

Co- Investigators:

Professor Aubrey Sheiham, Emeritus professor, Department of Epidemiology and Public Health, UCL.

Dr. Georgios Tsakos, Senior lecturer, Department of Epidemiology and Public Health, UCL.

Dr. Anja Heilmann, lecturer, Department of Epidemiology and Public Health, UCL. and

Masuma Pervin Mishu, Ph.D student, Department of Epidemiology and Public Health, UCL.

I wish every success of this study.

(Prof. Dr. S.M. Iqbal Hussain)
Principal and Director
Dhaka Dental College Hospital
Mirpur-14, Dhaka, Bangladesh.
E mail: hussain.iqbal60@yahoo.com

Appendix 3

Information sheets and consent forms

Information and consent form (English).

Information Sheet for Parents/Guardians in a Research Study

You will be given a copy of this information sheet

Title of the Project: Exploring the association between untreated dental caries and oral health related quality of life (OHRQoL) and anthropometric measures among 5 to 9 year old Bangladeshi children.

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 5348/001

Name, Address and Contact Details of the Investigator-

Masuma Pervin Mishu Department of Epidemiology and Public Health, University College London (UCL) 1-19 Torrington Place, London, WC1E 6BT Mobile:	Masuma Pervin Mishu Dhaka Dental College Hospital Mirpur -14, Dhaka, Bangladesh E-Mail: mpmishu @yahoo.com Mobile:
--	---

We would like to invite you and your son/daughter to participate in this research project.

Before you decide whether you and your child want to take part, it is important for you to read the following information carefully and discuss it

with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

Purpose of the research:

This research aims to assess the relationship between dental decay (holes in teeth) and children's height and weights. The study will also look at how dental decay might cause dental pain, loss of appetite and problems with sleeping, and how this might affect the growth of the children.

Research target group:

We aim to undertake this study on children aged 5-9 years who will come for dental treatment in Dhaka Dental College Hospital, Bangladesh.

Data will also be collected from the primary school children of the same age who attend local primary schools nearby the Dental Hospital.

What will be done?

Your child will be asked a few simple questions about their teeth. These questions will be followed by a brief clinical examination of his/her teeth. Then your child's height, weight will be measured. The whole process will be completed in no more than 30 minutes. The interviews and clinical examination will be performed by trained interviewers and experienced dental surgeons and do not involve any risk to your child. The dental surgeons will use clean and sterile equipment for the whole procedure. Every possible care will be taken to cause minimum inconvenience to your child.

We will also ask you few questions relating to your child's teeth; their sleeping habits, eating patterns and appetite, and some general questions about you.

Possible benefits for your child:

Your child will undergo a thorough examination of his/her teeth and you will be informed and advised if any major dental problems are found.

Possible disadvantages of taking part:

A disadvantage of taking part in this study is the time involved in providing responses to questions and undergoing the examination. We will make every effort to arrange interviews at a convenient time to minimise any disruptions to your child's routine.

Anonymity and Confidentiality:

All records gathered from you will be stored safely and the information will be held in the strictest confidence and will only be available to those involved in research.

Participation in this study is anonymous, so your name or any identifiable details will not be disclosed.

You and your child should only participate if you want to; choosing not to take part will not affect the standard of care of you or your child in any way.

It is up to you whether you and your child should take part or not. If you decide to take part, you and your child are still free to withdraw from the study at any time and without giving any reason.

Your and your child's participation is very important and is highly valued and appreciated.

If you have any questions about the study please do not hesitate to contact me at the above address and telephone number.

If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form.

Thank you for taking time to read this sheet and considering taking part in this research.

Informed Consent Form for Parents/Guardians in a Research Study

Please complete this form after you have read the information sheet and/or listened to an explanation about the research

Title of the Project: Exploring the association between untreated dental caries and oral health related quality of life (OHRQoL) and anthropometric measures among 5 to 9 year old Bangladeshi children.

**This study has been approved by the UCL Research Ethics Committee
(Project ID Number): 5348/001**

Thank you for your interest and willingness to participate in the study and also allowing your son/daughter to take part in this research. Before you agree to take part the person organizing the research must explain the project to you.

If you have any questions arising from the information sheet or explanation already given to you, please ask the researcher before you to decide whether to join in or allowing your son/daughter to join in. You will be given a copy of this consent form to keep and refer to at any time.

Parent's Statement:

(Please tick the box once you have read the statement)

I

.....

..... **(Please write your name)**

* have read the information sheet of the above mentioned study and understand what the research study involves.

☐

* understand that my participation will be anonymous and all information will be treated as strictly confidential.

☐

* understand that my and my son's/ daughter's participation is voluntary and that we are free to withdraw at any time without giving any reason.

☐

* agree to take part in the study and allow my son/daughter to take part in the study named above.

☐

(Investigator)

(Study participant)

Name and signature

Name and signature

Bengali version of Information sheets and consent forms

একটি গবেষণা সংক্রান্ত অভিভাবক গণের জন্য তথ্যবলী

গবেষণা প্রকল্পের শিরোনাম:

বাংলাদেশে বাচ্চাদের দন্ত ক্ষয়ের সাথে প্রাত্যহিক জীবন যাত্রার মান এবং শারীরিক বৃদ্ধির সম্পর্ক নির্ণয় বিষয়ক একটি গবেষণা প্রকল্প।

এই গবেষণা প্রকল্পটি ইউনিভার্সিটি কলেজ লন্ডনের নীতি নির্ধারক কমিটি কর্তৃক অনুমোদিত (আইডি নাম্বর: ৫৩৪৮/০০১)

গবেষকের নাম ও যোগাযোগের ঠিকানা:

মাসুমা পারভীন মিশু

ঢাকা ডেন্টাল কলেজ হাসপাতাল, মিরপুর- ১৪, ঢাকা, বাংলাদেশ

মোবাইল: ০১৯১৫৫৩৩১৬৫

আমরা আপনাকে এবং আপনার সন্তানকে একটি গবেষণা প্রকল্পে অংশ গ্রহণের জন্য বিনীত আমন্ত্রণ জানাচ্ছি। আপনি স্বেচ্ছায় সম্মতি প্রদান করলেই কেবল আপনাকে আমরা এই গবেষণায় সম্পৃক্ত করতে পারব। প্রথমে আপনি সতর্কতার সাথে এই তথ্যবলী পড়ুন এবং চাইলে অন্যদের সাথে আলোচনাও করে নিতে পারেন। এ সংক্রান্ত আরো কিছু জানতে চাইলে গবেষকদলের সদস্যদের যে কোন সময় প্রশ্ন করতে পারেন।

এই গবেষণার উদ্দেশ্য:

বাংলাদেশের ৫ থেকে ৯ বছর বয়সী বাচ্চাদের দন্ত ক্ষয় (ডেন্টাল ক্যারিস) এর সাথে জীবন যাত্রার মান এবং শারীরিক বৃদ্ধির সম্পর্ক নির্ণয় করাই এই গবেষণার প্রধান উদ্দেশ্য এবং এই সম্পর্কের সম্ভাব্য কারণ সমূহ (যেমন: দাঁত ব্যাথা, খাদ্যে অরুচি, খাবার খেতে ও রাতে ঘুমাতে সমস্যা) নিরূপণ করাও এই গবেষণার অপর উদ্দেশ্য।

যারা এই গবেষণার অংশ হবে:

এই গবেষণাটি ৫ থেকে ৯ বছর বয়সী যেসব শিশু ঢাকা ডেন্টাল কলেজ হাসপাতালে চিকিৎসা নিতে আসবে তাদের উপর পরিচালিত হতে যাচ্ছে। পাশাপাশি একই বয়সের প্রাথমিক স্কুলের শিশুরাও এতে অংশ গ্রহণ করবে।

কি করা হবে:

আপনার সন্তানের কাছে তার মুখ এবং দাঁত সংক্রান্ত কিছু সাধারণ প্রশ্নের উত্তর জানতে চাওয়া হবে। এরপর একজন দন্ত চিকিৎসক কর্তৃক তার দাঁত পরীক্ষা করা হবে। পাশাপাশি তার শরীরের ওজন এবং উচ্চতা পরিমাপ করা হবে। সমস্ত প্রক্রিয়া সম্পন্ন করবেন প্রশিক্ষণ প্রাপ্ত দন্ত চিকিৎসক এবং সাক্ষাৎকার গ্রহণকারী গণ।

এর কারণে বাচ্চা কোন প্রকার ক্ষতির কোন সম্ভাবনা নেই। দাঁত মুখের পরীক্ষার জন্য সর্বদা পরিষ্কার-বিশুদ্ধ পস্থা অবলম্বন করা হবে।

এছাড়াও সন্তানের অভিভাবক হিসেবে আপনাকে আপনার সন্তানের দাঁতের সমস্যা এবং তার দৈনন্দিন জীবন যেমন: ঘুম খাদ্যে রুচি, খাবার গ্রহণ এবং আপনার পরিবারের সাধারণ বিষয় সংক্রান্ত কিছু প্রশ্ন করা হবে।

আপনার এবং আপনার সন্তানের যেন কোন প্রকার অসুবিধা না হয় সে বিষয়ে সব ধরনের ব্যবস্থা গ্রহণ করা হবে এবং সমস্ত প্রক্রিয়া সম্পন্ন করতে ৩০ মিনিটের বেশি সময় লাগবে না।

অংশ গ্রহণের ফলে আপনার সন্তানের সম্ভাব্য সুবিধা সমূহ:

আপনার সন্তানের দাঁত- মুখ পরীক্ষা করার সময় যদি কোন প্রকার সমস্যা চিহ্নিত হয় হবে সে বিষয়ে অবহিত করা হবে এবং তার চিকিৎসার জন্য সঠিক পরামর্শ প্রদান করা হবে।

অংশ গ্রহণের ফলে সম্ভাব্য অসুবিধা:

এই গবেষণায় অংশ গ্রহণের কারণে আপনার এবং আপনার সন্তানের কিছুটা সময় এর জন্য ব্যয় হবে। তবে আমরা সব রকম চেষ্টা করব স্বল্পতম সময়ে এটাকে সম্পন্ন করার যাতে আপনার দৈনন্দিন কাজে কোন ব্যাঘাত না ঘটে।

নাম প্রকাশ না করা এবং গোপনীয়তা বজায় রাখা:

আপনার থেকে প্রাপ্ত সকল তথ্য সমূহ অতন্ত গোপনীয়তার সাথে রাখা হবে এবং এই গবেষক ব্যক্তিবর্গই কেবল তা দেখতে পারবে। আপনার নাম অথবা কোন প্রকার

ব্যক্তিগত পরিচয় কোথাও ব্যবহার করা হবে না। পরিশেষে আপনার এবং আপনার সন্তানের অংশগ্রহণ সম্পূর্ণভাবে আপনার বিবেচনা বা সিদ্ধান্তের উপর নির্ভর করে। অংশ গ্রহণ না করতে চাইলে সেটা আপনাদের কোন ক্ষতির কারণ হবে না। আপনি অংশ গ্রহণের সিদ্ধান্ত নেবার পরও যে কোন সময় কোন কারণ দর্শন ছাড়াই সিদ্ধান্ত পরিবর্তন করতে পারবেন।

আপনার এবং আপনার সন্তানের অংশগ্রহণ এই গবেষণার জন্য গুরুত্বপূর্ণ এবং আমাদের কাছে এটি অত্যন্ত মূল্যবান ও প্রশংসনীয়। আপনার আরো কিছু জানবার থাকলে যে কোন সময় আমাদের সাথে যোগাযোগ করতে পারেন। আপনি অংশ গ্রহণের সিদ্ধান্ত নিলে আমরা আপনাকে এই তথ্য সংক্রান্ত প্রতীতি প্রদান করব এবং অনুমতি পত্রে আপনাকে সাক্ষর করতে বলব। এই তথ্যাবলী পড়বার জন্য এবং গবেষণায় অংশ গ্রহণের সিদ্ধান্ত নেয়ার জন্য আপনাকে অনেক ধন্যবাদ জানাচ্ছি।

গবেষণা প্রকল্পের শিরোনাম:

বাংলাদেশে বাচ্চাদের দলত ক্ষয়ের সাথে প্রাত্যহিক জীবন যাত্রার মান এবং শারীরিক বৃদ্ধির সম্পর্ক নির্ণয় বিষয়ক একটি গবেষণা প্রকল্প।

অনুমতি পত্র

পূর্বে বর্ণিত গবেষণায় অংশগ্রহণ করতে সম্মতি জানান এবং আপনার সন্তানকে অংশগ্রহণ করার অনুমতি প্রদান করার জন্য আপনাকে আবারো ধন্যবাদ। প্রদত্ত তথ্যমালা পড়বার পর আপনার মনে যদি কোন ধরনের প্রশ্ন থেকে থাকে তবে দয়া করে মূল অংশ গ্রহণের পূর্বে তা গবেষকদলের সদস্যদের থেকে বিস্তারিত জেনে নিন। আপনাকে এই তথ্যমালা ও সম্মতি পত্রের একটি অনুলিপি কপি দেয়া হবে।

অভিভাবকের সম্মতি

প্রতিটি বাক্য পড়বার পর টিক ✓ দিন।

আমি(আপনার পূর্ণনাম লিখুন)

- এই গবেষণা সংক্রান্ত প্রদত্ত তথ্য মালাটি পড়েছি এবং এটি কি বিষয়ে সেটা বুঝতে পেরেছি।
- আমার অংশ গ্রহণের কোন নাম প্রকাশ করা হবে না এবং সকল তথ্যের গোপনীয়তা রক্ষা করা হবে সেটা বুঝতে পেরেছি।
- আমার এবং আমার সন্তানের অংশগ্রহণ স্বপ্রণোদিত এবং যে কোন সময় কোন কারণ দর্শন ছাড়াই আমরা অংশগ্রহণ থেকে বিরত থাকতে পারি। সেটা বুঝতে পেরেছি।
- এই গবেষণায় আমি এবং আমার সন্তান অংশ গ্রহণ করতে স্বেচ্ছায় সম্মতি জানাচ্ছি।

গবেষকের সাক্ষর

অংশগ্রহণকারীর সাক্ষর

Appendix 4

Pilot study

Pilot Study

A pilot study was conducted in January 2015 in Bangladesh among 5-9 year old children from Dhaka Dental College Hospital and from a nearby primary school (Model Academy). The pilot study provided the evidence for the following:

Feasibility of the study protocol

The research protocol was assessed for its adequacy and feasibility during the pilot study by asking participants to fill a written feedback form. A public engagement project was also conducted with the school children and their parents after the pilot study (funded by UCL Public Engagement body) (Public engagement project in Bangladesh) that also helped to get in touch with parents and getting their view regarding study participation. Both the written and verbal feedback revealed that the parents considered this issue as an important one and almost 99% of parents gave their opinion that the procedure of conducting the study was acceptable. So, the pilot study proved the overall feasibility of the procedures adopted for the study.

Appropriateness of the research instruments

The suitability of the research instruments was assessed from general observation by interviewers and examiners and from the feedback of the pilot study participants regarding their understanding of the questions, difficulties related to question wordings, and their ability to answer all questions.

Questionnaire length

The exact time to fill in the parental and child questionnaire was recorded, and it was not more than 15 minutes for parental questionnaire and 5-6

minutes for the child questionnaire. Parents were asked about the length of the questionnaire and most of them replied that the length was right.

Questionnaire orientation

Some parents suggested arranging the answer options horizontally rather than vertically, which would reduce the length of the questionnaire. In the parental SOHO-5 questionnaire the option of 'I don't know' has been omitted, to get more meaningful response.

Wording and translation issues

The wording of the questionnaire was acceptable by the participants. Only some words such as 'happiness with teeth', 'avoid smiling due to appearance' needed to be explained to some children.

Changes made after the pilot study

The pilot study identified some potential difficulties and resulted in some minor modifications of the procedures and questionnaires.

Changes made in parental questionnaire

* The question about 'was your child underweight in- 1st/2nd/3rd/4th year of life (with reference value) showed high difficulties in understanding and difficulties in answering.

This question was changed to: "Has your child ever been described by a health professional as underweight?"

* Regarding the eating disturbance question: in question no 5, many children reported that they used one side during chewing a food and avoided the affected side but didn't consider this as a problem.

To overcome this problem the question and the answer options was changed. (See pilot questionnaire of parental questionnaire on eating disturbance was changed as Appendix 5 on that section)

* Regarding additional sleep disturbance questions:

Question no. 1: Due to lack of time frame it was confusing to answer, so a time scale was used and answer options were changed in question no. 2 due to problem with the previous version (See pilot questionnaire of parental questionnaire on additional sleeping questions no 1 and 2, was changed as Appendix 5 on that section of same section) (Highlighted part of pilot questionnaire for parents showed where it was changed)

Change made in parental questionnaire administration

In the pilot study, the interviewers administered parental questionnaire was used in hospital setting. However it was not possible to carry out interviewer administration questionnaire in the schools due to low rate of attendance the parents for the interview even after sending the invitation letter for two times. Therefore the questionnaire was sent to their home. Most of these returned questionnaires were completed.

Finally, the change in the administration of questionnaire was adopted for the main study and self-administration of the questionnaires was adopted for both hospital and school parents to maintain the consistency of the study procedure.

Lessons from the field

Issues encountered by interviewers/examiners during the pilot study procedures and appropriate measures were taken to overcome those during the main study:

- ▶ The political unrest condition of Bangladesh affected the transportation of the survey team and attendance rate of the participants during the pilot study. Therefore, careful scheduling of the main study was done to avoid hazards.
- ▶ The classrooms were not properly illuminated to conduct dental examination and the electric supply was also interrupted, so hand torchlight was used during dental examination.
- ▶ The floor was uneven in some classroom and it was difficult to set the height, weight-measuring instrument properly. Therefore, it was set outside the classroom in some cases.
- ▶ It was difficult to manage the young children; additional volunteers (students from higher classes) helped the survey team to manage them.
- ▶ The schools had separate section for boys and girls in different shifts (morning and day shift). This issue was considered during the main data collection to get a more homogenous sample.
- ▶ To increase the number of returned filled up questionnaire in the school setting; regular contact with the class teachers was maintained during the main study, who reminded the children to return the questionnaire. All children who took part in the main study were provided a toothbrush and toothpaste as an incentive, which also helped to increase the response rate.

Questionnaire for Parental Interview-used in Pilot study

ID

Date:

Relationship with the child

☐ Mother

☐ Father

☐ Other (please specify.....)

Age and sex of respondent (parent):

Age and sex of child:

Date of Birth of the child: Month _____ Day: _____ Year: _____

School and class:

.....

Height of the mother of the child

.....

Height of the father of the child

.....

Number of siblings

Was the child born preterm? (before 37 completed weeks of pregnancy)

☐ No

☐ Yes

☐ Cannot remember

Birth weight of the child (if you can remember).....

Weight of the children at birth (up to 2.5 kg or 5.5 pound is considered as normal)

☐Average/ normal

☐Below average

☐More than average

Was the child breast fed?

☐No

☐Yes

If yes, for how long.....

Was the child suffered from any long standing illness in the first two years of his /her life?

☐No

☐Yes

If yes please specify.....

Was your child underweight in: (more than one answer can be ticked?)

☐ The 1st year of life (less than 8.5 kg/16.5 pound at the end of 1st year)

☐ The 2nd year of life (less than 11kg/22 pound at the end of 2nd year)

☐ The 3rd year of life (less than 13 kg/26 pound at the end of 3rd year)

☐ The 4th year of life (less than 14 kg/28 pound at the end of 4th year)

Questions about your child's toothache

1. Did your child experience any pain/discomfort when his/her teeth were coming through?

☐ Yes

☐ No

2a. Has your child ever had toothache in the past (other than pain linked to teeth coming through)?

☐ Yes (go to question 2b)

☐ No (go to question 3a)

2b. If yes, how bad do you think the toothache was?

☐ Mild
toothache

☐ Moderate
toothache

☐ Severe
toothache

☐ Very severe
toothache

3a. Does your child currently have toothache (other than pain linked to teeth coming through)?

☐ Yes (go to question 3b)

☐ No (go to question 4)

3b. If yes, how bad do you think the toothache is

☐ Mild
toothache

☐ Moderate
toothache

☐ Severe
toothache

☐ Very severe
toothache

Questions about your child's dental health and the effect of your child's teeth on his/her daily life

4. Has your child ever had any difficulty eating because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

5. Has your child ever had any difficulty speaking because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

6. Has your child ever had any difficulty playing because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

7. Has your child ever avoided smiling because of the appearance of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

8. Has your child ever avoided smiling because of the state (holes in teeth, pain) of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

9. Has your child ever had difficulty sleeping because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

10. Has your child's self-confidence ever been affected because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal ☐ don't know

**Questions about the effect of your child's teeth on
appetite and eating disturbance**

1. What is the general condition of your child's appetite?

☐	☐	☐	☐	☐
1	2	3	4	5

—————→

Very good appetitePoor appetite

2. Do you think dental pain is causing poor appetite of your child?

- ☐No
☐Yes
☐Not applicable

3. Does your child try to avoid hard food due to problems with the teeth?

- ☐No

☐Yes

4. Do you need to make any change in food preparation due to dental problem of your child? (solid to semiliquid or liquid, mash, pure, blend) of your child?

- ☐No

☐Yes

6. Does your child have any problems in eating/chewing of these foods due to problems with the teeth?

Common food item	Problem			
	No	Mild problem	Moderate problem	Severe problem
1. Rice/ Bread (Ruti/parata)				
2.Any kind of Meat/Fish				
3.Fresh fruits and vegetables				

Questions about the effect of your child's teeth on his/her sleep

Disorders of initiating and maintaining sleep:

1. How many hours of sleep does your child get on most nights.	1.9-11 hours	2.8-9 hours	3.7-8 hours	4.5-7 hours	5. Less than 5 hours
2. How long after going to bed does your child usually fall asleep.	1. Less than 15 min	2. 15-30 min	3. 30-45 min	4. 45-60 min	5. More than 60 min

	1. Never	2. Occasionally (once or twice per month or less)	3. Some times (Once or twice per week)	4. Often (3 or 5 times per week)	5. Always (daily)
3. The child goes to bed reluctantly					
4. The child has difficulty getting to sleep at night					
5. The child feels anxious or afraid when falling asleep					
6. The child wakes up more than twice per night					
7. After waking up in the night, the child has difficulty to fall asleep again					

Additional sleeping questions

1. Do you think your child has sleeping difficulties/ problem in sleeping/ poor quality sleep?

☐ No

☐ Yes

If yes

☐ It is due to problems with the teeth

☐ Any Other problem (Please specify.....)

2. How frequently does toothache cause the child's Sleep disturbance?

☐ Never

☐ Occasionally (once or twice per month or less)

☐ Some times (Once or twice per week)

☐ Often (3 or 5 times per week)

☐ Always

3. How much of a problem is sleep disruption due to toothache, for your child?

☐ Not a problem at all

☐ A small problem

☐ A very serious problem

Socio-economic condition

1. What is the level of father's education?
 - ☐ No education
 - ☐ Primary education
 - ☐ Secondary education
 - ☐ Higher Secondary education
 - ☐ Graduate/ Higher education
2. What is the level of mother's education?
 - ☐ No education
 - ☐ Primary education
 - ☐ Secondary education
 - ☐ Higher Secondary education
 - ☐ Graduate/ Higher education
3. What is father's occupation?
 - ☐ Service
 - ☐ Business
 - ☐ Labour
 - ☐ Domestic work
 - ☐ Other (Please specify.....)
4. What is mother's occupation?
 - ☐ Service
 - ☐ Business
 - ☐ Labour
 - ☐ Domestic work
 - ☐ Other (Please specify.....)
5. What is your gross house hold monthly family income?
 - ☐ <8000 taka/month
 - ☐ 8000-20,000 taka/month
 - ☐ >20,000-30,000 taka/month
 - ☐ >30,000 taka/month
6. Is the earning sufficient to provide your family's basic needs?
 - ☐ Sufficient
 - ☐ Moderately sufficient
 - ☐ Not sufficient

Thank you

পিতা, মাতা / অভিভাবকগণের সাক্ষাতকারের প্রশ্নমালা

চিহ্নিতকরণ নম্বরঃ

তারিখঃ

বাচ্চার সাথে সম্পর্ক:

☐ মাতা

☐ পিতা

☐ অন্যকেউ (দয়াকরে নির্দিষ্ট করে বলুন.....)

উত্তরদানকারী অভিভাবকের:

লিঙ্গ : ☐ পুরুষ

☐ মহিলা

বয়স :বছর

অংশগ্রহণকারী সন্তান:

☐ বালক

☐ বালিকা

বয়স :বছর

সন্তান জন্ম তারিখ: দিন.....মাস.....সাল.....

স্কুল এবং ক্লাস:.....

সন্তানের মায়ের গড় উচ্চতা (যদি জানা থাকে).....ফুট.....ইঞ্চি/.....মিটার..

সন্তানের পিতার গড় উচ্চতা (যদি জানা থাকে).....ফুট.....ইঞ্চি/.....মিটার..

বাচ্চার ভাই বোনের সংখ্যা:.....

আপনার অংশগ্রহণকারী সন্তান কি গর্ভধারণের ৩৭ সপ্তাহ পূর্ণের পূর্বেই জন্মগ্রহণ করেছিল?

☐ না

- ☐ হ্যাঁ
☐ মনে করতে পারছি না

জন্মের সময় তার ওজন কত ছিল? (যদি স্মরণ থাকে).....

জন্মের সময় তার ওজন (২.৫ কেজি / ৫.৫ পাউন্ড পর্যন্ত স্বাভাবিক ওজর ধরা হয়।)

- ☐ সাধারণ / গড়পরতা ছিল।
☐ সাধারণের চাইতে কম ছিল।
☐ সাধারণের চাইতে বেশি ছিল।

আপনার সন্তান কি ছয় মাস পর্যন্ত পর্যাপ্ত মায়ের দুধ পান করেছে?

- ☐ না
☐ হ্যাঁ

আপনার সন্তান তার জন্মের প্রথম দুই বছরের মধ্যে কি কোন দীর্ঘমেয়াদী অসুখে ভুগছে?

- ☐ না
☐ হ্যাঁ

‘হ্যাঁ’ উত্তর হয়ে থাকলে দয়াকরে সেই অসুখ সম্পর্কে বিস্তারিত বলুন.....

আপনার সন্তান কি তার জন্মের পর বিগত বছর গুলোর কোন সময়ে সাধারণ ওজনের চাইতে স্বল্প ওজনের ছিল?

- ☐ না
☐ হ্যাঁ

উত্তর হ্যাঁ হলে সেটা কোন বছরে? (একের অধিক উত্তর হতে পারে।)

- ☐ জন্মের প্রথম বছরে (১ম বছর শেষে ওজন ৮.৫ কেজি/ ১৬.৫ পাউন্ডের কম হলে)
☐ জন্মের দ্বিতীয় বছরে (২য় বছর শেষে ওজন ১১ কেজি/ ২২ পাউন্ডের কম হলে)
☐ জন্মের তৃতীয় বছরে (৩য় বছর শেষে ওজন ১৩ কেজি/ ২৬ পাউন্ডের কম হলে)
☐ জন্মের চতুর্থ বছরে (৪র্থ বছর শেষে ওজন ১৪ কেজি/ ২৮ পাউন্ডের কম হলে)

আপনার সন্তানের দাঁত ব্যাথা সংক্রান্ত প্রশ্নাবলী :

১. আপনার সন্তানের স্বাভাবিকভাবে দাঁত উঠার / গজানোর সময় কি সে ব্যাথা / অস্বস্তিতে ভোগে?

- ☐ না
☐ হ্যাঁ
☐ জানা নাই

২. (ক) আপনার সন্তান কি তার জীবনে কখনও দাঁত ব্যাথায় ভুগেছে?

(দাঁত গজানোর ময়ের ব্যাথা ছাড়া)

- ☐ না (৩-(ক) নম্বর প্রশ্নে যান)
☐ হ্যাঁ (২-(খ) নম্বর প্রশ্নে যান)

২. (খ) সেই দাঁত ব্যাথা কতটা মারাত্মক ছিল বলে আপনি মনে করেন?

- ☐ সামান্য/ অল্প দাঁত ব্যাথা
☐ মাঝারি ধরনের দাঁত ব্যাথা বেশিও না আবার খুব কমও না)
☐ বেশি দাঁত ব্যাথা
☐ প্রচণ্ড / অসহনীয় পর্যায়ের দাঁত ব্যাথা।

৩. (ক) বর্তমানে কি আপনার সন্তানের দাঁত ব্যাথা আছে?

(দাঁত গজানোর সময়ের ব্যাথা ছাড়া)

- ☐ না (৪ নম্বর প্রশ্নে যান)
☐ হ্যাঁ (৩-(খ) নম্বর প্রশ্নে যান)

৩. (খ). যদি বর্তমানে তার দাঁত ব্যাথা থাকে তবে সেই ব্যাথা কতটা মারাত্মক বলে আপনি মনে করেন?

- ☐ সামান্য / অল্প দাঁত ব্যাথা
☐ মাঝারি ধরনের দাঁত ব্যাথা
☐ বেশি দাঁত ব্যাথা
☐ প্রচণ্ড / অসহনীয় পর্যায়ের দাঁত ব্যাথা।

৪. আপনার সন্তানের জীবনে কখনও কি তার দাঁতের কারণে খাবার খেতে সমস্যা
হয়েছে?

- ☐ একদম নয়/ কখনও সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেক সমস্যা হয়েছে।
- ☐ প্রচণ্ড/ মারাত্মক সমস্যা হয়েছে।

☐ আমি সঠিক জানি না/ মনে করতে পারছি না।

৫. আপনার সন্তানের জীবনে কখনও কি তার দাঁতের কারণে কথা বলতে সমস্যা
হয়েছে?

- ☐ একদম নয়/ কখনও সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেক সমস্যা হয়েছে।
- ☐ প্রচণ্ড/ মারাত্মক সমস্যা হয়েছে।
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না।

৬. আপনার সন্তানের জীবনে কখনও কি তার দাঁতের স্বাভাবিক খেলাধুলা করতে অথবা
স্কুলে যেতে সমস্যা হয়েছে?

- ☐ একদম নয়/ কখনও সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেক সমস্যা হয়েছে।
- ☐ প্রচণ্ড/ মারাত্মক সমস্যা হয়েছে।
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না।

৭. দাঁত দেখতে সুন্দর নয় অথবা দাঁতের অবস্থা ভাল নয়, সেটা ভেবে কি আপনার সন্তান কখনও তার স্বাভাবিক হাসি-খুশি থাকা থেকে বিরত থেকেছে?

- ☐ কখনও নয়।
- ☐ সামান্য
- ☐ মাঝে মাঝে
- ☐ প্রায় সময়
- ☐ সব সময়
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না

৮. দাঁতের সমস্যা অথবা দাঁত ব্যাথার কারণে কি সে কখনও তার স্বাভাবিক হাসি খুশি থাকা থেকে বিরত থেকেছে?

- ☐ কখনও নয়।
- ☐ সামান্য
- ☐ মাঝে মাঝে
- ☐ প্রায় সময়
- ☐ সব সময়
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না

৯. দাঁতের সমস্যার কারণে কি আপনার সন্তানের কখনও ঘুমের সমস্যা হয়েছে?

- ☐ একদম নয়/ কখনও সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেক সমস্যা হয়েছে।
- ☐ প্রচণ্ড/ মারাত্মক সমস্যা হয়েছে।
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না।

১০. দাঁতের সমস্যার কারণে কি কখনও আপনার সন্তানের আত্ম বিশ্বাস ক্ষতিগ্রস্ত হয়েছে?

- ☐ কখনও নয়।
- ☐ সামান্য
- ☐ মাঝে মাঝে
- ☐ প্রায় সময়
- ☐ সব সময়
- ☐ আমি সঠিক জানি না/ মনে করতে পারছি না

দাঁতের সমস্যা জনিত কারণে খাদ্যে রুচি এবং খাবার গ্রহণে সমস্যা সংক্রান্ত প্রশ্নাবলী

১. সাধারণ অবস্থায় আপনার সন্তানের খাবারের প্রতি রুচি কেমন? (উপযুক্ত ঘরে টিক দিতে হবে)



খাদ্যে ভাল রুচি

(খাবার খেতে চায়)

একদম রুচি নাই

(খাবার খেতে চায় না)

২. দাঁতের সমস্যা বা ব্যাথার কারণে তার খাদ্যে রুচি কমে গেছে বলে কি আপনি মনে করেন?

- ☐ না
- ☐ হ্যাঁ
- ☐ প্রয়োজ্য নয়

৩. দাঁতের সমস্যা বা ব্যাথার কারণে কি সে শক্ত জাতীয় খাবার গ্রহণ থেকে বিরত থাকে?

☐ না

☐ হ্যাঁ

৪. আপনার সন্তানের দাঁতের সমস্যার কারণে তার খাবার নির্বাচন বা প্রস্তুতিতে আপনাকে কি বিশেষ কোন ব্যবস্থা নিতে হয়?

(যেমন: শক্ত খাবার কে নরম করে রান্না করা, ছেঁচে দেয়া, ভর্তা করে দেয়া, ব্লেন্ডিং করা প্রভৃতি)

☐ না

☐ হ্যাঁ

৫. আপনার সন্তানের নিম্নের তালিকা ভুক্ত খাবার গুলো চিবিয়ে খেতে কি কোন ধরনের সমস্যা হয়?

(উপযুক্ত ঘরে টিক দিতে হবে)

সাধারণ খাদ্যের তালিকা	সমস্যার ধরন			
	কোন সমস্যা হয় না	অল্প সমস্যা	মাঝারি ধরনের সমস্যা	প্রচণ্ড/মারাত্মক সমস্যা
১. জাতীয় খাবার ভাত/রম্মটি/ পরাটা/পাউরম্মটি				
২. যে কোন ধরনের মাংস/মাছ				
৩. কাঁচা সবজী/ফলমূল				

দাঁতের সমস্যা জনিত কারণে ঘুমের ব্যাঘাত সংক্রান্ত প্রশ্ন সমূহ

বাচ্চার ঘুমের বিঘ্নতা পরিমাপক স্কেল

“ঘুমাতে শুরু করা এবং স্বাভাবিক ঘুম বজায় থাকা সংক্রান্ত সমস্যা”

(উপযুক্ত ঘরে টিক দিতে হবে)

১. অধিকাংশ রাতে আপনার সন্তান গড়ে কত ঘন্টা ঘুমায়?	৯-১১ ঘন্টা	৮-৯ ঘন্টা	৭-৮ ঘন্টা	৫-৭ ঘন্টা	৫ ঘন্টার কম
২. সাধারণত বিছানায় শোবার কতক্ষণ পর আপনার সন্তান ঘুমিয়ে পড়ে?	১৫ মিনিটের চাইতে কম সময়ে	১৫-৩০ মিনিটের মধ্যে	৩০-৪৫ মিনিটের মধ্যে	৪৫-৬০ মিনিটের মধ্যে	৬০ মিনিটের বেশি সময় লাগে

১. অধিকাংশ রাতে আপনার সন্তান গড়ে কত ঘন্টা ঘুমায়?	কখনই না	কদাচিৎ (মাসে ১-২ বার)	মাঝে মাঝে (সপ্তাহে ১-২ বার)	প্রায়শঃ (সপ্তাহে ৩-৫ বার)	সব সময় (প্রতি রাতেই)
২. সাধারণত বিছানায় শোবার কতক্ষণ পর আপনার সন্তান ঘুমিয়ে পড়ে?					
৩. অনিচ্ছার সাথে সে বিছানায় ঘুমাতে যায়:					
৪. রাতে বাচ্চার ঘুমের সমস্যা হয়:					

৫. রাতে ঘুমানোর সময় সে উদ্বেগ বা ভীতি অনুভব করে:					
৬. রাতে ঘুম থেকে সে দুই বারের বেশি জেগে ওঠে:					
৭. রাতে একবার ঘুম ভেঙ্গে গেলে আবার ঘুমিয়ে পড়তে তার সমস্যা হয়:					

ঘুম সংক্রান্ত আরো কিছু প্রশ্ন

১. আপনি কি মনে করেন আপনার সন্তানের ঘুমের সমস্যা আছে অথবা তার ঘুম ভাল হচ্ছে না?

☐ না (২ নং প্রশ্নে যেতে হবে)

☐ হ্যাঁ

(উত্তর হ্যাঁ হয়ে থাকলে)

☐ এটা তার দাঁতের সমস্যার কারণে হচ্ছে

☐ অন্য কোন কারণে হচ্ছে (জানা থাকলে নির্দিষ্ট করে বলুন.....)

২. দাঁত ব্যাথা তার ঘুমের কতটা বিঘ্নিত ঘটায় বলে আপনি মনে করেন?

☐ কখনই ঘুমের ব্যাঘাত ঘটায় না।

☐ কদাচিৎ (মাসে ১-২ বার)

☐ মাঝে মধ্যে (সপ্তাহে ১-২ বার)

☐ প্রায়শই (সপ্তাহে ৩-৫ বার)

☐ সর্বদা / সবসময়ই ব্যাঘাত ঘটায়

৩. দাঁত ব্যাথার কারণে আপনার সন্তানের ঘুমের ব্যাঘাতকে আপনি কতটা সমস্যা বলে মনে করেন?

- ☐ কোনই সমস্যা নয়
- ☐ সামান্য সমস্যা
- ☐ খুবই মারাত্মক সমস্যা

আপনার শিক্ষা, পেশা এবং আয় সংক্রান্ত কিছু তথ্য:

১. বাচ্চার পিতার শিক্ষার স্তর:

- ☐ কোন প্রাতিষ্ঠানিক শিক্ষা নাই
- ☐ প্রাথমিক শিক্ষা
- ☐ মাধ্যমিক শিক্ষা
- ☐ উচ্চ মাধ্যমিক শিক্ষা
- ☐ স্নাতক / স্নাতকোত্তর / উচ্চ শিক্ষা

২. বাচ্চার মাতার শিক্ষার স্তর:

- ☐ কোন প্রাতিষ্ঠানিক শিক্ষা নাই
- ☐ প্রাথমিক শিক্ষা
- ☐ মাধ্যমিক শিক্ষা
- ☐ উচ্চ মাধ্যমিক শিক্ষা
- ☐ স্নাতক / স্নাতকোত্তর / উচ্চ শিক্ষা

৩. বাচ্চার পিতার পেশা:

- ☐ চাকুরীজীবী
- ☐ ব্যবসা
- ☐ শ্রমিক
- ☐ গৃহস্থালী কাজ
- ☐ অন্যকোন (দয়া করে নির্দিষ্ট করে বলুন.....)

৪. বাচ্চার মাতার পেশা:

- ☐ চাকুরীজীবী
- ☐ ব্যবসা
- ☐ শ্রমিক
- ☐ গৃহস্থালী কাজ
- ☐ অন্যকোন (দয়াকরে নির্দিষ্ট করে বলুন.....)

৫. আপনার গড়পরতা মাসিক পারিবারিক আয় কত?

- ☐ মাসিক ৮ হাজার টাকার চাইতে কম।
- ☐ মাসিক ৮ হাজার থেকে ২০ হাজার টাকা।
- ☐ মাসিক >২০ হাজার থেকে ৩০ হাজার টাকা।
- ☐ মাসিক ৩০ হাজার টাকার চাইতে বেশি।

৬. এই আয় আপনার পরিবারের খরচের সাথে কতটা সঙ্গতি পূর্ণ বলে আপনি মনে করেন?

- ☐ পর্যাপ্ত আয় / যথেষ্ট আয়।
- ☐ মাঝারি ধরনের / কোনভাবে চলে যায়।
- ☐ পর্যাপ্ত নয় / অপর্যাপ্ত / যথেষ্ট নয়।

ধন্যবাদ

Appendix 5

Questionnaire used for the main study

English version of parental questionnaire

Self-administered questionnaire for the parents:

Thank you for your help in the survey. By answering these questions you will help us to find out more about dental decay and its impact on your child's life and health. All the children of your child's class will take part in the study.

Your answers will only be used for research purpose and will be looked at by the related researchers. These will be treated as confidential and anonymous. Most questions need to be answered by putting a tick (V) in the box next to the answer that applies to you. Like:

Does your child go to school?

☐Yes ☐No

For few questions, a line is given where you can write the answer.

Usually after answering each question you will go on to the next one. Unless if any of the options in a given question is followed by the expression "Go to question...", which means you should go straight to that question.

Read each question carefully and try to give answer of all the questions. If you do not understand or unable to answer please be in touch with us by the school (class teacher) or call in the provided number 01915533165 Remember that your answer is highly valuable for our study and it is not a test.

Your child's name:

Class roll:

Class:

Section:

Age of child:

Sex of child:

Questionnaire for Parent's Interview

ID no:

Date:

Relationship with the child

☐ Mother

☐ Father

☐ Other (please specify.....)

Sex

☐ Female

☐ Male

Date of Birth of the child: Month _____ Day: _____ Year: _____

Height of the mother of the child

Height of the father of the child

Number of siblings

Was the child born preterm? (before 37 completed weeks of pregnancy)

☐ No

☐ Yes

☐ Cannot remember

Birth weight of the child (if you can remember).....

Weight of the children at birth (up to 2.5 kg or 5.5 pound is considered as normal)

☐ Average/ normal

☐ Below average

☐ More than average

Was the child breast fed?

☐ No

☐ Yes

If yes how long (.....year/.....month)

Was the child suffered from any long standing illness in the first two years of his /her life?

☐No

☐Yes

If yes please specify.....

Has your child ever been described by a health professional as underweight?

☐No

☐Yes

(if yes could you remember which year? You can give more than one answer)

☐ The 1st year of life ☐ The 2nd year of life ☐ The 3rd year of life ☐ The 4th year of life

Questions about your child's toothache

1. Did your child experience any pain/discomfort when his/her teeth were coming through?

☐ Yes

☐ No

2a. Has your child ever had toothache in the past (other than pain linked to teeth coming through)?

☐ Yes (go to question 2b)

☐ No (go to question 3a)

2b. If yes, how bad do you think the toothache was?

☐ Mild
toothache

☐ Moderate
toothache

☐ Severe
toothache

☐ Very severe
toothache

3a. Does your child currently have toothache (other than pain linked to teeth coming through)?

☐ Yes (go to question 3b)

☐ No (go to question 4)

3b. If yes, how bad do you think the toothache is?

☐ Mild
toothache

☐ Moderate
toothache

☐ Severe
toothache

☐ Very severe
toothache

Questions about your child's dental health and the effect of your child's teeth on his/her daily life

4. Has your child ever had any difficulty eating because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

5. Has your child ever had any difficulty speaking because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

6. Has your child ever had any difficulty playing because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

7. Has your child ever avoided smiling because of the appearance of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

8. Has your child ever avoided smiling because of the state (holes in teeth, pain) of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

9. Has your child ever had difficulty sleeping because of his/her teeth?

☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

10. Has your child's self-confidence ever been affected because of his/her teeth?

- ☐ not at all ☐ a little ☐ moderate ☐ a lot ☐ a great deal

Questions about the effect of your child's teeth on appetite and eating disturbance

1. What is the general condition of your child's appetite?

- ☐ Verygood ☐ good ☐ moderate ☐ poor ☐ veryPoor

2. Do you think dental pain is causing poor appetite of your child?

- ☐ No
☐ Yes
☐ Not applicable

3. Does the child try to avoid hard food due to problems with the teeth?

- ☐ Never
☐ Sometimes
☐ Often

4. Does the child prefer to chew on one side?

- ☐ Never
☐ Sometimes
☐ Often

5. Do you need to make any change in food preparation due to dental problem of your child? (solid to semiliquid or liquid, mash, pure, blend) of your child?

- ☐ Never
☐ Sometimes
☐ Often

6. Was your child's ability of chewing/eating ever hampered due to problems with the teeth? (Using one side of jaw will be considered hamper of ability)

(Please give tick (V) in the appropriate box)

Common food item	Chewing ability			
	Good ability (Not hampered due to dental caries)	Ability mildly hampered due to dental caries	Ability moderately hampered due to dental caries	Ability seriously hampered due to dental caries.
1. Rice/ Bread (Ruti/parata)				
2.Any kind of Meat/Fish				
3.Fresh fruits and vegetables				

Questions about the effect of your child's teeth on his/her sleep: Sleep disturbance scale for children

Try to answer every question; in answering, consider each question as pertaining to the past 6 months of the child's life. (Please give tick (V) in the appropriate box striking the number 1 to 5.

Disorders of initiating and maintaining sleep:

1. How many hours of sleep does your child get on most nights.	1.9-11 hours	2.8-9 hours	3.7-8 hours	4.5-7 hours	5. Less than 5 hours
2. How long after going to bed does your child usually fall asleep	1. Less than 15 min	2. 15-30 min	3. 30-45 min	4. 45-60 min	5. More than 60 min

	1. Never	2. Occasionally (once twice or month per or less)	3. Some times (Once or twice per week)	4. Often (3 or 5 times per week)	5. Always (daily)
3. The child goes to bed reluctantly					
4. The child has difficulty getting to sleep at night					
5. The child feels anxious or afraid when falling asleep					

6.The child wakes up more than twice per night					
7.After waking up in the night, the child has difficulty to fall asleep again					

Additional sleeping questions

1. Do you think your child ever has any sleeping difficulties/ problem in sleeping/ poor quality sleep?

☐ No

☐ Yes

If yes

☐ It is due to problems with the teeth

☐ Any Other problem (Please specify.....)

2. How frequently does toothache cause the child's Sleep disturbance?

☐ Never

☐ Once or twice in life

☐ Few episodes in a year

☐ Few episodes in a month

3. How much of a problem do you consider your child's sleep disturbance due to dental problem?

☐ Not a problem at all

☐ A small problem

☐ A very serious problem

Socio-economic condition

2. What is the level of father's education?
 - ☐ No education
 - ☐ Primary education
 - ☐ Secondary education
 - ☐ Higher Secondary education
 - ☐ Graduate/ Higher education
2. What is the level of mother's education?
 - ☐ No education
 - ☐ Primary education
 - ☐ Secondary education
 - ☐ Higher Secondary education
 - ☐ Graduate/ Higher education
3. What is father's occupation?
 - ☐ Service
 - ☐ Business
 - ☐ Labour
 - ☐ Domestic work
 - ☐ Other (Please specify.....)
4. What is mother's occupation?
 - ☐ Service
 - ☐ Business
 - ☐ Labour
 - ☐ Domestic work
 - ☐ Other (Please specify.....)
5. What is your gross house hold monthly family income?
 - ☐ <8000 taka/month
 - ☐ 8000-20,000 taka/month
 - ☐ >20,000-30,000 taka/month
 - ☐ >30,000 taka/month
6. Is the earning sufficient to provide your family's basic needs?
 - ☐ Sufficient
 - ☐ Moderately sufficient
 - ☐ Not sufficient

Thank you for taking time to answer the questions

Bengali version of parental questionnaire

পিতা,মাতা/ অভিভাবকগণের সাক্ষাতকারের প্রশ্নমালা

এই গবেষণায় অংশ গ্রহনের জন্য আপনাকে অনেক ধন্যবাদ জানাচ্ছি। এই প্রশ্নগুলোর উত্তর দেয়ার মাধ্যমে আপনি আমাদেরকে “দন্তুক্ষয় এর সাথে বাচ্চাদের দৈনন্দিন জীবন ও সাধারণ স্বাস্থ্যের উপর প্রভাব” সম্পর্কে জানতে সাহায্য করেছেন।

অধিকাংশ প্রশ্নের উত্তরের ক্ষেত্রে আপনাকে উপযুক্ত বাক্সে টিক চিহ্ন (V) দিতে হবে।
যেমন:

আপনার সন্তান কি স্কুলে যায়?

☐ হ্যাঁ ☐ না

তবে কিছু প্রশ্নের উত্তর নির্ধারিত স্থানে আপনাকে লিখতে হবে। সাধারনত একটি প্রশ্নের উত্তরের পর পরবর্তী প্রশ্নে চলে যেতে হবে।

দয়া করে প্রশ্নটি পরে সকল উত্তর দেয়ার চেষ্টা করুন। কোন প্রশ্ন বুঝতে সমস্যা হলে সরাসরি ০১৯১৫৫৩৩১৬৫ নাম্বারে গবেষণা দলের সাথে যোগাযোগ করুন। মনে রাখবেন আপনার এই উত্তর গুলো আমাদের কাছে অত্যন্ত মূল্যবান এবং গোপনীয়তার সাথে শুধুমাত্র গবেষণার কাজে ব্যবহৃত হবে এবং আপনার নাম কোথাও প্রকাশ করা হবে না।

উত্তর প্রদান শেষে প্রশ্নপত্রটি আপনার সন্তানের মাধ্যমে তার ক্লাশ টিচারের কাছে জমা দিতে হবে। (স্কুলের জন্য প্রযোজ্য)

বাচ্চার নাম:

উত্তর প্রদানের তারিখ:

☐ হাসপাতাল ☐ স্কুল

স্কুলের নাম :

ক্লাস:

শাখা/বিভাগ:

ক্লাস রোল :

অংশগ্রহনকারীর সন্তান:

☐ বালক ☐ বালিকা

বাচ্চার বয়স: বছর

সন্তান জন্ম তারিখ: দিন.....মাস.....সাল.....

বাচ্চার সাথে সম্পর্ক

☐ মাতা

☐ পিতা

☐ অন্যকেউ (দয়া করে নির্দিষ্ট করে বলুন

.....)

উত্তরদানকারী অভিভাবক:

লিঙ্গ : ☐ পুরুষ ☐ মহিলা

অভিভাবকের বয়স : বছর

সন্তানের মায়ের গড় উচ্চতা (যদি জানা থাকে)

.....ফুট.....ইঞ্চি/.....মিটার.....

সন্তানের পিতার গড় উচ্চতা (যদি জানা থাকে)

.....ফুট.....ইঞ্চি/.....মিটার.....

সন্তানের মায়ের ওজন (যদি জানা থাকে).....কেজি

সন্তানের পিতার ওজন (যদি জানা থাকে).....কেজি

বাচ্চর ভাই বোনের সংখ্যা:.....

আপনার অংশগ্রহনকারী সন্তান কি গর্ভধারণের ৩৭ সপ্তাহ পূর্ণের পূর্বেই জন্মগ্রহণ করেছিল ?

☐ না ☐ হ্যাঁ ☐ মনে করতে পারছি না

জন্মের সময় তার ওজন কত ছিল ? (যদি স্বরন থাকে)

.....

জন্মের সময় তার ওজন (২.৫কেজি /৫.৫ পর্যন্ত স্বাভাবিক ওজন ধরা হয়)

☐ সাধারণ গড়পরতা ছিল ।

☐ সাধারণের চাইতে কম ছিল ।

☐ সাধারণের চাইতে বেশি ছিল ।

আপনার সন্তান কি মায়ের দুধ পান করেছে ?

- ☐ না
- ☐ হ্যাঁ

(উত্তর হ্যাঁ হলে কতদিন পর্যন্ত:.....বছর/.....মাস)

আপনার সন্তান জন্মের প্রথম দুই বছরের মধ্যে কি কোন দীর্ঘমেয়াদী অসুখে ভুগছে ?

- ☐ না
- ☐ হ্যাঁ

হ্যাঁ উত্তর হয়ে থাকলে দয়া করে সেই অসুখ সম্পর্কে বিস্তারিত
বলুন.....

আপনার সন্তানকে জীবনে কখনও কি কোন ডাক্তার/স্বাস্থ্যকর্মী সাধারণ ওজনের
চাইতে স্বল্প ওজনের বলেছে ?

- ☐ না
- ☐ হ্যাঁ

হ্যাঁ উত্তর হলে সেটা কোন বছরে ? (একের অধিক উত্তর হতে পারে।)

- ☐ জন্মের প্রথমে বছরে
- ☐ জন্মের দ্বিতীয় বছরে
- ☐ জন্মের তৃতীয় বছরে
- ☐ জন্মের চতুর্থ বছরে

আপনার সন্তানের দাঁত ব্যাথা সংক্রান্ত প্রশ্নাবলী :

১. আপনার সন্তানের স্বাভাবিকভাবে দাঁত উঠার/গজানো সময়/দাঁত নাড়ে পরার সময় কি সে ব্যাথা/ অস্বস্তিতে ভোগে ?

- ☐ না ☐ হ্যাঁ

২.(ক) আপনার সন্তান কি তার জীবনে কখনো দাঁত ব্যাথায় ভুগেছে ?
(দাঁত গজানোর সময়ের ব্যাথা ছাড়া।

- ☐ না (৩-(ক) নম্বর প্রশ্নে যান)
☐ হ্যাঁ (২-(খ)নম্বর প্রশ্নে যান)

২. (খ) সেই দাঁত ব্যাথা কতটা মারাত্মক ছিল বলে আপনি মনে করেন ?

- ☐ সামান্য/অল্প দাঁত ব্যাথা
☐ মাঝারি ধরনের দাঁত ব্যাথা (বেশিও না আবার খুব কমও না)
☐ বেশি দাঁত ব্যাথা
☐ প্রচণ্ড/অসহনীয় পর্যায়ের দাঁত ব্যাথা।

৩. (ক) বর্তমানে আপনার সন্তানের দাঁত ব্যাথা আছে ?

(দাঁত গজানোর সময়ের ব্যাথা ছাড়া)

- ☐ না (৪-নম্বর প্রশ্নে যান)
☐ হ্যাঁ (৩-(খ) নম্বর প্রশ্নে যান)

৩. (খ). যদি বর্তমানে তার দাঁত ব্যাথা থাকে তবে সেই ব্যাথা কতটা মারাত্মক বলে আপনি মনে করেন ?

- ☐ সামান্য/অল্প দাঁত ব্যাথা
☐ মাঝারি ধরনের দাঁত ব্যাথা (বেশিও না আবার খুব কমও না)
☐ বেশি দাঁত ব্যাথা
☐ প্রচণ্ড/অসহনীয় পর্যায়ের দাঁত ব্যাথা।

**আপনার সন্তানের দাঁতের অবস্থা
এবং তার দৈনন্দিন জীবনে এর
প্রভাব সংক্রান্ত প্রশ্নাবলী**

৪. আপনার সন্তানের জীবনে কখনো কি তার দাঁতের কারণে খাবার খেতে সমস্যা হয়েছে ?

- ☐ একদম নয়/ কখনো সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেকে সমস্যা হয়েছে।
- ☐ প্রচন্ড/ মারাত্মক সমস্যা হয়েছে।

৫. আপনার সন্তানের জীবনে কখনো কি তার দাঁতের কারণে কথা বলতে সমস্যা হয়েছে ?

- ☐ একদম নয়/ কখনো সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেকে সমস্যা হয়েছে।
- ☐ প্রচন্ড/ মারাত্মক সমস্যা হয়েছে।

৬. আপনার সন্তানের জীবনে কখনো কি তার দাঁতের কারণে স্বাভাবিক খেলাধুলা করতে অথবা স্কুলে যেতে সমস্যা হয়েছে ?

- ☐ একদম নয়/ কখনো সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেকে সমস্যা হয়েছে।
- ☐ প্রচন্ড/ মারাত্মক সমস্যা হয়েছে।

৭. দাঁত দেখতে সুন্দর নয় অথবা দাঁতের অবস্থা ভাল নয় , সেটা ভেবে কি আপনার সন্তান কখনও তার স্বাভাবিক হাসি-খুশি থাকা থেকে বিরত থেকেছে ?

- ☐ কখনও নয় ।
- ☐ জীবনে ১-২ বার
- ☐ মাঝে মাঝে
- ☐ প্রায় সময়
- ☐ সব সময়

৮. দাঁতের সমস্যা অথবা দাঁত ব্যাথার কারণে কি সে কখনও তার স্বাভাবিক হাসি-খুশি থাকা থেকে বিরত থেকেছে?

- ☐ কখনও নয় ।
- ☐ জীবনে ১-২ বার
- ☐ মাঝে মাঝে
- ☐ প্রায় সময়
- ☐ সব সময়

৯. দাঁতের সমস্যার কারণে কি আপনার সন্তানের কখনও ঘুমের সমস্যা হয়েছে?

- ☐ একদম নয়/কখনও সমস্যা হয় নাই।
- ☐ সামান্য সমস্যা হয়েছে।
- ☐ মাঝারি ধরনের সমস্যা হয়েছে।
- ☐ অনেক সমস্যা হয়েছে।
- ☐ প্রচণ্ড/মারাত্মক সমস্যা হয়েছে।

১০. দাঁতের সমস্যার কারণে কি আপনার সন্তানের আত্মবিশ্বাস ক্ষতিগ্রস্ত হয়েছে?

- ☐ একদম নয়
- ☐ সামান্য
- ☐ মাঝারি ধরনের
- ☐ বেশি
- ☐ খুব বেশি

দাঁতের সমস্যা জনিত কারণে খাদ্যে রুচি এবং খাবার গ্রহণে সমস্যা সংক্রান্ত প্রশ্নাবলী

১. সাধারণ অবস্থায় আপনার সন্তানের খাবারের প্রতি রুচি কেমন?
(উপর্যুক্ত ঘরে টিক দিতে হবে)

- ☐ খাদ্যে খুব ভাল রুচি (খাবার খেতে চায়)
- ☐ খাদ্যে ভাল রুচি
- ☐ খাদ্যে মাঝারি রুচি
- ☐ রুচি নাই
- ☐ একদম রুচি নাই (খাবার খেতে চায় না)

২. দাঁতের সমস্যা বা ব্যাথার কারণে তার খাদ্যে রুচি কমে গেছে বলে কি আপনি মনে করেন?

- ☐ না
- ☐ হ্যাঁ
- ☐ প্রযোজ্য নয়

৩. দাঁতের সমস্যা বা ব্যাথার কারণে কি সে শক্ত জাতীয় খাবার গ্রহণ থেকে বিরত থাকে?

- ☐ কখনোই নয়
- ☐ মাঝে মাঝে
- ☐ সব সময়

৪. সে কি মুখের এক পাশ দিয়ে খাবার চাষায়?

- ☐ কখনোই নয়
- ☐ মাঝে মাঝে
- ☐ সব সময়

৫. আপনার সন্তানের দাঁতের সমস্যার কারণে তার খাবার নির্বাচন বা প্রস্তুতিতে আপনাকে কি বিশেষ কোন ব্যবস্থা নিতে হয়?
(যেমন: শক্ত খাবার কে নরম করে রান্না করা, ছেঁচে দেয়া, ভর্তা করে দেয়া, ব্লেন্ডিং করা প্রভৃতি)

- ☐ কখনোই নয়
☐ মাঝে মাঝে
☐ সব সময়

৬. আপনার সন্তানের নিম্নের তালিকা ভুক্ত খাবার গুলো চিবিয়ে খাবার সামর্থ কেমন?
(উপযুক্ত ঘরে টিক দিতে হবে)

সাধারণ খাদ্যের তালিকা	খাবার চাবানোর সামর্থ			
	ভালভাবে চাবাতে পারে/কোন সমস্যা হয়না	দাঁতে সমস্যার জন্য চাবাতে অল্প সমস্যা হয়	দাঁতে সমস্যার জন্য চাবাতে মাঝারি ধরনের সমস্যা	দাঁতে সমস্যার জন্য চাবাতে প্রচণ্ড/মারাত্মক সমস্যা
1. জাতীয় খাবার ভাত/রুটি/পরা টা/পাউরুটি				
2. যে কোন ধরনের মাংস/মাছ				
3. কাঁচা সবজী/ফলমূল				

**দাঁতের সমস্যা জনিত কারণে ঘুমের ব্যাঘাত সংক্রান্ত প্রশ্ন
সমূহ**

- বাচ্চার ঘুমের বিঘ্নতা পরিমাপক স্কেল
(উপযুক্ত ঘরে টিক দিতে হবে)

1. অধিকাংশ রাতে আপনার সন্তান গড়ে কত ঘন্টা ঘুমায়?	৯-১১ ঘন্টা	৮-৯ ঘন্টা	৭-৮ ঘন্টা	৫-৭ ঘন্টা	৫ ঘন্টার কম
2. সাধারনত বিছানায় শোবার কতক্ষণ পর আপনার সন্তান ঘুমিয়ে পড়ে?	১৫ মিনিটের চাইতে কম সময়ে	১৫-৩০ মিনিটের মধ্যে	৩০-৪৫ মিনিটের মধ্যে	৪৫-৬০ মিনিটের মধ্যে	৬০ মিনিটের বেশি সময় লাগে

	কখনই না	কদাচিৎ (মাসে ১- ২ বার)	মাঝে মধ্যে (সপ্তাহে ১-২ বার)	প্রায়শ: (সপ্তাহে ৩-৫ বার)	সব সময় (প্রতি রাতেই)
3. অনিচ্ছার সাথে সে বিছানায় ঘুমাতে যায়:					
4. রাতে বাচ্চার ঘুমের সমস্যা হয়:					
5. রাতে ঘুমানোর সময় সে উদ্বিগ্নতা বা ভীতি অনুভব করে:					

6. রাতে ঘুম থেকে সে দুই বারের বেশি জেগে ওঠে:					
7. রাতে একবার ঘুম ভেঙ্গে গেলে আবার ঘুমিয়ে পড়তে তার সমস্যা হয়:					

➤ ঘুম সংক্রান্ত আরো কিছু প্রশ্ন

১. আপনি কি মনে করেন আপনার সন্তানের ঘুমের কখনও সমস্যা হয়েছে অথবা তার ঘুম ভাল হচ্ছে না?

☐ না (২ নং প্রশ্নে যেতে হবে)

☐ হ্যাঁ

(উত্তর হ্যাঁ হয়ে থাকলে)

☐ এটা তার দাঁতের সমস্যার কারণে হচ্ছে

☐ অন্য কোন কারণে হচ্ছে (জানা থাকলে নির্দিষ্ট করে
বলুন.....)

২. দাঁত ব্যাথার কারণে কত বার তার ঘুমের ব্যাঘাত ঘটেছে?

☐ কখনই ব্যাঘাত ঘটে নাই।

☐ জীবনে ১-২ বার

☐ বছরে কয়েক বার

☐ মাসে কয়েক বার

৩. দাঁত ব্যাথার কারণে আপনার সন্তানের ঘুমের ব্যাঘাতকে আপনি কতটা সমস্যা বলে মনে করেন?

☐ কোনই সমস্যা নয়

☐ সামান্য সমস্যা

☐ খুবই মারাত্মক সমস্যা

আপনার শিক্ষা, পেশা এবং আয় সংক্রান্ত কিছু তথ্য:

১. বাচ্চার পিতার শিক্ষার স্তর:

- ☐ কোন প্রাতিষ্ঠানিক শিক্ষা নাই
- ☐ প্রাথমিক শিক্ষা
- ☐ মাধ্যমিক শিক্ষা
- ☐ উচ্চ মাধ্যমিক শিক্ষা
- ☐ স্নাতক/স্নাতকোত্তর/উচ্চ শিক্ষা

২. বাচ্চার মাতার শিক্ষার স্তর:

- ☐ কোন প্রাতিষ্ঠানিক শিক্ষা নাই
- ☐ প্রাথমিক শিক্ষা
- ☐ মাধ্যমিক শিক্ষা
- ☐ উচ্চ মাধ্যমিক শিক্ষা
- ☐ স্নাতক/স্নাতকোত্তর/উচ্চ শিক্ষা

৩. বাচ্চার পিতার পেশা:

- ☐ চাকুরীজীবী
- ☐ ব্যবসা
- ☐ শ্রমিক
- ☐ গৃহস্থালী কাজ
- ☐ অন্য কোন (দয়া করে নির্দিষ্ট করে বলুন.....)

৪. বাচ্চার মাতার পেশা:

- ☐ চাকুরীজীবী
- ☐ ব্যবসা
- ☐ শ্রমিক
- ☐ গৃহস্থালী কাজ
- ☐ অন্য কোন (দয়া করে নির্দিষ্ট করে বলুন.....)

৫. আপনার গড়পরতা মাসিক পারিবারিক আয় কত?

- ☐ মাসিক ৮ হাজার টাকার চাইতে কম।
- ☐ মাসিক ৮ হাজার থেকে ২০ হাজার টাকা।
- ☐ মাসিক >২০ হাজার থেকে ৩০ হাজার টাকা।
- ☐ মাসিক ৩০ হাজার টাকার চাইতে বেশি।

৬. এই আয় আপনার পরিবারের খরচের সাথে কতটা সঙ্গতি পূর্ণ বলে আপনি মনে করেন?

- ☐ পর্যাপ্ত/যথেষ্ট আয়।
- ☐ মাঝারি ধরনের/কোনভাবে চলে যায়।
- ☐ পর্যাপ্ত নয়/অপর্যাপ্ত/যথেষ্ট নয়।

(উত্তর প্রদানের জন্য ধন্যবাদ জানাচ্ছি)

English version of child questionnaire

Questionnaire for Children

ID no:

Date of interview:

Sex: ☐ Male ☐ Female

Age:

Class:

Toothache questions

1. Did your teeth hurt when they were coming through?

- ☐ No
- ☐ A little
- ☐ A lot

2. Do your teeth hurt now (other than your teeth coming through)?

- ☐ No
- ☐ A little
- ☐ A lot

3. Have your teeth ever hurt you?

- ☐ No
- ☐ A little
- ☐ A lot

4. Has it ever been hard for you to eat because of your teeth?

- ☐ No
- ☐ A little
- ☐ A lot

5. Has it ever been hard for you to drink because of your teeth?

- ☐ No
- ☐ A little
- ☐ A lot

6. Has it ever been hard for you to speak because of your teeth?

- ☐ No
- ☐ A little
- ☐ A lot

7. Has it ever been hard for you to play because of your teeth?

- ☐ No
- ☐ A little
- ☐ A lot

8. Have you ever not smiled because your teeth were hurting?

- ☐ No
- ☐ A little
- ☐ A lot

9. Have you ever not smiled because of how your teeth look?

- ☐ **No**
- ☐ **A little**
- ☐ **A lot**

10. Has it ever been hard for you to sleep because of your teeth?

- ☐ **No**
- ☐ **A little**
- ☐ **A lot**

11. How happy are you with your teeth?

- ☐ **Not happy**
- ☐ **A little happy**
- ☐ **Very happy**

12. Do you have any holes in your teeth?

☐ **Yes**

☐ **No**

☐ **Don't know**

Thank you

ANSWER CARD

“For each question, I will show you a card with three faces. If you had no problem or you did not have a sore tooth, then choose the happy face. If you had a little bit of a problem or your tooth was a little sore, then you can choose the middle face. If you had a lot of problem or your tooth was very sore, then choose the sad face.”

Point to the face that shows how much your teeth hurt."



No



A little



A lot

Bengali version of child questionnaire

বাচ্চার জন্য প্রশ্নমালা

চিহ্নিতকরণ নাম্বার :

সাক্ষাৎকার

গ্রহণের তারিখ:

লিঙ্গ : ☐ ছেলে

☐ মেয়ে

বয়স :

শ্রেণী :

স্কুল :

দাঁত ব্যাথা সংক্রান্ত প্রশ্নাবলী

১. দাঁত উঠা বা গজানোর সময় তুমি কি ব্যাথা/ কষ্ট পাও/ পেয়েছিলে?

☐ না

☐ অল্প/ সামান্য

☐ খুব বেশি

২. তোমার কি এখন দাঁত ব্যাথা আছে? (দাঁত উঠা/ গজানোর ব্যাথা ছাড়া)

☐ না

☐ অল্প/ সামান্য

☐ খুব বেশি

৩. তোমার কি জীবনে কখনও দাঁত ব্যাথা হয়েছিল? (দাঁত উঠা গজানোর ব্যাথা ছাড়া)

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

দৈনন্দিন কার্যাবলী সংক্রান্ত প্রশ্নমালা

১. দাঁতের সমস্যা বা দাঁত ব্যাথার কারণে কি তোমার খাবার খেতে সমস্যা হয়/
কখনও হয়েছিল?

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

২. দাঁতের সমস্যা বা দাঁত ব্যাথার কারণে কি তোমার পানি/ অন্য কোন পানীয় খেতে
(পান করতে) সমস্যা হয়েছিল?

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

৩. তোমার দাঁতের কারণে কি কথা বলতে সমস্যা হয়/ কখনও হয়েছিল?

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

৪. দাঁতের সমস্যা বা ব্যাথার কারণে কি তোমার খেলতে সমস্যা হয়/ কখনও হয়েছিল?

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

৫. দাঁত ব্যাথার কারণে তুমি হাসতে পারো নাই/ হাসি খুশি ছিলেনা এমন কি কখনও হয়েছে?

- ☐ না
- ☐ মাঝে মধ্যে
- ☐ অনেক সময়

৬. দাঁত দেখতে কেমন লাগবে এই কথা ভেবে তুমি হাসে নাই এমন কি কখনও হয়েছে?

- ☐ না
- ☐ মাঝে মধ্যে
- ☐ অনেক সময়

৭. দাঁতের সমস্যা/ ব্যাথার কারণে কি তোমার রাত ঘুমাতে সমস্যা হয়/ কখনও
হয়েছে?

- ☐ না
- ☐ অল্প/ সামান্য
- ☐ খুব বেশি

৮. তোমার দাঁত নিয়ে কি তুমি কতটা খুশী?

- ☐ একটুও খুশী না
- ☐ অল্প/ সামান্য খুশী
- ☐ খুবই খুশী

৯. তোমার দাঁতে কি কোন গর্ত আছে?

- ☐ না
- ☐ হ্যাঁ
- ☐ জানি না

ধন্যবাদ

উত্তর প্রদানের কার্ড

প্রতিটি প্রশ্নের জন্য আমি তোমাকে তিন ধরনের মুখের চেহারা দেখাব। তোমার যদি কোন সমস্যা না থাকে অথবা দাঁতে ব্যাথা বা কষ্ট না থাকে তাহলে হাসি মুখে চেহারাটি দেখাবে। যদি তোমার অল্প সমস্যা বা অল্প দাঁত ব্যাথা থাকে তাহলে মধ্যের চেহারাটি দেখাবে। আর যদি তোমার খুব বেশি সমস্যা থাকে অথবা খুব বেশি দাঁত ব্যাথা থাকে তাহলে দুঃখী মুখের চেহারাটি দেখাবে।

তোমার দাঁতে ব্যাথা আছে কিনা সেটা যে মুখটিতে বোঝা যাচ্ছে সেটা দেখাও।



না

☐

অল্প/ সামান্য

☐

খুব বেশি

☐

Appendix 6

Sample size calculation

Sample size calculation

Based on the results obtained from the pilot study the required sample size for the main study was calculated. As in the pilot study, the mean difference in BMI-for-age z-scores between groups 1 and 2 was 0.36, while between groups 2 and 3 it was 0.37. So, the sample size calculation was done considering mean BMI-for-age z-scores difference of 0.33 between two caries groups, and standard deviation of 1.

sample size calculation of the study

Two-sided confidence level(1-alpha) 95

Power(% chance of detecting) 80

Ratio in each group: 1

At 95% level of significance the true value the required simple size is calculated as

Sample Size For Comparing Two Means

Input Data

Confidence Interval (2-sided) 95%

Power 80%

Ratio of sample size (Group 2/Group 1) 1

	Group 1	Group 2	Difference*
Mean			0.33
Standard deviation	1	1	
Variance	1	1	

Sample size of Group 1	145
------------------------	-----

Sample size of Group 2	145
------------------------	-----

The Open Epi version 3 online calculator has been used for this calculation (Dean et al. 2015).

Based on this calculation the minimum required simple size was 145 children in each group, resulting in a total of 435 (145×3) children for three groups. Considering design effect of 1.5, estimated sample size became 653. Finally, assuming a response rate of 82% (following the results from the pilot study), the final total estimated sample size was 797.

Appendix 7

Training and Calibration

Preparing training protocol

A field manual was prepared before training of the survey team for field work which contained the details of study background, study participants, questionnaire guide, planning of field work, managing participants, height and weight measurement and clinical oral examination guidelines. A separate log book was maintained for monitoring of fieldwork and addressing any issues from the field. Survey team leader (PhD candidate) managed the logbook, ordered supplies, as well as managed other administrative and logistic procedures.

Training procedure

Day 1	Session 1	Session 2	Session 3
Topics	-Introduction of team members. -Discussion on study background, aim, objectives and methods. -Discussion on interview questionnaire. -Cross infection procedures and survey manners. (All team members took part here.)	-Training and discussion on clinical indices and tooth coding based on the training CD from 'Children's Dental Health Survey 2013, UK' with all dentists and recording assistants. The training CD was played for them and there was a short discussion for further clarification. At the end of this session a copy of training CD and notes on tooth coding was distributed to all dentists.	-Briefing with the interviewer and anthropometric measurement takers on how to use the instrument and how to measure with it. -Demonstration on how to use the questionnaire and conduct the interview. -A practical session on height weight measurement and conduction of interview was run with them.

Day 2	Session 1	Session 2	Session 3
Topics	Final discussion and clarification based on training CD to make the team prepared to get the practical training in child's oral cavity.	A practical training on dental examination of children. Five children with a wide range of levels of dental caries were examined by all three dentists and the recording assistants recorded that. Their reports were examined for any disagreement and in case of any disagreement the patient was re-examined and the issue was discussed at that time so that inter-examiner differences could be reviewed and resolved by group discussion.	

Procedure for calibration test

Twelve patients participated in the first day of calibration who were invited for the procedure. Each patient was examined by the calibrator (PhD candidate) and then by each examiner. Finally the findings of the calibrator were compared with those of other two examiners.

On the next day every examiner independently examined the same group of patients (this time seven of them were present) and then inter and intra examiner reproducibility were checked.

Appendix 8

The procedure of clinical dental examination

Procedure of clinical dental examination

Three trained and calibrated dentists (including the PhD candidate) performed the non-invasive clinical dental examination and three recorders recorded that. Examinations were done with the children by sitting straight on a stool. Dental examination was conducted visually using hand torchlight with blue-white colour spectrum and disposable plastic dental mirror. Tweezers and cotton was used to remove any gross deposition of food debris and plaque if needed. Standardized procedures were used employing cross infection management policies and practice so that there were minimum risk to the participants. Each child was examined by a dentist wearing a new pair of gloves and using disposable sterile instruments, and all used disposable instruments was discarded (Picture is shown in Appendix 14).

Dental caries measure

Following the CDHS 2013, the tooth was examined by each tooth surface as mesial, distal, facial, lingual and occlusal surfaces and checked for whether it is sound, carious, restored, or missing due to caries. Tooth status was categorized as sound, visual change in enamel, localized enamel breakdown because of caries with no visible dentin or underlying shadow, underlying dark shadow from dentin, distinct cavity with visible dentin and extensive distinct cavity reaching the pulp (Ismail et al. 2007). However, for analysis purpose the visible dentin caries was considered as dental caries at tooth level was considered.

Oral Examination form

Childs unique code:

Setting: Hospital/School(.....)
Age:

Sex: Boy/ Girl

Criteria:

Tooth codes: Unerupted: 8, Extracted (caries): 6, Missing(truma): T

(Please circle which tooth you are examining)

Surface codes:

Sound-0

Enamel caries (non cavitated)-Av; Enamel caries (cavitated)-Ac

Visual caries in dentin (non cavitated)-2v; Cavitated caries-2c; Decayed pulpal involvement 3.

Filled, recurrent (no visual cavity)-4V; Filled,recurrent (cavity)-4c ; Filled (no decay)-5; Crown or advanced restoration-C , Traumatized surface-t

DMFT code

Upper teeth

Right

	7	6	e 5	d 4	c 3	b 2	a 1
D							
O							
M							
B							
L							

Left

a 1	b 2	c 3	d 4	e 5	6	7	
							D
							O
							M
							B
							L

Lower teeth

Right

	7	6	e 5	d 4	c 3	b 2	a 1
D							
O							
M							
B							
L							

Left

a 1	b 2	c 3	d 4	e 5	6	7	
							D
							O
							M
							B
							L

PUFA/pufa code

Right

7	6	e 5	d 4	c 3	b 2	a 1

Left

a 1	b 2	c 3	d 4	e 5	6	7

Lower teeth

Right

7	6	e 5	d 4	c 3	b 2	a 1

Left

a 1	b 2	c 3	d 4	e 5	6	7

Status	Code for PUFA
Sound	0
Visible Pulpal involvement	P
Ulceration caused by dislocated tooth fragments	U
Fistula	F
Abscess	A

Appendix 9

Procedure of anthropometric measurement

Height and weight measurement of the children was measured by the same examiner. The measurement for height and weight was taken to the nearest 0.1 cm and 0.1 kg, respectively. Height was measured with the child standing without shoes using a portable stadiometer (Leicester height measure). The child was asked to stand straight with heels together and head placed in the Frankfurt plane. Weight was measured with the child standing and wearing light clothes and not wearing shoes, by using a pre-calibrated digital Seca scale. The portable digital scale was placed on a firm surface during the examination and was calibrated every morning. Two measurements were taken for each child and the average was used for the final analysis.

Height and weight Assessment Form for Children

ID no:

Date of interview:

Sex: ☐ Male ☐ Female

Age:

Class:

Height measurement

Reading	Height (CM)
1 st measurement	
2 nd measurement	

Weight measurement

Reading	Weight (KG)
1 st measurement	
2 nd measurement	

Appendix 10

Validity and reliability of the Bengali SOHO-5

The validity of the Bengali version of SOHO-5 questionnaire was evaluated in terms of face, content and constructs validity and the tests for reliability (internal consistency and test-retest reliability) were also conducted.

Face and content validity

Face validity refers to whether the items appear to be measuring what they are supposed to measure. There are no empirical approaches to test it (Streiner et al. 2014). Content validity is a similar concept, but in this case a panel of experts examines the instrument and determines the degree to which its items address the topics of the instrument that it is supposed to measure (Streiner et al. 2014). The assessment of face and content validity of the Bengali version of SOHO-5 was carried out in close collaboration with the team who designed the original SOHO-5 (Tsakos et al. 2012). This was followed by a discussion among the dentists involved in conducting the pilot study, and a review of the comments given by participants' parents, with the aim to explore the comprehensiveness of the translated SOHO-5 items and the relevance and understanding of the content of the questionnaire. In light of the feedback given by experts and parents, the translated version underwent some minor changes with wording before the main study.

Construct validity

Construct validity is tested by linking the attribute of the measure to some other attribute by a hypothesis or construct. Many constructs arose from theories or clinical observations or objective measures. There is no one experimental design or statistic, which is common to construct validation studies (Streiner et al. 2014). Among many ways of establishing construct validation, 'convergent and discriminant validation' is one that was used in this study.

Convergent validity

Convergent validity referred as how closely the scale is related to other variables or other measures of the same construct to which it should be related. It is expected that the index should correlate with other measures of this construct (Streiner et al. 2014).

In this study the association of the SOHO-5 score with subjective oral health status measures (satisfaction with teeth, reported cavities, current toothache, and toothache experience) was examined. To address this, the following variables were included in child questionnaire: satisfaction with oral health (How happy are you with your teeth? With answer options: very happy = 0, a little happy = 1, and not happy = 2) and presence of dental cavities (Do you have any holes in your teeth? With answer options: no = 0, yes = 1, 2=don't know), for current or ever toothache (Do you have toothache? With answer options: no=1, a little=2 and a lot=2). The association with overall quality of life score and these measures was tested by nonparametric test (as the

frequency distribution for SOHO-5 score was skewed). Kruskal Wallis test was used (as there were more than two categories) for testing association of overall child's SOHO-5 scores with perceived satisfaction with teeth and toothache experience groups (Tsakos et al. 2012; Yusuf et al. 2006; Tubert-Jeannin et al. 2005). For the analysis purpose, the 'don't know' category of perceived tooth decay measure was excluded (6.7% children were in this group) and Wilcoxon rank-sum (Mann-Whitney) test was used for testing the association. It was expected that lower the self-satisfaction level, having hole in teeth and having toothache experience, the higher the mean and median of SOHO-5 score.

Discriminant validity

The study assessed whether the SOHO-5 can discriminate between different clinical groups. Data from the children's clinical dental examination (caries and pufa+PUFA experience) was used to test discriminant validity by assessing the association between SOHO-5 and clinical measures, thereby looking at its ability to distinguish between different clinical groups. It was tested by difference in mean and median of overall SOHO-5 scores among four caries severity groups of children (dmft+DMFT=0, 1-2, 3-5, 6-max) by using Kruskal Wallis test and two dental sepsis groups (pufa+PUFA =0, pufa+PUFA >0) by using Wilcoxon rank-sum (Mann-Whitney) tests (Tubert-Jeannin et al. 2005; Tsakos et al. 2012). It was expected that the higher the caries and sepsis score, the higher the mean and median of SOHO-5 score.

The previous 'validity' tests provide evidence that the tool is measuring what it is intended.

Reliability of the questionnaire

In this study reliability was assessed for internal consistency and test-retest reliability.

Internal consistency

If the measure has different items addressing the same underlying dimension then it is reasonable to expect that the scores on each item would be correlated with scores on all other items. Measures of internal consistency are based on a single administration of the measure and represent the average of the correlations among all the items in the measure. In this study it was tested by using standard Cronbach alpha, interitem and item-total score correlation. The reliability coefficient (alpha) can range from 0 to 1, with 0 representing an instrument having maximum level of error and 1 representing total absence of error. Various authors have made different recommendations regarding the minimum accepted level of reliability (Streiner et al. 2014). The level of reliability coefficient of Cronbach alpha 0.70 or higher was considered as acceptable reliability for this study (Abanto et al. 2013).

Test-retest reliability

Test-retest reliability provides evidence of the stability of the scale by measuring the degree of agreement between two observations/measurements of the patient on two occasions separated by some interval of time using the same scale and with the same respondents. So, this provides an estimation of the degree to which the results are reproducible, where Kappa value of 1 implies perfect agreement and values less than 1 imply less than perfect agreement (Altman 1991). The interpretation of Kappa used in this study was following:

- Poor agreement = Less than 0.20
- Fair agreement = >0.20 to 0.40
- Moderate agreement = >0.40 to 0.60
- Good agreement = >0.60 to 0.80
- Very good agreement = >0.80 to 1.00

In this study test-retest reliability of the questionnaire was assessed by repeated administration of the questionnaire on a sub-sample of children. The sub-sample consisted of 20 children. Second interviews were conducted in two schools with randomly selected 10 children from the previous sample in each school. Test-retest reliability was assessed by the weighted kappa for the total SOHO-5 score to measure the agreement between the two measurements (Tubert-Jeannin et al. 2005).

Appendix 11

Sleep disturbance

Sleep disturbance score

Sleep disturbance was assessed by a sleep disturbance scale that has been translated to Bengali and adapted for use in Bangladesh from the sleep disturbance scale for children (Bruni et al. 1996). Seven questions were taken from this to assess problems with initiating and maintenance of sleep. These questions were: total duration of night sleep, approximate time for sleep onset, whether the child is reluctant to go to bed, difficulty and anxiety to fall asleep, night time awaking more than two times and difficulty to fall asleep again. These questions assess sleeping difficulties over the last 6 months. The answer options for total duration of sleep were: 9-11 hours (score of 1), 8 hours (score: 2), 7 hours (scores: 3), 5 to 6 hours (score: 4) and less than 5 hours (score: 5). For the second question 'the approximate time for sleep onset, the answer options were less than 15 minutes that scores 1, 15-30 minutes scores 2, 30-45 minutes scores 3, 45-60 minutes scores 4 and more than 60 minutes scores 5. The answers of the last five questions were assessed with five answer options: never scores 0, occasionally (once/ twice per month) scores 1, sometimes (once/twice per week) scores 3, often (3-5 times per week) scores 4 and always (daily) scores 5. The cumulative score of these seven questions was considered as the sleep disturbance score for the child. So, the scale was ranged from 7 to 35 and the aggregate higher score was considered as more sleep disturbance.

Appendix 12

Sensitivity analysis

Table A 1 Results of multiple linear regression models testing the association of dental caries and HAZ, WAZ and BAZ adjusted for potential confounders and parental height and weight: presented as Regression coefficient (95% CI)(N= 371)

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
Dental caries (ref: dmft+DMFT=0)						
Mild caries (dmft+DMFT= 1-2)	-0.02 (-0.35, 0.32) ^{NS}	-0.09 (-0.42, 0.23) ^{NS}	-0.07 (-0.47, 0.33) ^{NS}	-0.17 (-0.55, 0.21) ^{NS}	-0.09 (-0.51, 0.33) ^{NS}	-0.16 (-0.57, 0.24) ^{NS}
Moderate (dmft+DMFT= 3-5)	-0.34 (-0.68, -0.00) ^{NS}	-0.32 (-0.64, 0.01) ^{NS}	-0.57 (-0.97, -0.16)**	-0.52 (-0.90, -0.14)**	-0.54 (-0.96, 0.12)*	-0.49 (-0.90, 0.09)*
Severe (dmft+DMFT= 6-max)	-0.42 (-0.87, 0.02) ^{NS}	-0.31(-0.74, 0.12) ^{NS}	-0.63 (-1.16, -0.10)*	-0.48 (-0.98, 0.02) ^{NS}	-0.55 (-1.10, 0.00) ^{NS}	-0.42 (-0.96, 0.11) ^{NS}
Maternal education (ref= no and primary education)						
Secondary	0.29 (0.15, 0.73) ^{NS}	0.43 (-0.00, 0.86) ^{NS}	0.15 (-0.37, 0.67) ^{NS}	0.35 (-0.15, 0.84) ^{NS}	-0.06 (-0.61, 0.49) ^{NS}	0.11 (-0.42, 0.64) ^{NS}
Higher secondary	0.56 (0.13, 0.99)*	0.57 (0.15, 0.99)**	0.58 (0.07, 1.09)*	0.58 (0.09, 1.06)*	0.37 (-0.17, 0.90) ^{NS}	0.35 (-0.17, 0.86) ^{NS}
Tertiary	0.84 (0.39, 1.29)***	0.86 (0.42, 1.30)***	0.63 (0.10, 1.17)*	0.68 (0.17, 1.18)**	0.18 (-0.38, 0.75) ^{NS}	0.23 (-0.32, 0.77) ^{NS}

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
Monthly family income (ref=<8000 Taka)						
8-20 thousand	0.09 (-0.40, 0.57) ^{NS}	0.02 (-0.45, 0.49) ^{NS}	0.13 (-0.71, 0.44) ^{NS}	-0.24 (-0.79, 0.31) ^{NS}	-0.24 (-0.85, 0.36) ^{NS}	-0.34 (-0.92, 0.24) ^{NS}
>20-30 thousand	0.50 (-0.01, 1.02)*	0.27 (-0.23, 0.77) ^{NS}	0.53 (-0.08, 1.14) ^{NS}	0.20 (-0.38, 0.78) ^{NS}	0.37 (-0.27, 1.01) ^{NS}	0.08 (-0.54, 0.70) ^{NS}
>30 thousand	0.07 (-0.48, 0.61) ^{NS}	-0.20 (-0.73, 0.34) ^{NS}	0.18 (-0.47, 0.82) ^{NS}	-0.20 (-0.82, 0.42) ^{NS}	0.24 (-0.43, 0.92) ^{NS}	-0.08 (-0.75, 0.58) ^{NS}
Setting (ref=Hospital)						
School children	0.75 (0.40, 1.10)***	0.75 (0.40, 1.09)***	0.67 (0.25, 1.08)**	0.65 (0.25, 1.05)**	0.28 (-0.16, 0.71) ^{NS}	0.26 (-0.17, 0.68) ^{NS}
Birth weight (ref= normal weight)						
Low weight	-0.07 (-0.49, 0.35) ^{NS}	0.01 (-0.39, 0.42) ^{NS}	-0.71 (-1.21, -0.21)**	-0.58 (-1.05, -0.11)*	-0.99 (-1.51,-0.46)***	-0.87 (-1.37, -0.37)**
High weight	0.32 (-0.09, 0.72) ^{NS}	0.26 (-0.13, 0.65) ^{NS}	0.49 (0.01, 0.97)*	0.41 (-0.04, 0.87) ^{NS}	0.49 (-0.02, 0.99) ^{NS}	0.42 (-0.06, 0.91) ^{NS}
Childhood diseases (ref=no)						
Any diseases	-0.17 (-0.51, 0.16) ^{NS}	-0.08 (-0.41, 0.25) ^{NS}	-0.23 (-0.63, 0.17) ^{NS}	-0.15 (-0.54, 0.23) ^{NS}	-0.19 (-0.61, 0.23) ^{NS}	-0.16 (-0.57, 0.25) ^{NS}

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
Parental height						
Mother's height		0.18 (-1.36, 1.72) ^{NS}		-1.20 (-2.99, 0.59) ^{NS}		-1.85 (-3.76, 0.05) ^{NS}
Father's height		0.84 (-0.62, 2.30) ^{NS}		1.34 (-0.35, 3.04) ^{NS}		1.18 (-0.63, 2.99) ^{NS}
Parental weight						
Mother's weight		0.22 (0.01, 0.04) ^{**}		0.03 (0.01, 0.05) ^{***}		0.03 (0.01, 0.05) ^{**}
Father's weight		0.02 (0.00, 0.03) ^{**}		0.03 (0.01, 0.05) ^{**}		0.03 (0.01, 0.04) ^{**}

*** p<0.001 **p<0.01 *p<0.05

Model H1: HAZ + dental caries + maternal education + family income + setting + birth weight + childhood disease.

Model H2: HAZ + dental caries + maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Model W1: WAZ + dental caries+ maternal education + family income + setting + birth weight + childhood disease.

Model W2: WAZ + dental caries+ maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Model B1: BAZ + dental caries+ maternal education + family income+ setting + birth weight + childhood disease.

Model B2: BAZ + dental caries+ maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Table A 2 Results of multiple linear regression models testing the association of dental sepsis and HAZ, WAZ and BAZ adjusted for potential confounders and parental height and weight: presented as Regression coefficient (95% CI)(N= 371)

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
Dental sepsis (ref= pufa+PUFA=0)						
Dental sepsis (pufa+PUFA≥ 1)	-0.38 (-0.67, -0.08)*	-0.29 (-0.58, -0.01)*	-0.43 (-0.78, -0.08)*	-0.30 (-0.64, 0.03) ^{NS}	-0.33 (-0.69, 0.04) ^{NS}	0.21 (-0.57, 0.14) ^{NS}
Maternal education (ref= no and primary education)						
Secondary	0.26 (-0.18, 0.70) ^{NS}	0.41 (0.02, 0.83) ^{NS}	0.11 (-0.41, 0.64) ^{NS}	0.32 (-0.18, 0.82) ^{NS}	0.09 (-0.64, 0.46) ^{NS}	0.09 (-0.45, 0.62) ^{NS}
Higher secondary	0.53 (0.10, 0.96)*	0.55 (0.13, 0.96)*	0.54 (0.03, 1.06)*	0.55 (0.07, 1.04)*	0.34 (0.20, 0.88) ^{NS}	0.33 (-0.19, 0.85) ^{NS}
Tertiary	0.84 (0.39, 1.29)***	0.85 (0.41, 1.29)***	0.64 (0.10, 1.18)*	0.68 (0.16, 1.19)*	0.19 (0.38, 0.76) ^{NS}	0.23 (-0.31, 0.78) ^{NS}
Monthly family income (ref=<8000)						
8-20 thousand	0.08 (-0.40, 0.56) ^{NS}	0.00 (-0.46, 0.47) ^{NS}	-0.15 (-0.73, 0.42) ^{NS}	-0.28 (-0.82, 0.26) ^{NS}	-0.26 (-0.86, 0.34) ^{NS}	-0.38 (-0.96, 0.20) ^{NS}
>20-30 thousand	0.48 (-0.03, 0.99) ^{NS}	0.25 (-0.25, 0.75) ^{NS}	0.51 (-0.10, 1.12) ^{NS}	0.17 (-0.41, 0.76) ^{NS}	0.35 (-0.29, 0.99) ^{NS}	0.06 (-0.56, 0.69) ^{NS}

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
>30 thousand	0.05 (-0.49, 0.59) ^{NS}	-0.22 (-0.75, 0.31) ^{NS}	0.14 (-0.50, 0.79) ^{NS}	-0.24 (-0.87, 0.38) ^{NS}	0.21 (-0.47, 0.89) ^{NS}	-0.13 (-0.79, 0.53) ^{NS}
Setting (ref=Hospital)						
School children	0.73 (0.37, 1.08) ^{***}	0.73 (0.38, 1.07) ^{***}	0.69 (0.27, 1.12) ^{**}	0.68 (0.28, 1.09) ^{**}	0.32 (-0.12, 0.77) ^{NS}	0.31 (-0.12, 0.74) ^{NS}
Birth weight (ref= normal weight)						
Low weight	-0.12 (-0.54, 0.30) ^{NS}	-0.02 (-0.43, 0.39) ^{NS}	-0.76 (-1.26, -0.26) ^{**}	-0.61 (-1.09, -0.13) [*]	-1.02(-1.55, -0.50) ^{***}	-0.89 (-1.40, -0.38) ^{**}
High weight	0.30 (-0.10, 0.71) ^{NS}	0.24 (-0.14, 0.63) ^{NS}	0.47 (-0.01, 0.95) [*]	0.39 (-0.06, 0.85) ^{NS}	0.47 (-0.04, 0.97) ^{NS}	0.40 (-0.08, 0.89) ^{NS}
Childhood diseases (ref=no)						
Any diseases	-0.20 (-0.53, 0.14) ^{NS}	-0.10 (-0.43, 0.23) ^{NS}	-0.26 (-0.66, 0.14) ^{NS}	-0.18 (-0.57, 0.21) ^{NS}	-0.22 (-0.64, 0.20) ^{NS}	-0.18 (-0.59, 0.23) ^{NS}
Parental height						
Mother's height		0.20 (-1.32, 1.74) ^{NS}		-1.20 (-2.99, 0.59) ^{NS}		-1.87 (-3.78, 0.04) ^{NS}
Father's height		0.77 (-0.68, 2.23) ^{NS}		1.32 (-0.39, 3.02) ^{NS}		1.19 (-0.63, 3.01) ^{NS}

Categories	Model H1-HAZ	Model H2-HAZ	Model W1-WAZ	Model W2-WAZ	Model B1-BAZ	Model B2-BAZ
Parental weight						
Mother's weight		0.02 (0.01, 0.04)**		0.03 (0.01, 0.05)***		0.03 (0.01, 0.05)**
Father's weight		0.02 (0.01, 0.04)**		0.03 (0.01, 0.05)**		0.03 (0.01, 0.05)**
*** p<0.001 **p<0.01 *p<0.05						

Model H1: HAZ + dental sepsis + maternal education + family income + setting + birth weight + childhood disease.

Model H2: HAZ + dental sepsis + maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Model W1: WAZ + dental sepsis + maternal education + family income + setting + birth weight + childhood disease.

Model W2: WAZ + dental sepsis + maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Model B1: BAZ + dental sepsis + maternal education + family income+ setting + birth weight + childhood disease.

Model B2: BAZ + dental sepsis + maternal education + family income + setting + birth weight + childhood disease + Parental height and weight.

Appendix 13

Correlation coefficients matrix

Correlation coefficients matrix: exposures, outcomes, potential mediators, and demographic, socio economic and early childhood factors R (Pearson's Correlation Coefficient) p-value

	dmft+ DMFT	pufa+ PUFA	HAZ	WAZ	BAZ	SOHO- 5	Eat. diff.	Sleep dis.	Tooth ache	Poor appetite	Sex	Age	M. edu	Family income	Birth wt.	C. dis.
dmft+ DMFT	1															
pufa+ PUFA	0.64*	1														
HAZ	-0.25*	-0.17*	1													
WAZ	-0.28*	-0.19*	0.80*	1												
BAZ	-0.22*	-0.15*	0.44*	0.89*	1											
SOHO- 5	0.49*	0.43*	-0.18*	-0.22*	-0.19*	1										
Eat. Diff.	0.54*	0.48*	-0.27*	-0.31*	-0.25*	0.57*	1									
Sleep dis.	0.43*	0.38*	-0.15*	-0.17*	-0.13*	0.66*	0.53*	1								
Tootha che	0.58*	0.44*	-0.21*	-0.25*	-0.21*	0.62*	0.51*	0.56*	1							
Poor appe.	0.26*	0.19*	-0.20*	-0.34*	-0.36*	0.27*	0.34*	0.30*	0.30*	1						
Sex	-0.01 NS	0.00 NS	0.07 ~	0.11 #	0.11 #	0.02 NS	-0.00 NS	0.00 NS	-0.02 NS	0.01 NS	1					
Age	-0.07 NS	-0.06 NS	-0.24*	-0.10 #	0.02 NS	-0.03 NS	-0.11* #	-0.01 NS	-0.04 NS	-0.13*	0.10 #	1				

	dmft+ DMFT	pufa+ PUFA	HAZ	WAZ	BAZ	SOHO- 5	Eat. diff.	Sleep dis.	Tooth ache	Poor appetite	Sex	Age	M. edu	Family income	Birth wt.	C. dis.
M.edu	-0.17*	-0.15*	0.33*	0.34*	0.25*	-0.15*	-0.21*	-0.14*	-0.17*	-0.08 ~	0.10 #	-0.03 NS	1			
Fam. income	-0.04 NS	-0.09 ~	0.18*	0.23*	0.21*	-0.08 ~	-0.10 #	-0.06 NS	-0.06 NS	-0.04 NS	0.13*	0.07 NS	0.43*	1		
Birth wt.	-0.04 NS	-0.02 NS	0.11 #	0.1718 *	0.18*	-0.03 NS	-0.06 NS	-0.03 NS	-0.05 NS	-0.09 ~	0.04 NS	0.08 ~	0.06 NS	0.02 NS	1	
Child. diseas es	0.12* #	0.11*0 #	-0.07 NS	-0.10 #	-0.10 NS	0.09 ~	0.17 ~	0.09 ~	0.10 #	0.14*	-0.08 ~	-0.06 NS	-0.08 ~	-0.03 ^{NS}	-0.03 NS	1
p-value *<0.001 #<0.01 ~<0.05 ^{NS} Not significant																

Appendix 14

Photo Glossary of the survey



Picture of conducting interview



Picture of clinical dental examination



Picture of oral hygiene instruction after the survey



Picture of distribution of toothbrush, toothpaste



Picture of Dhaka Dental College Hospital



Picture of a primary school participated in the survey

Appendix 15

Miscellaneous

Conference presentation

Associations between dental caries and BMI among 5-9 year old Bangladeshi children.

MP Mishu, R Watt, G Tsakos, A Heilmann

Eur J Public Health (2016) 26 (suppl_1): ckw171.021.

Published: 02 November 2016

DOI:<https://doi.org/10.1093/eurpub/ckw171.021>

Aim

Previous research on associations between dental caries and BMI among children has produced inconsistent results. The aim of this study was to assess the associations between dental caries and height, weight and BMI among 5 to 9 year old Bangladeshi children.

Methods

A cross sectional observational study was conducted among 5-9 year old children in Dhaka, Bangladesh. Ethical approval was granted by the UCL Research Ethics Committee and National Research Ethics Committee Bangladesh. All parents gave their written consent. Children were recruited from those coming for dental treatment to Dhaka Dental College Hospital and from three nearby primary schools. Clinical dental data were collected by trained and calibrated dentists, using WHO Oral Health Survey Basic Methods (2013). Outcome measures were height, weight and BMI of the children, converted to Z-scores: weight-for-age (WAZ), height-for-age (HAZ) and BMI-for-age (BAZ). The main exposure was a combined measure of decayed, missing and filled deciduous and permanent teeth (dmft+DMFT). Multiple linear regression analysis was used to assess the associations of interest, adjusting for potential confounders (age, sex, parental education, occupation and household income).

Results

The final sample comprised 788 children and response rate was 92%. The mean dmft+DMFT in the study population was 2.8 (95% CI: 2.6-3.0). Children with high level of caries experience had significantly lower HAZ, WAZ and BAZ scores compared to low and no caries groups. In the fully adjusted model, one-point increase in dmft+DMFT score was associated with 0.1 decreases in each of the HAZ, WAZ and BAZ scores ($P < 0.001$).

Conclusions

The results of this study provide evidence that dental caries was associated with lower height, weight and BMI among Bangladeshi children. As dental caries appears to contribute to lower height and weight in children; so, it is important to reduce the high levels of dental caries among Bangladeshi children.

Key messages

- Dental caries was associated with lower height, weight and BMI among Bangladeshi children
- The caries level is high in this country and most of the decay remains untreated. So, it is important to reduce the high levels of dental caries among Bangladeshi children

© The Author 2016. Published by Oxford University Press on behalf of the European Public Health Association. All rights reserved.

**Presented in 9th European Public Health Conference, 9-12 November
2016, Vienna, Austria.**

Publication from UCL Public Engagement



Healthy Eating and Healthy Mouths for Children

Masuma Pervin Mishu

The Project

'Healthy Eating and Healthy Mouths for Children' was run by PhD student Masuma Pervin Mishu. Masuma brought children, parents and dentists together in two schools in Dhaka, Bangladesh to discuss tooth decay, caries, healthy eating and oral hygiene. To form her team, Masuma recruited dentists from Dhaka Dental College Hospital who were enthusiastic about helping these school children and opening dialogue on oral hygiene.

Masuma's team hosted workshops on early detection of tooth decay and dental cavities and on healthy eating. These workshops were practical in nature, showing children and parents how to take control of their own dental hygiene and enquiring into the issues they faced getting treatment in their community.

Train and Engage

Masuma highlights the Train and Engage program as integral to the success of this event and that it gave her a 'practical idea of how people think and feel about dental caries and healthy eating issues'.

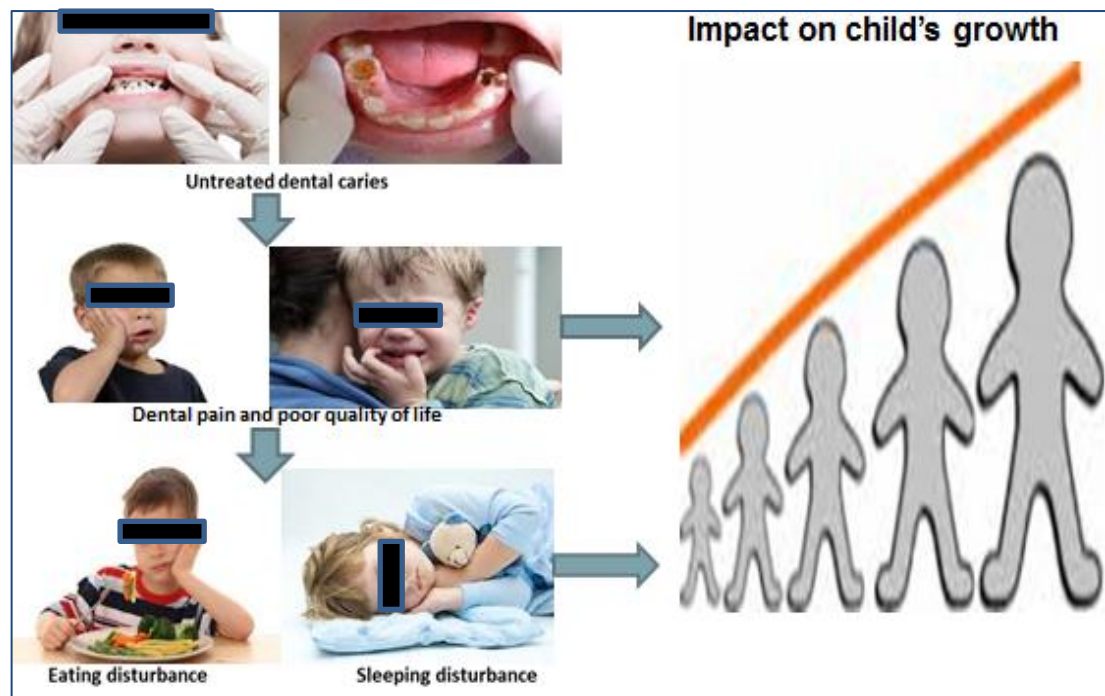
The Public Engagement Unit helped to guide the project, ensuring that strong evaluation techniques were used to enhance its value as a pilot. Masuma developed skills in need assessment and project planning.

Legacy

Masuma's team reached 400 school children and 200 parents through this project and provided plastic dental mirrors to these families. The conversations evoked by the project further informed Masuma's research and gave her an insight into the day to day issues facing those who benefit from that research. The dentists involved also received specialised support from Mishu, bringing them up to date on best practices employed at UCL. The relationships created from this project have led to further projects on dental health in these schools and allowed research at UCL to connect with international groups.

Public and Cultural Engagement, UCL

Three minutes thesis presentation



Presentation on: The association between dental caries and anthropometric measures in 5-9-year-old Bangladeshi children.

