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Oral health related quality of life among Iowa adolescents

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ORAL HEALTH RELATED QUALITY OF LIFE AMONG IOWA ADOLESCENTS

by

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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To my loving husband Gaurav Ahuja, for his unfailing love and support always.

By three methods we may learn wisdom: First, by reflection, which is noblest; second, by imitation, which is easiest; and third by experience, which is the bitterest.

Confucius

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CHAPTER I

INTRODUCTION

<u>Overview</u>

Oral health is an essential part of general health and well-being and is an important factor that impacts an individual's quality of life. The psychosocial impact of oral diseases can have a detrimental effect on the quality of life (The World Oral Health Report 2003, Surgeon General's Report on Oral Health). Perceptions of dental and facial appearance can vary from person to person and different people can have different expectations from treatment outcomes (Shulman et al, 2004). People with concerns over facial appearance have a poorer quality of life and tend to avoid healthy social interactions (Oral Health in America: A Report of the Surgeon General). As a result, oral health may have profound impacts on the physical, social, and psychological well-being of individuals (Locker et al, 2004; Oliviera et al, 2004; Shaw et al, 1980).

These issues become particularly significant when dealing with adolescents, as they are more aware of the appearance of their teeth and have greater aesthetic concerns about their teeth, as compared to others (Clark and Berkowitz, 1997). Adolescent patients expect dental treatment to boost their self-esteem and confidence (Tung & Kiyak, 1998). This maybe because they are more concerned about acceptance by peers and, thus, their oral health status can have an exaggerated effect on their self-worth and self-confidence. Therefore, it is important to focus research on assessing the oral health-related quality of life of adolescents, as it can help us better understand the expectations of these patients and in choosing the appropriate ways to address their concerns.

Even though this topic has gained a great deal of attention in the recent years, there is a disconcerting lack of knowledge in the literature. There are only a few published studies that are based in the United States and it might not be appropriate to extrapolate the results from studies done in other parts of the world to U.S. adolescents, due to the cross-cultural differences. Thus, it is important to conduct studies of adolescent oral health-related quality of life in a developed country like the United States. This can aid in shaping a healthier and more positive future for our youth.

The purpose of this thesis research is to assess whether the oral health-related quality of life is affected by the presence of dental caries, dental fluorosis, enamel opacities, and malocclusion in a sample of 17-year old U.S. adolescents. This study is a cross-sectional study nested in an ongoing prospective cohort study, the Iowa Fluoride Study. Working with secondary data from a large scale cohort study provides the opportunity to analyze quality data, which otherwise is difficult to collect due to time and money constraints.

The participants of the Iowa Fluoride Study were originally recruited beginning in 1992 from eight Iowa hospital post-partum units. Dental examinations were conducted at age 5, 9, 13, and 17, using identical protocols for all study examinations with data collection for the 17 year-old time point still ongoing. Although the IFS is a longitudinal prospective cohort study, the data related to the oral health-related quality of life have been collected only at the 17-year old time point and is therefore cross-sectional

CHAPTER II

REVIEW OF LITERATURE

<u>Overview</u>

Oral health is an essential component of an individual's overall health and therefore, oral diseases and conditions can have an adverse impact on the life of an individual, as well as their families. According to the U.S. Surgeon General's Report, oral health is an integral part of general health, these should not be interpreted as separate entities, and oral health must be included in the provision of health care and while designing community programs (Oral Health in America: A Report of the Surgeon General, 2000). The report also emphasized that oral health is a mirror for general health and that the oral cavity is a gateway for infectious organisms. Several recent studies have found associations between oral infections and diabetes (Mealey and Oates, 2006), cardio-vascular health (Bahekar et al, 2007; Haraszthy et al, 2000), and low-birth weight (Boggess et al, 2006). This emphasizes the fact that good oral health is essential for the overall health of an individual and oral diseases can affect other organ systems beyond the oral cavity.

According to National Institutes of Health estimates, 20% to 30% of children and adolescents in the United States have chronic health conditions (National Institutes of Health; Chronic illness self-management in children). Dental caries is the most prevalent chronic disease of childhood and it occurs 5 to 8 times more frequently than asthma (Oral Health in America: A Report of the Surgeon General, 2000). Dental caries affects about half of U.S. children aged 12-15 years and about 20% of U.S. adolescents aged 12-19 years have untreated decay (Centers for Disease control and Prevention, 2011). Children

and adolescents from low income families and those from some racial and ethnic groups (for example, Mexican-Americans and African-Americans) have more untreated tooth decay, as compared with non-Hispanic whites (Centers for Disease Control and Prevention, 2011).

Dental caries can be very distressful, as it can cause pain, dysfunction, inability to concentrate, and poor school attendance (Jackson et al, 2011; Krisdapong et al, 2013; Blumenshine et al, 2008). Thus, it can have a negative impact on the life of an individual and can hamper their ability to succeed (Barbosa and Gavia~o, 2008). Based on the 1984 National Health Interview Survey data, it was reported that children and adolescents less than 18 years had approximately 5 million restricted activity days, more than 1.6 million days in bed, and more than 1.7 million missed school days as a result of acute dental conditions (Waldman, 1987). Furthermore, based on the analysis of the 1989 NHIS data, conducted by Gift et al (1992), more than 51 million school hours are lost annually because of illnesses related to dental problems.

Untreated dental decay can lead to loss of teeth, which later can cause malocclusion and lower a child's self-esteem. In some cases, untreated dental decay can lead to infectious complications and abscesses that can even lead to death, as in the case of Deamonte Driver, a 12-year-old homeless child in the U.S., who died from complications of an abscessed tooth in February 2007 (Maryland Department of Health and Mental Hygiene).

Malocclusion, or misalignment of teeth, is another oral health condition that is prevalent in the U.S. Based on the NHANES data from 1988-1994, crowding of anterior teeth was observed in the majority of the U.S. population, irrespective of their race and

ethnicity (Proffit et al, 1998). Approximately 15% had severe tooth irregularities, and 20% had an abnormal bite relationship (Proffit et al, 1998). Malocclusion can have wide-ranging effects on individuals and their families. These can include physical, social, psychological, and economic effects.

Thus, oral health problems can disrupt various aspects of daily life, such as the ability to perform daily activities and expected social roles and affect the emotional well-being and social well-being of an individual. In contrast, good oral health can have a positive impact on an individual's overall health and well-being and, thus, can have positive benefits for their families as well. Good oral health and tooth appearance can enhance an individual's self-esteem.

The perceptions of the shape, color, and alignment of teeth can vary from person to person and can affect people accordingly. Therefore, normative measures or clinical measures of assessing oral health should be supplemented with subjective measures that are reported by the patients themselves. This can aid in better understanding of the impact of the oral health conditions on the people suffering from those conditions, and can aid in better treatment planning, and better allocation of resources. Keeping this in mind, the self-reported or patient-reported health outcomes such as health-related quality of life and oral health-related quality of life have been developed in the past years.

The concept of quality of life and the subjective measures used to assess the oral health-related quality of life in adolescents are discussed in the next section of this literature review.

<u>Quality of Life and Oral Health-Related Quality of Life</u>

The terms 'quality of life' and 'oral health-related quality of life' have gained broad recognition over the past few years due to a paradigm shift from the traditional clinical dental criteria such as caries or malocclusion toward a more patient-centric oral-healthcare delivery system that focuses on a person's social, emotional, and physical experience (Sischo & Broder,2011). There has been a growing recognition that more subjective, patient-based outcomes, such as those that assess quality of life, should be used to assess the impact of an individual's oral health status, as oral disorders can have a significant impact on one's physical, social, and psychological well-being (Locker,2004; Fernandes et al,2006; Oliviera and Sheiham,2004).

Health-Related Quality of Life

Although the term health-related quality of life (HRQoL) has no strict definition, there is consensus that it is a multidimensional construct capturing people's perceptions about aspects that are important in their daily lives (Slade, 2002). The World Health Organization defines quality of life as an "individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHO, 1993). The concept of HRQoL has become well-established in health services research, health economics and epidemiology (Slade, 2002). It is no longer considered as a secondary outcome to complement biologic and clinical markers of disease (Slade, 2002). The concept has gained widespread recognition, putting it at the forefront of public health policy (Slade, 2002). QoL improvement was listed as the first of the two major goals for the U.S. population in

Healthy People 2010 (US Department of Health and Human Services: Healthy People 2010).

<center>Oral Health-Related Quality of Life</center>

Just like with HRQoL, there is no single definition for oral health-related quality of life (OHRQoL). It can be defined as "the absence of negative impacts of oral conditions on social life and a positive sense of dentofacial self-confidence" (Inglehart and Bagramian, 2002). This concept has also been defined as "a standard of health of the oral and related tissues which enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment and which contributes to general well-being"(Department of Health, 1994). It is recognized by the World Health Organization (WHO) as an important segment of the Global Oral Health Program (2003).

The purpose of this literature review is to provide information related to the concept of quality of life, the tools used in the assessment of OHRQoL, and the development of an OHRQoL tool for children aged 11 to 14 years. It also provides more detailed information pertaining to studies that related various oral conditions, like dental caries, fluorosis, enamel opacities, orthodontic factors, and esthetic perceptions, to parents' and children's OHRQoL.

<u>Why is OHRQoL important?</u>

The measures used to assess oral-health-related quality of life (OHRQoL) are very useful and provide essential information for assessing the treatment needs of individuals and populations. They help in making clinical decisions and in evaluating interventions, services and programs (Jokovic et al, 2006). The use of OHRQoL measures has led to a shift from the traditional dental/medical criteria toward a more

patient-centered, biopsychosocial approach to oral healthcare. OHRQoL assessment has become central to dental research, as it has implications for oral health disparities and access to care (Sischo and Broder, 2011).

<p style="text-align:center">Origin of HRQoL perspective: theoretical models and
WHO definition of health</p>

The World Health Organization defines health as "a complete state of physical, mental and social well-being and not just the absence of disease and infirmity" (Preamble to the Constitution of the World Health Organization ,Official Records of the World Health Organization, no. 2, p. 100). This definition of health is holistic and complies with the contemporary concepts of health and health-related quality of life. The concept of HRQoL originates from both the WHO definition of health, as well as some theoretical models of disease/disorder. These concepts link the biological variables related to disease conditions or symptoms with the self-perceived health and quality-of-life outcomes, thereby integrating biophysical and psychosocial concerns (Locker et al, 2004). Some of the theoretical/ explanatory models are discussed below.

<u>Theoretical models</u>

Wilson and Cleary model (1995)

The Wilson and Cleary model (1995) postulates five dimensions to assess treatment outcomes: physiological factors, symptom status, functional health, general health perceptions, and overall quality of life. Thus, this model integrates both biological and psychological aspects of health outcomes (Wilson and Cleary, 1995). For example, a person suffering from dental caries could experience excruciating pain that hinders his

normal functioning, such as related to chewing food, talking, and ability to concentrate. This in turn can lead to negative perceptions of health and poor overall quality of life.

Gray and Hendershot model (2000)

This model was developed by the International Classification of Functioning, Disability and Health (Gray and Hendershot, 2000). This is a more complex model that posits interactive phenomena among the entities that it classifies (i.e., diseases, impairments, and disabilities). It links health conditions (defined as disease, disorder, injuries, or trauma) to related problems with respect to body structure and appearance, functioning, activity limitations, and participation in life situations (Gray and Hendershot, 2000).

These two models integrate body, individual, and society into broad explanatory frameworks and, thus, identify strategies that can enhance the well-being and quality of life of those with health conditions (Locker et al, 2004).

Sischo & Broder model for OHRQoL in children (2011)

Their theoretical model for OHRQoL incorporates biological, social, psychological, and cultural factors (Sischo & Broder, 2011). This model has been adapted from the Wilson and Cleary model (1995), discussed above. It links biological/clinical variables, functional status, oral-facial appearance, psychological status, OHRQoL, and overall QoL (Sischo and Broder, 2011). In addition, this model also identifies the effects of environmental or contextual factors, such as education, family income and structure, sociocultural factors and access to care, on an individual's perceptions of his oral health and related QoL (Sischo & Broder, 2011). Figure 2-1 shows

the graphical representation of the Sischo and Broder theoretical model for OHRQoL.
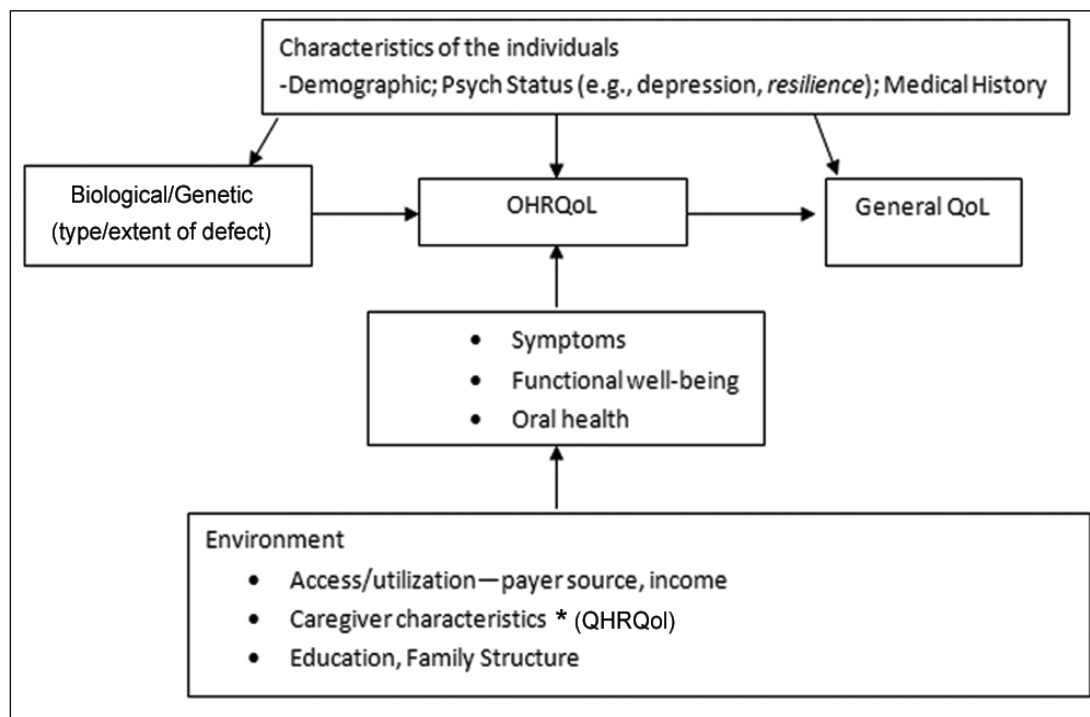
Figure 2-1.Theoretical model for OHRQoL (Sischo and Broder, 2011)

Tools and assessment methods for measuring HRQoL and

OHRQoL

There are two types of measures that are used to assess HRQoL: generic measures and disease-specific measures. The former are more general and can be applied to a number of diseases to assess the impact of disease on the quality of life of an individual, whereas the disease-specific measures are comprised of questions that are more specific

to the problems and symptoms of that particular disease. However, it has been pointed out by some researchers that it is not appropriate to use generic measures for the assessment of OHRQoL in people suffering from oral or orofacial conditions, as they do not highlight the main concerns of individuals with these disorders and are, therefore, not very sensitive (Allen et al, 1999, Jokovic et al,2005). Also, it should be kept in mind that generic tools generally have higher 'floor effects' (i.e., no impact), since many of the symptoms captured by them are less prevalent or relevant among samples of individuals seeking dental care (Sischo & Broder, 2011).

Thus, with increasing recognition of the concept of OHRQoL, efforts were invested in developing measurement tools that were specific to oral diseases and conditions (Slade and Spencer, 1994; Broder et al, 2000; McGrath and Bedi, 2003). However, most of the OHRQoL measures developed in the initial years were focused on the adult and elderly populations (Cushing et al, 1986; Atchison and Dolan, 1990; Locker and Miller, 1994; Slade and Spencer, 1994; Leão and Sheiham, 1996). Oral health can change with the age of an individual, therefore, an age-specific measure would be the most relevant to tap the differences in the OHRQoL of people of different age groups. Also, the content and form of the OHRQoL measures developed for adults and the elderly make them inappropriate for use in children (Locker et al, 2004). In recent years, there has been an increase in the number of OHRQoL-related publications concerning younger age groups (Sischo and Broder, 2011). This reflects the changing trend of research on healthier and younger populations, in order to study both the positive and negative aspects of OHRQoL (Sischo and Broder, 2011).

OHRQoL measures specific to children

Due to the lack of an OHRQoL measure designed specifically for use in children,

Jokovic et al (2000) developed the Child Oral Health Quality of Life Questionnaire

(COHQoL) in Toronto, Canada. This measure will be discussed in detail later in this

chapter. Table 2-1 lists some commonly used HRQoL and OHRQoL measures.

Table 2-1. Commonly used generic HRQoL and OHRQoL measures for children, adults and elderly.

Commonly used HRQoL and OHRQoL measures		
Generic HRQoL measures	OHRQoL measures for adults and elderly	OHRQoL measures for children
• Sickness Impact Profile (Bergner et al, 1981), • Nottingham Health Profile (Hunt et al, 1980),and the • SF-36 (Ware and Sherbourne, 1992)	• Oral Health Impact Profile (OHIP) [Slade and Spencer, 1994] • Short form of OHIP (OHIP-14) [Slade, 1997] • Geriatric Oral Health Assessment Index [Atchison and Dolan, 1990] • Dental Impact Profile [Strauss and Hunt, 1993] • Oral Impact on Daily Performances (OIDP) index [Adulyanon and Sheiham, 1997; Åström et al, 2005]	• Child Oral Health Quality of Life (COHQoL) questionnaire [Jokovic et al,2000, 2002, 2003, 2004] • Child Oral Health Impact Profile (COHIP) [Broder et al, 2007] • Child-Oral Impacts on Daily Performances (Child-OIDP) [Gherunpong et al,2004] • Early Childhood Oral Health Impact Scale (ECOHIS) [Pahel et al, 2007] • Scale of Oral Health Outcomes (SOHO-5) [Tsakos et al, 2012]

Development of OHRQoL Measurement Tools

Child Oral Health Quality of Life Questionnaire

(Jokovic et al, 2000)

It was the first instrument specifically developed to assess the health-related quality of life of children with different oral and orofacial conditions. Prior to the development of the Child Oral Health Quality of Life Questionnaire (COHQoL), there were not many studies undertaken to assess the oral-health-related quality of life of children with oral and orofacial conditions. Most of the previous studies reported on generic pediatric tools used to assess the health-related quality of life. These generic OHRQoL tools did not specifically measure the impact of oral diseases and conditions on the quality of life of children. Also, as discussed previously in this literature review, most of the OHRQoL measures developed earlier were designed mainly for the adult and elderly populations and, therefore, their structure and content were not appropriate for use in children. Keeping this in mind, Jokovic et al (2000) developed the Child Oral Health Quality of Life Questionnaire (COHQoL) for use specifically for children with oral and orofacial conditions.

The COHQoL is a set of multi-dimensional scales that measure the negative impacts of oral and oro-facial diseases and disorders on the overall well-being of 6- to 14-year-old children, as well as their families (Jokovic et al, 2002, 2006). The COHQoL is comprised of the following:

i) A Parental Perception Questionnaire (PPQ),

ii) A Family Impact Scale, and

iii) Three age-specific Child Perception Questionnaires for children aged 6-7 years

(CPQ$_{6-7}$), 8-10 years (CPQ$_{8-10}$), and 11-14 years (CPQ $_{11-14}$), specifically.

The PPQ was designed to assess the parent's perceptions of their child's

OHRQoL, the Family Impact Scale (also to be completed by the parents) was designed to

assess the impact of the child's oral/orofacial condition on the family, and the three age-

specific Child Perception Questionnaires were designed to measure children's

perceptions of their OHRQoL (Jokovic et al, 2000).

Child Perception Questionnaire for children aged 11-14 years (CPQ$_{11-14}$)

The CPQ$_{11-14}$ is just one component of the COHQoL. It consists of 37 questions

that are organized into four health domains: oral symptoms, functional limitations,

emotional well-being and social well-being (Jokovic et al, *2000)*. A Likert-type scale is

used to record the response options: 'Never' = 0; 'Once/twice' = 1; 'Sometimes' = 2;'Often'

= 3; and 'Everyday/almost every day' = 4. Apart from the questions on the four health

domains, the CPQ $_{11-14}$ also contains two global ratings of the child's oral health and the

extent to which the oral/orofacial condition affects his/her overall well-being. They are

worded as follows:

   i)   Question: "Would you say that the health of your teeth, lips, jaws and mouth is..."
 Response options: range from 'Excellent' = 0 to 'Poor' = 4.

   ii) Question: "How much does the condition of your teeth, lips, jaws or mouth affect

        your life overall?"

Response options: range from 'Not at all' = 0 to 'Very much' = 4.

Both these ratings use a 5-point response format (Jokovic et al, 2002, 2003, 2006). Figure 2-2 shows the components and domains of the Child Oral Health Quality of Life Questionnaire (COHQoL). It includes the Child Perception Questionnaire (CPQ), the Parent Perception Questionnaire (PPQ), and the Family Impact Scale. The following domains are included in the CPQ and PPQ: oral symptoms, functional limitations, emotional well-being, and social well-being (Jokovic et al, 2000).
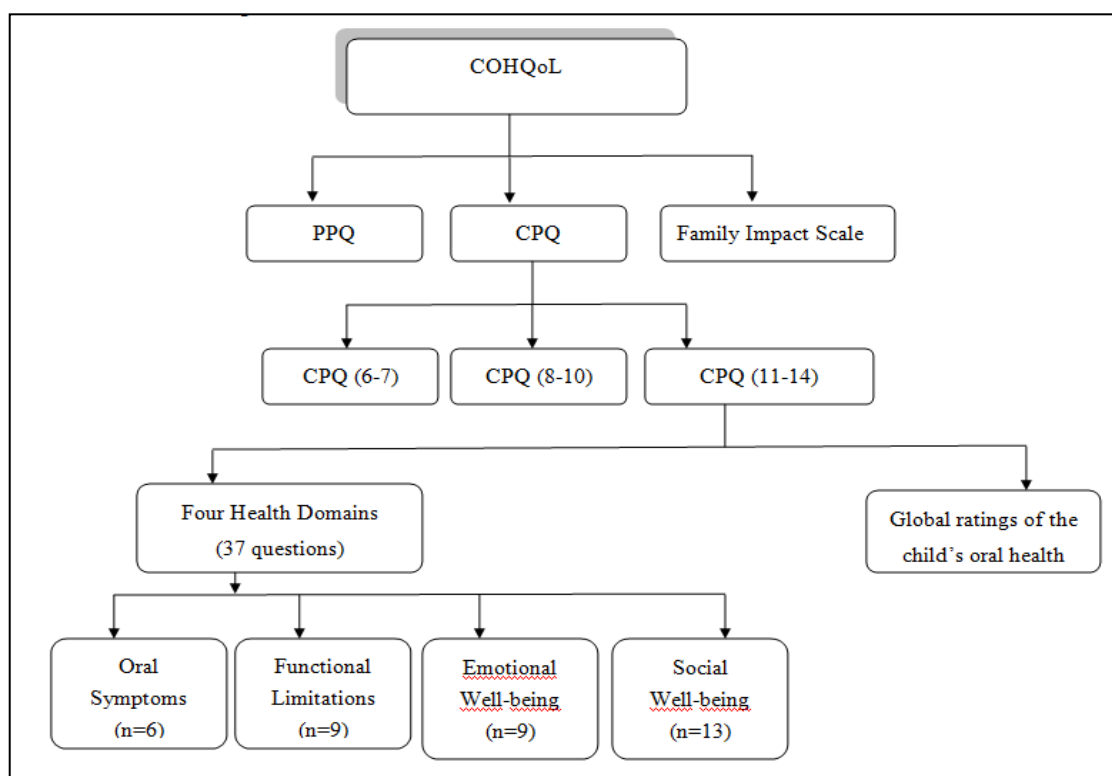
Figure 2-2. Child Perception Questionnaire (11-14): a component of the Child Oral Health Quality of Life Questionnaire

Development and Evaluation of the Child Perceptions Questionnaire (CPQ$_{11-14}$)

Study Background

Locker et al (2005) conducted an observational study in Toronto to develop and evaluate a tool for assessing the OHRQoL of children aged 11-14 years. In this study, a convenience sample of children aged 11-14 years was recruited from three clinical groups: clinics at the Faculty of Dentistry, University of Toronto, and The Hospital for Sick Children, Toronto, and clinics operated by Toronto Public Health Department. This study had two parts: i) the development of CPQ$_{11-14}$, its evaluation, and the assessment of its validity and reliability, and ii) the comparison of the health-related quality of life of children with orofacial and dental conditions.

Development of CPQ$_{11-14}$

A systematic multistage process was used to construct the CPQ$_{11-14}$ (Locker et al, 2005). This process was based on the theory of measurement and scale development (Streiner and Norman 1996, DeVellis 1991). The process for the development and evaluation of CPQ$_{11-14}$ was similar to that described by Guyatt et al (1986) and Juniper et al (1996) for the development of health-related quality of life (HRQoL) measures. Figure 2-3 describes this process, which began with an initial literature review to construct a preliminary pool of questions.
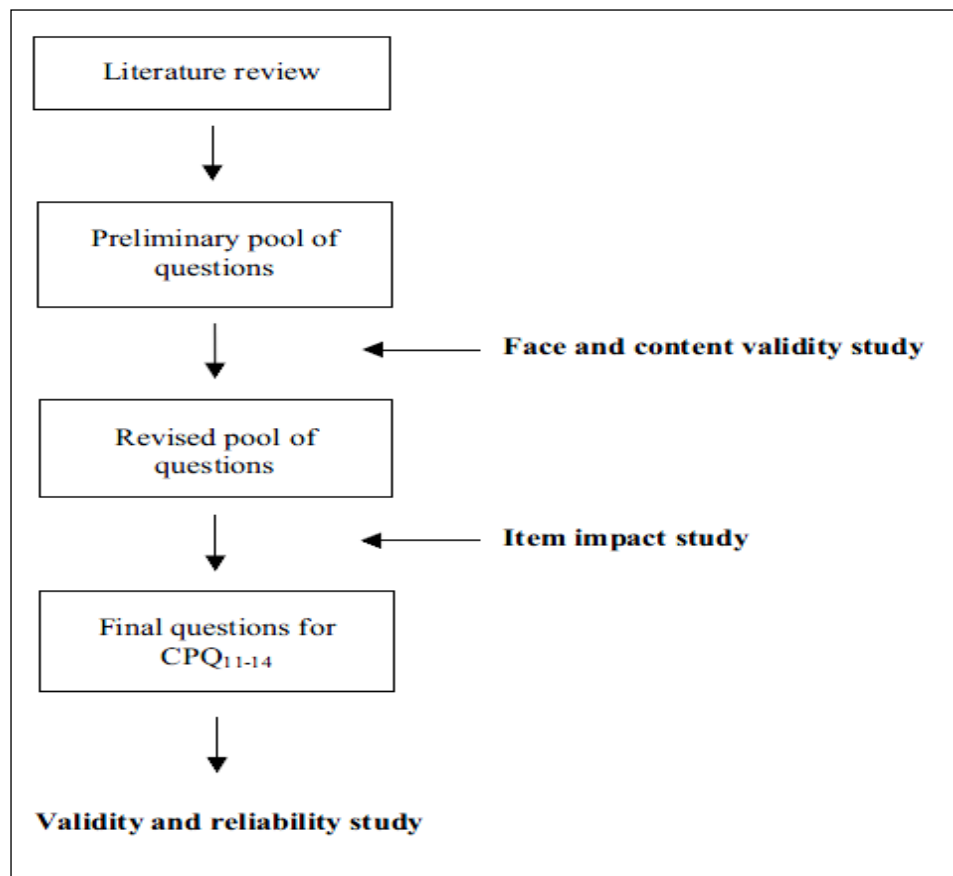
Figure 2-3.Schematic representation of the development of the long form $CPQ_{11\text{-}14}$ questionnaire (Jokovic et.al, 2006).

A review of existing patient-based oral health and child health outcome measures was conducted to develop this preliminary item pool (Locker et al, 2005). A face and content validity study then was conducted to assess the comprehensiveness and relevance of this preliminary set of questions (Locker et al, 2005). This question pool was revised based on the comments from interviews with health professionals who treat children with orofacial conditions, parents of children suffering from such conditions, and the child patients themselves (Locker et al, 2005). After this step, an item impact study was conducted to select the questions for the final questionnaire (Locker et al, 2005). The

purpose of this impact study was to identify items of most importance to the patient population in question. To collect data for the impact study, face-to-face interviews were conducted with 83 children from the three clinical groups defined above, and a questionnaire constructed from the modified item pool was administered. An impact score for each item was calculated by multiplying the percentage of children giving a positive response to the item by the mean importance rating of the item (Locker et al, 2005).

The items were ranked according to their impact scores for each of the three clinical groups (Locker et al, 2005). The final questionnaire consisted of items that were rated most frequently and as most bothersome. This entire process led to the development of a final questionnaire that consists of 37 items which fall into four domains: symptoms, functional limitations, emotional well-being, and social well-being. Each of these questions asks the child about the frequency of events during the previous three months. For example,

''Over the last 3 months, how often have you . . . been teased by other children . . . because of your teeth, mouth, lips, or jaws?'' The response options include: ''Never''= 0; ''Once or twice'' = 1; ''Sometimes'' = 2; ''Often'' = 3; ''every day or almost every day'' = 4.

Apart from these 37 questions that fall in the four domains/subscales mentioned above, the CPQ_{11-14} also consists of the following:

i) Global ratings of oral health, and

ii) The extent to which the oral or orofacial condition in question affected overall well-being (Locker et al, 2005).

The finalized items in the CPQ_{11-14} were tested for validity and reliability on a new sample of 123 children (Locker et al, 2005). An initial questionnaire was administered to these 123 children at their visits to the clinics, while the second copy was mailed two weeks later to a subgroup of 70 participants to be completed at home. The four domain scores and an overall scale score were calculated and used in assessments of construct validity and test-retest reliability (Locker et al, 2005).

The CPQ_{11-14} showed excellent construct validity, internal consistency, and test-retest reliability (Locker et al, 2004). Also, as none of the children scored zero or maximum scores, there were no floor or ceiling effects. The intraclass correlation coefficient (ICC) of the overall scale was 0.90 and ICC for the domains ranged from 0.79 to 0.88. Thus, it was concluded that the CPQ_{11-14} has excellent test-retest reliability. Figure 2-3 shows the schematic representation of the development of the long form CPQ_{11-14} questionnaire (Jokovic et.al, 2006).

<center>Comparison of the Oral Health-Related Quality of Life of
children with orofacial and dental conditions</center>

In addition to the development and evaluation of CPQ_{11-14} in the study by Locker et al (2005), this tool was also used to compare the OHRQoL of 32 children with dental caries and no other orofacial conditions with 39 children with oral and orofacial/craniofacial conditions. Data from the evaluation of the CPQ_{11-14} were used for this assessment. The two groups of children (i.e., the one with orofacial conditions only

and second one with dental caries and no other orofacial conditions) were compared for the following:

i) The overall and domain scores of children in the two groups,

ii) The magnitude of the differences between groups (effect size),

iii) Responses to individual items comprising the questionnaire, and

iv) Responses to the global ratings of oral health and overall well-being.

The orofacial group was found to have slightly higher scores on the CPQ_{11-14} as compared to the dental group (p<0.05) (Locker et al, 2005). It was observed that the orofacial group had slight to moderately higher scores on the functional limitations (p<0.01) and social well-being (p<0.01) domains, although there was no significant difference with respect to oral symptoms or emotional well-being between the two groups. The issues that were reported more frequently by the orofacial group (p<0.01) included: mouth breathing, speech problems, missing school, being teased, and being asked questions about their condition. Apart from these issues, no evidence of social inhibition or withdrawal was found in the orofacial group. The effect sizes were found to be moderate for the CPQ overall and domain scores. This was indicative of a smaller difference between the two groups relative to the variability within the sample as a whole. Also, it was observed that the children with orofacial conditions rated their oral health better than the children with dental decay on the two global ratings (p<0.05). Thus, the study concluded that there were few differences in the health-related quality of life (HRQoL) of 11- to 14-year-olds in the two study groups. This suggests that most of the children with orofacial conditions were well-adjusted to cope with the adversities

associated with their conditions, which may be as a result of the good quality team approach used at their care settings (Locker et al, 2005).

However, it's important to note that this study had a few limitations (Locker et al, 2005). The conclusions of this study are valid only if it is accepted that children being treated for dental caries are an appropriate comparison group (Broder, 2001). Also, as this study was descriptive only, it did not assess the factors that may account for the variation in the oral health-related quality of life within each of the two study groups (Locker et al, 2005).

Validation of the Child Perception Questionnaire:

(CPQ $_{11-14}$)

Background

The use of OHRQoL measures in children lagged behind that with adults, due in part to the difficulties that are associated with developing and validating such measures in children (Foster Page et al, 2005). Jokovic et al (2002) examined the validity and reliability of the CPQ$_{11-14}$ in a clinical convenience sample of 123 children recruited from among pediatric dentistry, orthodontic, and craniofacial patients in Toronto. However, the validity and reliability of the CPQ$_{11-14}$ was not tested at that time in other populations besides the convenience sample in the study by Jokovic et al (2002). Due to the lack of such studies in a more representative sample, the performance of the CPQ$_{11-14}$ remained uncertain and could not be generalized to other child populations which exhibit the full distribution of clinical presentations. Due to the bias associated with clinical samples, it is important to validate measures such as CPQ$_{11-14}$ at the population level. Clinical samples could give a misleading picture of the utility of such measures (Locker, 2000). Thus,

validation of the CPQ11-14 was conducted in a population-based sample in New Zealand (Foster Page et al, 2005).

Validation of the CPQ_{11-14} in a probability-based population

sample of 12- and 13-year-old New Zealanders

Researchers in New Zealand conducted a cross-sectional study in 2003 to examine the construct validity of the Child Perceptions Questionnaire (CPQ_{11-14}) in a population-based random sample of 12- to 13-year-old children (Foster Page et al, 2005). These children were enrolled with the Taranaki District Health Board's (TDHB) school dental service. A random sample of 600 children was selected based on power estimation. The consent documentation and two questionnaires were mailed to parents/caregivers of the sampled children: the Parent Perceptions Questionnaire (developed along with the CPQ_{11-14}, Jokovic et al, 2002), and a questionnaire which sought information on whether the child had received any orthodontic advice and/or treatment. Consent was obtained from both the parent and the child before proceeding further. The mailings yielded a total of 435 children who had parent/caregiver consent to be examined. The children completed the CPQ_{11-14} in the dental clinic waiting room just prior to the dental examination. Children with more severe malocclusions and those with greater dental caries experience were hypothesized to have higher (less favorable) overall and domain-specific CPQ_{11-14} scores (Foster Page et al, 2005).

The final sample consisted of 430 children who completed the CPQ_{11-14} and were assessed for malocclusion (using the Dental Aesthetic Index) and dental caries (using the DMFS index) (Foster Page et al, 2005). The Dental Aesthetic Index (Cons et al, 1986) was used to assess the 'relative social acceptability of dental appearance based upon

public perceptions of dental aesthetics' (Foster Page et al, 2005; Page no. 651). An overall CPQ_{11-14} score was computed by summing up all of the 37 item scores, and scores for each of the four domains (i.e., oral symptoms, functional limitations, emotional well-being and social well-being) were also computed. A distinct ascending gradient was observed in the mean CPQ_{11-14} scores by malocclusion severity. However, there were differences across the four domain subscales. The emotional well-being and the social well-being domains showed an ascending gradient in the mean CPQ_{11-14} scores by malocclusion severity, while the oral symptoms and the functional limitations domains did not. It was found that children in the worst 25% of the DMFS distribution (i.e., the top quartile of the DMFS distribution) had higher CPQ_{11-14} scores overall and also for each of the four subscales. Thus, it was concluded that the construct validity of the CPQ_{11-14} appears to be acceptable as children with more severe malocclusions or with greater dental caries experience showed higher overall scores for CPQ_{11-14}(Foster Page et al, 2005).

Short forms of the Child Perceptions Questionnaire for 11-
to 14-year-old children (CPQ_{11-14}): development and initial
evaluation

Jokovic et al (2006) conducted an observational study (n=83) in Toronto, Canada, to develop short forms of the CPQ $_{11-14}$ and to compare the content and properties (cross-sectional validity and reliability) of the short versions derived from this study, using the stepwise regression method and the item impact method respectively. The CPQ_{11-14} questionnaire was shortened to two separate short-form versions containing 16 and 8 questions, respectively. Two different analytic approaches (the item impact

method and the stepwise regression method) were used to create these two short form versions, thereby resulting in a total of 4 short-forms, two from each approach (Jokovic et al, 2006).

These short forms were created to broaden the application of the CPQ_{11-14} in clinical settings and population-based health surveys, as shorter forms reduce the time, financial and other costs of data collection (Jokovic et al, 2006). Also, short form questionnaires reduce the risk of total and individual item non-response associated with the longer version of the questionnaire (Jokovic et al, 2006).

Methods used to create short forms of CPQ_{11-14}

The following methods were used to create the short forms of CPQ_{11-14}:

a) Item Impact Method: The data collected from the CPQ_{11-14} item reduction study were used in the item impact method. This method selects the questions with the highest scores of OHRQoL in each domain (Jokovic et al, 2006).

b) Stepwise Regression Method: The stepwise regression method was applied to the data collected in the validity study for the CPQ_{11-14}. The dependent variable in the regression method was the overall CPQ_{11-14} score and the independent variables were the individual questions in the CPQ_{11-14} (Jokovic et al, 2006).

The measurement properties such as criterion validity, construct validity, internal consistency, reliability of what and test-retest reliability were evaluated using the data from the validity and reliability studies for the CPQ_{11-14} (Jokovic et al, 2006). It was found that the short forms detected substantial variability in children's OHRQoL. Strong, statistically significant correlations were observed between the short-form scores and CPQ_{11-14} scores (0.87-0.98; $p < 0.001$). It was concluded that the short forms

demonstrated excellent criterion validity and good construct validity. Also, the reliability

coefficients were found to exceed the standards for group-level comparisons. However,

the authors acknowledged that, as these findings are based on convenience sampling,

further testing is warranted to establish the measurement sensitivity and discriminative

properties of these questionnaires (Jokovic and Guyatt, 2006). Figure 2-4 shows the

approaches used to develop the short forms of the CPQ_{11-14} (Jokovic et al, 2006).
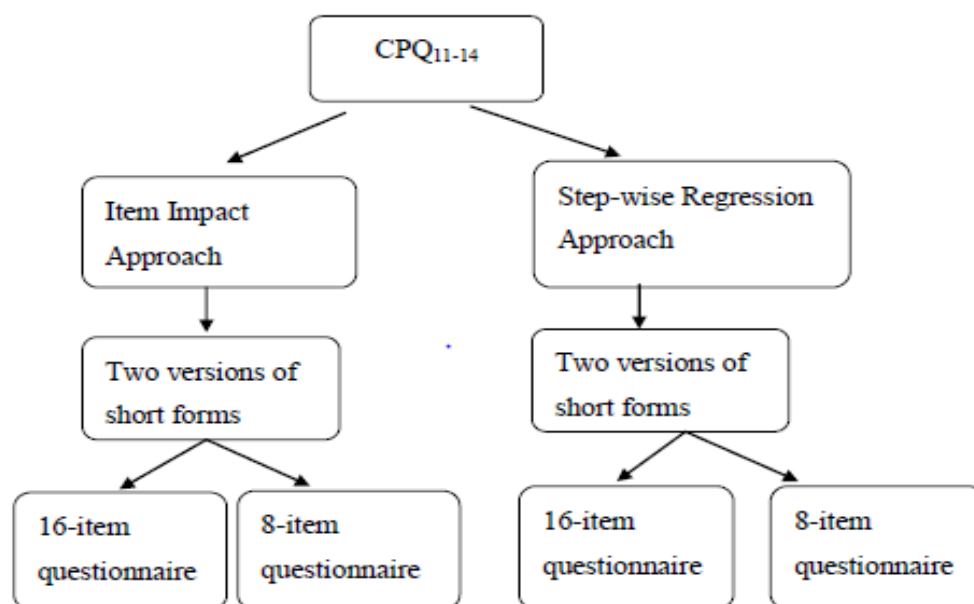
Figure 2-4. Short forms of the Child Perception Questionnaire (CPQ_{11-14}).

Section Summary

The Child Perceptions Questionnaire for children aged 11–14 years (CPQ$_{11-14}$) was developed in Toronto as a measure of OHRQoL for children ∕ adolescents (Jokovic et al, 2002). It included 37 items organized into four health domains, i.e., oral symptoms, functional limitations, emotional wellbeing, and social well-being. It was later shortened to 16-item and 8-item short forms using the item impact approach (i.e. ISF: 16 and ISF: 8 respectively) and stepwise regression approach (i.e.RSF:16 and RSF: 8 respectively) to reduce the burden on the participants (Jokovic et al, 2006).

Specific Literature Review

In this section, specific studies pertaining to oral health related quality of life are reviewed under the following sections: i) studies that measured the association between oral health-related and general health-related quality of life, ii) studies that related OHRQoL to dental caries and dental fluorosis, iii) Studies that related OHRQOL measurements to orthodontic factors, iv) other qualitative methods/ assessments besides QOL (Web-based digital imaging studies)

Studies that assessed the association between oral health-related and general health-related quality of life

Zimmer et al (2009) evaluated the general HRQoL and OHRQoL of patients attending dental offices in Germany in 2006. A total of 10,342 dental offices were randomly selected from a data set of 45,000 dental offices representing 97.4 percent of all dental offices in Germany. Of these, only 1,113 offices (or 11%) consented to participate. These offices received 20 questionnaires to be filled in by a convenience sample of patients 14 years and older. The questionnaire included the OHIP-14-form (John et al,

2002) for OHRQoL, as well as the German version of the SF-12-form (Bullinger et al, 1998) for general HRQoL (GHRQoL). The questionnaires were to be completed (anonymously) and sent back in a prefabricated closed envelope reword to the Department of Operative and Preventive Dentistry and Endodontics of the Heinrich-Heine University, Germany, for analysis. A reminder mailing was sent to the dentists if no answer was received 6 weeks after sending the questionnaires (Zimmer et al, 2009)

The SF (Short Form)-36 health survey is an instrument used to measure general health-related quality of life (Zimmer et al, 2009). It is comprised of 36 items of subjective health in eight dimensions. The SF-36 was translated into a German version and validated. For the purpose of this study, a 12-item short version of SF-36, the SF-12 was used. Based on the SF-12 data, physical (PCS) and mental (MCS) component scores were calculated as described by Bullinger and Kirchberger (5). The higher the physical and mental component scores are, the better is the quality of life (Zimmer et al, 2009)

The Oral Health Impact Profile (OHIP) is an instrument used to measure oral health-related quality of life (Zimmer et al, 2009). The original questionnaire consists of 49 questions, but for this study a short version, OHIP-14, comprised of 14 questions, was used. The frequency scale for OHIP-14 ranges from 0 (never) to 4 (very often). Consequently, the summary score ranges from 0 (best condition, no complaints) to 56 (worst condition, maximum number of complaints) (Zimmer et al, 2009).

A total of 12,392 completed questionnaires were analyzed (Zimmer et al, 2009). The mean summary score of OHIP-14 was 6.30 (SD 7.46). The mean physical component summary scale (PCS) of the SF-12 was 51.15 (SD 7.23) and the mean mental component summary scale (MCS) was 50.17 (SD 8.55). The variance of PCS and MCS

could be explained to 10 percent each by oral health-related quality of life ($r^2 = 0.095$

and 0.101, $P < 0.001$). A statistically significant positive correlation was found between

OHRQoL and GHRQoL. Pearson's correlation coefficients (r) were 0.30 (PCS) and 0.32

(MCS) ($P < 0.001$) (Zimmer et al, 2009).

Based on the results from this study, it was concluded that OHRQoL is

considerably related to GHRQoL (Zimmer et al, 2009). However, these results should be

interpreted with caution, as the study sample was a convenience sample of patients

attending dental offices in Germany and also due to cross-cultural variations, it may not

be appropriate to extrapolate these results to other populations (Zimmer et al, 2009).

Studies that assessed the association between dental

fluorosis and OHRQoL

Introduction

Dental fluorosis occurs due to the hypomineralization of dental enamel and can

cause changes in the appearance of dental enamel that can manifest with various degrees

of severity. Fluorosed teeth may appear to be discolored (opaque white areas present) and

in severe cases may even exhibit pitting of the enamel surface. Based on the NHANES

data from 1999-2004, of all the age groups, dental fluorosis was most prevalent among

children aged 12-15 (40.7%). Most of the children had very mild (28.5%) and mild

fluorosis (8.6%), and only 3.6% had severe fluorosis (Beltran-Aguilar et al, 2010).

However, there has been an increase in the prevalence of fluorosis in this age group since

1986-1987, when it was 22.6%. Mild forms of fluorosis can impact an individual's

perception of the color of their teeth while severe fluorosis can cause functional

limitations.

Review of specific studies that related fluorosis to OHRQoL

Oral health-related quality of life is affected both by oral conditions and individual perceptions [Astrom and Moshoto (2002), Shulman et al (2004), Do and Spencer (2007), Agou et al, 2011]. Clark et al (1993) studied the esthetic concerns of children and parents in relation to their fluorosis status in two communities in British Columbia: a fluoridated community and a non-fluoridated community. It was a cross-sectional/retrospective investigation. The main aim of this study was to ascertain if the extent of esthetic perceptions posed any public health concern. The principles of stratification and random selection were used to choose the participating schools from the two communities. The total number of eligible children in these schools was 3,126. From this total population, 1,131 children were examined and had questionnaires completed and returned by parents. For children who had consistent residence histories for the first 6 years of life, telephone confirmation for lifelong residence histories were made. Children with mixed residence histories were excluded from the analysis. The 1,057 remaining children were categorized into various subsets, depending upon their exposures to various home and community fluoride sources (Clark et al, 1993).

The clinical examiners used the Tooth Surface Index of Fluorosis (TSIF) (Clark et al, 1993). A standard dental light was used to examine the subjects and the teeth were not air-dried prior to application of the TSIF. No standard assessments of reliability or validity were reported and there were neither examiner nor peer ratings. Questionnaires were sent to the parents through their children. Through these questionnaires, the child's exposures to fluoridated water, infant formula, fluoride supplementation, and fluoride dentifrice during the first six years of life were determined. The study concluded that, for

some children with TSIF scores ranging from "4" to "6 ", esthetic problems were of concern both to parents and children. For children with TSIF score "1", both child and parental ratings suggest rare problems specifically due to dental fluorosis. Even for children with TSIF scores of "2" and " 3 ", only a few cases were observed to have esthetic problems in the presence of dental fluorosis. Out of the 681 children with dental fluorosis, only 19, or 3% of the children, indicated that they perceived an esthetic problem with their teeth. This is likely in part due to the relatively low severity of fluorosis in North America (Clark et al, 1993).

The extent of the public health problem posed by fluorosis and its impact on the quality of life depends largely on the fluoride level of water found in different geographic locations, as some places have high naturally occurring fluoride in drinking water and thus the prevalence of fluorosis in such places may be high, with esthetic concerns being more severe, especially if the fluoride content in drinking water is not optimized. The fluorosis found in North America is mainly mild or very mild, with very few cases of severe fluorosis, so it is rarely an esthetic concern (Shulman et al, 2004).

In fact, Do and Spencer (2007) observed mild fluorosis to be associated with more positive oral health- related quality of life. The main objective of their study was to evaluate the impact of dental caries and fluorosis on the OHRQoL of children. The study sample was randomly chosen from the South Australian school dental service population, and children were 8 to 13 years old. The study sample was nested in a larger population-based study of the South Australian (SA) school dental service (SDS) population. The participants were recruited from metropolitan, fluoridated Adelaide and three other regional non-fluoridated towns in South Australia .Out of the 677 children with fluorosis

examination, 654 parents completed the PPQ, while 304 eight to ten years old children completed the CPQ_{8-10} and 334 eleven to fourteen years old children the CPQ_{11-14} respectively (Do and Spencer, 2007).

Caries data were collected from school dental service records and children were grouped by combined deciduous and permanent tooth caries experience (Do and Spencer, 2007). Children were examined for fluorosis using the Thylstrup and Fejerskov (TF) Index (Fejerskov et al, 1988) and were grouped according to their fluorosis scores on maxillary central incisors. Their occlusal traits were assessed using the Dental Aesthetic Index (Cons et al, 1986). Children completed the Child Perceptions Questionnaire (CPQ) and a global rating of oral health (OH), while their parents completed the Parental Perceptions Questionnaire (PPQ) and a global rating of oral health (OH) of their children. OHRQoL indicators and the mean overall CPQ/PPQ scores were compared between groups, by fluorosis scores and caries experience (Do and Spencer, 2007).

The CPQ domain scores were not directly comparable as they were collected using different reference periods for the two age groups: 4 weeks for the 8-10-year-olds and 3 months for the older group (Do and Spencer, 2007). Therefore, these scores were analyzed separately. This reduced the sample size for analyses that involved child domain scores (Do and Spencer, 2007).

The CPQ and PPQ responses were used to calculate mean domain scores and overall CPQ and PPQ scores (Do and Spencer, 2007). The percentage of respondents who perceived their (or their child's) oral health as 'Excellent' or 'Very good' was used as another indicator of OHRQoL. These two indicators of OHRQoL were compared between children grouped by caries experience, fluorosis scores, and DAI categories in a

bivariate analysis. Analyses were also done using multivariable models for both OH and CPQ/PPQ indicators. The three clinical indicators (i.e. CPQ, PPQ, and OH) were included as independent variables in multivariate models for the OHRQoL. The multivariable models also included other controlling factors like socioeconomic indicators, such as sex, age, urban/rural residence, parental education, and household income (Do and Spencer, 2007).

The proportion of children/parents who rated OH as Excellent/Very good was significantly associated with their children's caries experience (Do and Spencer, 2007). Also, this proportion increased when fluorosis severity increased from a TF score of 0 to 2, but decreased with a TF of 3.The study findings indicated that tooth staining caused by fluorotic lesions is perceived both by the children and their parents and this perception was more obvious with TF scores of 2 or 3. Also, a significant proportion of children who were diagnosed as not having dental fluorosis perceived their teeth as stained or their parents perceived the child's teeth as stained. This suggests that numerous other conditions contribute to tooth discoloration besides fluorosis. Children who had a TF score of 1 were actually more likely to perceive their teeth as 'Attractive' or 'Very attractive' compared with children with a TF score of 0 or 2-3. This suggests that severe fluorosis (a TF score of 3 and higher) may have a negative association with OHRQoL. Thus, it was concluded that caries experience and less acceptable appearance (based on DAI) had negative associations with the perception of oral health of children, while mild fluorosis had a positive impact on both child and parental perception of OHRQoL (Do and Spencer, 2007).

However, the authors acknowledged few limitations to this study (Do and Spencer, 2007). First, as they examined the association of caries and fluorosis concurrently, it might have reduced the ability to detect statistical significance of the association between OHRQoL and caries. Secondly, as caries and fluorosis were used as ordinal variables in the analysis, it may have reduced the power of the analysis to detect statistical significance. There is also a possibility of recall bias as young children (8-10 years-old) may be less likely to recall events related to caries experience (Do and Spencer, 2007).

However, as the study sample was drawn from a larger multistage, stratified random sample of children, therefore, it allowed for extrapolation of these results to a greater population and made the study findings more generalizable (Do and Spencer, 2007). Also, the use of a moderately large sample in this study increased the study's power (Do and Spencer, 2007).

In contrast to this, in developing countries where severe fluorosis is sometimes more prevalent, the quality of life may be significantly affected by the disfiguring and disabling impacts of severe dental fluorosis (Mwaniki et al, 1994 and Tobayiwa et al, 1991).

Astrom and Moshoto (2002) studied children's perceptions of their oral health status among first-year secondary school students from Arusha, Tanzania, where dental fluorosis is endemic. They then explored the relationship of these esthetic perceptions with clinically assessed dental fluorosis. Based on convenience, they selected four secondary schools for this study. A total of 478 students (mean age 15.7 years) completed the questionnaires. For the clinical examinations, 461 clinical photographs of the

maxillary central incisors were taken under field conditions and were rated under standard laboratory conditions. The severity of dental fluorosis in the permanent maxillary central incisors was assessed using the Thylstrup & Fejerskov Index (TFI) (Astrom and Moshoto, 2002).

The prevalence of dental fluorosis at TFI score ≥ 2 was 74% and 42% children had severe dental fluorosis, with TFI score ≥ 5 (Astrom and Moshoto, 2002). Dissatisfaction with dental appearance was reported by 58% of boys and 68% of girls ($P < 0.05$). It was concluded that that dental fluorosis impacts negatively on the functional, social and psychological well-being of secondary school children in Arusha (Astrom and Moshoto, 2002).

The study concluded that social and personal factors are also important in determining the responses of school children to oral conditions and dental appearance (Astrom and Moshoto, 2002). Similar observations were also reported by Agou et al (2011), who found that children with better psychological well-being tend to report better OHRQoL. Thus, it can be said that individual perceptions and psychological factors have an impact on a person's quality of life (Astrom and Moshoto, 2002).

In a study by Shulman et al (2004), it was found that esthetic perceptions of dental appearance differ amongst dentists, parents and children. Therefore, all of them see the potential outcome of the esthetic treatment differently. Though some studies have examined differences in parents', children's and dentists' perceptions of tooth color and malocclusion, only a few have attempted to look for covariates that could explain the reason for such differences in opinion. Shulman et al (2004) conducted this observational study in order to better understand the esthetic perceptions of dentists, parents and

children in North America. The study sample was nested in a large-scale fluoridation cessation study, the British Columbia Fluoridation Cessation Study. Four standardized examiners assessed 8,281 children who were in grades two, three, eight and nine, for dental fluorosis using the TF index. The analysis was mainly focused on 2,495 subjects for whom there was complete set of data (from parent, subject, and dentist) and other data for age, sex, TFI and the reason why the subject was dissatisfied with tooth color. The examiners were blinded to data concerning parent's esthetic rating of their child's tooth color and fluoride history (Shulman et al, 2004).

It was observed that, out of the 2,495 subjects analyzed, 62.0 percent, 19.8 percent, 13.3 percent and 4.3 percent had TFI scores of 0, 1, 2 and ≥ 3, respectively (Shulman et al, 2004). Also, it was found that 31.6 percent of subjects were dissatisfied with their tooth color, while 19.2 percent of parents expressed dissatisfaction with their children's tooth color. On the other hand, dentists felt that only 8.5 percent subjects had unsatisfactory tooth color. This study highlights that the esthetic perceptions of children, parents and dentists vary. Therefore, it reinforces that it is very important for the dentist to ensure that parents, children, and the dentist are all on the same page during treatment planning and have similar expectations for the treatment (Shulman et al, 2004).

Section Summary

Based on the review of the studies that related OHRQoL to dental fluorosis, it can be conferred that severe dental fluorosis (TF score ≥ 3) has a negative impact on the OHRQoL of adolescents, while mild fluorosis (TF score= 1) actually may have a positive impact on their OHRQoL. Thus, it is a bigger concern in geographic locations with a high prevalence of severe fluorosis, as compared to places where only mild to moderate

fluorosis is prevalent. But it still has an important public health implication for countries with prevalence of mild to moderate fluorosis, as they must maintain an optimum balance to benefit from the protective effect of fluoride. Fluoride acts a double edged sword, as administering fluoride in the right proportion protects dental caries, (which in itself can negatively impact OHRQoL if untreated) but at the same time, over-use of fluoride (from various sources) may lead to severe fluorosis, which is an important esthetic concern and can impact the OHRQoL of an individual Thus, prudent use of the various fluoride modalities is very important.

Also, it is important to assess the impact of dental caries and dental fluorosis on the OHRQoL of an individual and clinical measures alone are not sufficient in assessing this impact. This emphasizes the use of self-reports or questionnaires that aid in assessing the impact of dental caries and fluorosis on the OHRQoL of individuals.

Studies that related OHRQoL to dental caries

Dental caries can be very stressful as they can cause pain, discomfort, inability to concentrate, and even lead to absence from school or work. Furthermore, the financial burden posed by dental treatment can be stressful for the family of the patient. Even though there have been improvements in the oral health of the U.S. population over the past few decades, however, dental diseases such as caries continues to affect people and impact their lives. Dental caries affects about half of U.S. children aged 12-15 years and about 20% of U.S. adolescents aged 12-19 years have untreated decay (Centers for Disease control and Prevention, 2011). Some studies have reported an association between dental caries and OHRQoL. Some of the studies that assessed the impact of

dental caries on the OHRQoL of children and adolescents have been discussed in this section.

Do and Spencer (2007) assessed the impact of dental caries, dental fluorosis (discussed in the previous section), and malocclusion (as indicated by the Dental Aesthetic Index) in 8- to 13-year old Australian children (Do and Spencer, 2007). The dependent variables included two OHRQoL indicators: i) the mean overall CPQ/PPQ score, and ii) the percentage of respondents who perceived their or their children's oral health as excellent or very good (global oral health rating). Based on the bivariate analyses, it was reported that, as caries experience increased, there was a gradual decrease in the proportion of respondents (both parents and children aged 8-to 13-years) who perceived their/their children's oral health as excellent or very good ($P < 0.05$) (Do and Spencer, 2007).

For multivariable analyses, both linear regression and logistic regression were used (Do and Spencer, 2007). Three linear regression models were generated for the overall CPQ/PPQ scores (one for parents and one each for children aged 8-10 years and 11-13 years) (Do and Spencer, 2007). In addition, two logistic regression models were generated for the percentage of respondents who perceived their or their children's oral health as excellent or very good (one for parents and one for all the children combined) (Do and Spencer, 2007).

Based on the linear regression model, greater caries experience (having 3-4 surfaces with caries experience) was found to be significantly associated with higher CPQ scores (reported by 8- to 10-year old children) (Do and Spencer, 2007). The CPQ_{8-10} scores of children (8-10 years old) with caries experience on 3-4 tooth surfaces were 3.36

units higher as compared to children (8-10 years old) who had no caries experience (unstandardized coefficient = 3.36, P<0.05). However, no significant associations were reported between caries experience and PPQ/CPQ$_{11-14}$ scores, based on the linear regression models (Do and Spencer, 2007).

In addition, based on the logistic regression model, having 5+ tooth surfaces with caries experience was associated with significantly lower odds for parents to perceive their child's oral health as excellent or very good compared with the odds for parents whose children had no caries experience (Do and Spencer, 2007). For parents whose children had 5+ tooth surfaces with caries experience, the odds for perceiving their child's oral health as excellent or very good were 0.32 times as great as compared to parents whose children had no caries experience (OR= 0.32, 95% CI: 0.19-0.53) (Do and Spencer, 2007). Thus, it was concluded that caries experience has a negative association with the OHRQoL of children (Do and Spencer, 2007).

Robinson et al (2005) conducted a cross-sectional study to assess the OHRQoL among a group of 12-year old children in rural Uganda and compared the impacts of dental caries and fluorosis on the OHRQoL of the study participants. Clinical and questionnaire data were available from 174 children, out of the 200 children who were approached. Clinical examination was done using the WHO basic methods and the TF index of fluorosis. The OHRQoL data were collected using the self-administered CPQ$_{11-14}$ questionnaire. The CPQ$_{11-14}$ data were summarized in three ways: i) the total score was calculated as the sum of responses to all the items in the questionnaire, ii) the number of dental impacts experienced by each child 'often' or 'everyday' was recorded, and iii) the

prevalence of impact: the number of children recording one or more impacts at the same threshold (Robinson et al, 2005).

The mean DMFT was 0.68, the man total CPQ_{11-14} score was 25.8 (standard deviation, 1.1) (Robinson et al, 2005). Two-thirds of the study subjects reported having a dental impact 'often' or 'everyday'. About 76% of children showed no signs of dental fluorosis. The authors reported a significant association between lower OHRQoL and dental caries experience in the study participants. They reported dental caries experience to be associated with higher CPQ_{11-14} total scores (P < 0.01), thus suggesting a negative association between dental caries experience and OHRQoL. The mean CPQ_{11-14} total scores for children with caries experience (DMF>0) were significantly higher (mean CPQ = 32.5, 95% CI: 27.5-37.5) as compared to the mean CPQ_{11-14} total scores for children with no caries experience (mean CPQ=21.9, 95% CI: 18.2-25.6) (t-test P-value <0.01). Thus, it was concluded that the study participants experienced appreciable impacts on their OHRQoL, despite the low prevalence of oral disease in the study sample and dental caries was associated with poor OHRQoL. (Robinson et al, 2005).

Barbosa et al (2013) evaluated the association between oral conditions, masticatory performance (MP), and oral health-related quality of life (OHRQoL) in 8- to 12-years old children in Brazil. The purpose of their study was to assess the associations between dental caries experience, malocclusions, MP parameters and OHRQoL in the study participants. Consent forms were distributed to 300 students attending four public schools in Brazil. The authors received consent for participation from 210 parents/guardians. Sixty children were excluded because they did not fulfill all examinations. Finally, 150 public school students (74 boys and 76 girls) participated in

the study. The study participants belonged to very low economic class and their mothers had limited schooling. Dental caries and malocclusions were examined in accordance with World Health Organization (WHO) criteria (Oral health surveys: basic methods, World Health Organization; 1997) (Barbosa et al, 2013).

Based on the multiple linear regression models, the authors reported higher number of decayed (β=0.245, P=0.017) and missing teeth (β=0.318, P=0.002) to be significantly associated with higher CPQ_{8-10} scores (suggesting worse OHRQoL), even after controlling for confounding factors. Thus, they concluded that children with more caries tend to rate their OHRQoL less favorably (Barbosa et al, 2013).

Castro et al (2011) also reported similar findings among 11- to 12-year-old school children (n=571) in Brazil. They conducted a cross-sectional study to assess the association between OHRQoL, measured through the Child-OIDP (Child Oral Impacts on Daily Performance/Child-OIDP) (Gherunpong et al, 2004), and demographic characteristics, self-reported oral problems, and clinical oral health measures, among 11- to 12-year-old school children in Brazil. Stratified cluster sampling technique was used to obtain a probabilistic sample (Castro et al, 2011).

Bivariate analyses were done to compare the mean Child-OIDP scores between clinical groups and sexes using the Mann–Whitney–Wilcoxon-test (Castro et al, 2011). Multivariable analyses were conducted using a logistic regression model, with the Child-OIDP index as the dependent variable in a dichotomous form (Child-OIDP = 0 versus Child-OIDP > 0). The independent variables such as sociodemographic characteristics, clinical oral characteristics, and self-reported oral problems were explored and the inclusion criterion of P < 0.20 was used for including the independent variables in the

multivariable model. In addition, a multinomial logistic regression was generated to distinguish among the explanatory factors of being in the five different levels of Child-OIDP score (dependent variable). The absence of impacts (Child-OIDP = 0) was set as the reference category, followed by the first quartile (index > 0–2), the second quartile (index > 2–4), the third quartile (index > 4–7), and the fourth quartile (index >7–37) (Castro et al, 2011).

The mean Child-OIDP index was 7.1 (95% CI from 6.2 to 8.1) and it was higher in girls (mean = 7.7) than in boys (mean = 6.2) (P < 0.001) (Castro et al, 2011). The presence of at least one impact was found in 91.2% of the girls and 85.0% of the boys (P = 0.04). Also, based on the bivariate analyses, OHRQoL was found to be significantly associated with dental caries experience (DMFT + dmft), presence of thick dental biofilm, presence of enamel defects, and dental trauma (Castro et al, 2011).

Based on the logistic regression model, the Child-OIDP was found to be significantly associated with dental caries experience (DMFT + dmft > 0), and with the perception of sensitive teeth, perception of gingival bleeding, and perception of inadequate position of the teeth (Castro et al, 2011). The odds of having poor OHRQoL were 2.2 times as great in children with dental caries experience as compared to children with no dental caries experience (OR=2.2, 95% CI: 1.1,4.5, P=0.03) (Castro et al, 2011).

In the multinomial regression, the odds of having higher levels of Child-OIDP score were found to be positively associated with dental caries experience (DMFT) (Castro et al, 2011). Specifically, based on the multinomial model, being in the highest quartile of Child-OIDP was found to be significantly associated with the presence of biofilm and DMFT (P≤0.05) (Castro et al, 2011). Thus, the authors concluded a

significant association between dental caries experience and the OHRQoL (assessed using the Child-OIDP index) of the 11- to 12-year-old study participants (Castro et al, 2011).

Section Summary

Most of the studies assessing the impact of dental caries on the OHRQoL of children and adolescents have reported significant associations (Do and Spencer, 2007; Robinson et al, 2005; Barbosa et al, 2013; Castro et al, 2011; Arrow, 2013; Bastos et al, 2012; Martinis et al, 2012).

Studies that related OHRQOL measurements to orthodontic

factors

Many studies have been conducted in the past to understand the connection between malocclusion/orthodontic treatment and OHRQoL. It has been observed in these studies that young children and their parents have higher expectations for better appearance and improved social interactions as an outcome of orthodontic treatment as compared to merely restoring improved oral function (Tung and Kiyak, 1998; Reichmuth et al, 2005; Ostler and Kiyak, 1991). Locker et al (2007) found a significant relationship between OHRQoL measures and children's' self-rating of their oral health. Do and Spencer (2008) conducted a cross-sectional study (discussed in detail previously) to examine the association between the presence of unacceptable occlusion (assesses using DAI) and oral health-related quality of life (OHRQoL) among children and their parents in South Australia. They found unacceptable occlusion to be associated with the emotional and social well-being domains of the child oral health-related quality of life scale (COHQoL), among the 8- to 10-year-old children and their parents.

However, there have been conflicting results from different studies. While a few studies have found orthodontic treatment to improve the OHRQoL (Oliviera and Sheiham, 2004 ;Vig et al,2007), others have concluded that there is no discernible long-term effect of malocclusion on patients' self-esteem and QoL, and that psychological well-being is not positively impacted by orthodontic treatment (Shaw et al,2007).

Oliveira and Sheiham (2003) conducted a cross-sectional study to assess the impact of orthodontic treatment on the oral health-related quality of life in Brazilian adolescents. A two-stage sampling method was used to select a random sample of 1675 adolescents from 21 public and private secondary schools in Bauru-SP, Brazil. Based on the history of orthodontic treatment, the subjects were divided into three groups: treated, currently under treatment, and untreated. Adolescents were clinically examined for orthodontic treatment need using the Index of Orthodontic Treatment Need (IOTN) (Brook and Shaw, 1989). The adolescents' oral health-related impacts were assessed using two oral health-related quality of life measures, namely the Oral Impacts on Daily Performance (OIDP) (Adulyanon et al, 1996) and the shortened version of the Oral Health Impacts Profile (OHIP-14) (Slade, 1997). Multiple logistic regression was used to examine the association between orthodontic treatment status and overall oral health impact.

It was found that the adolescents who had completed orthodontic treatment had fewer oral health-related impacts compared to the other two groups (Oliveira and Sheiham, 2003). They were 1.84 times (95% CI 1.30 to 2.62) less likely to have an oral health impact on their daily life activities than adolescents currently under treatment or 1.43 (95% CI 1.01 to 2.02) times less likely than those who never had treatment. The

study concluded that orthodontic treatment can reduce the oral health impacts among adolescents. However, it may have a negative impact on the quality of life of the adolescent during the treatment duration (as corroborated by other study findings like Feu et al, 2010 discussed later).Therefore, orthodontists should be aware of the negative impact caused during the treatment duration and often remind patients of the positive outcomes that shall follow (Oliveira and Sheiham, 2003).

In a recent cross-sectional study by Feu et al (2010), the impact of orthodontic treatment-seeking on the oral health-related quality of life (OHRQoL) of 12 to 15 year-old Brazilian adolescents was evaluated. Two study groups were assessed: the first group included 12-15 year olds who were scheduled for orthodontic treatment evaluation (at the Department of Orthodontics of Rio de Janeiro State University in 2006) and a comparison group of age-matched peers (from a nearby public school) who had never undergone or had not sought orthodontic treatment. The final sample consisted of 194 subjects, 102 in the orthodontic group and 92 in the comparison group. Similar conditions were used to examine the students in the comparison group (at their school's dental office) by the same orthodontist examiner.

Data collection was done through interviews, self-administered questionnaires, and clinical evaluations performed by an orthodontist (Feu et al, 2010). The Brazilian version of the short form of the oral health impact profile (OHIP-14) was used to assess OHRQOL and the index of orthodontic treatment need (IOTN) was used to assess malocclusion severity. The oral health impact profile (OHIP) (Slade and Spencer, 1994) and its short form (OHIP-14) are widely used instruments, that have been designed to measure the impact of dental outcomes on oral health-related quality of life of

individuals. The items in the original instrument as well as its short form are grouped into

7 domains: functional limitation, physical pain, psychological discomfort, physical

disability, psychological disability, social disability, and handicap (Slade and Spencer,

1994; Slade, 1997). The 14 items on this questionnaire have ordinal responses that are

coded from 0 ('never') to 4 for ('very often'). The composite score (0 to 56) was obtained

by summing up all 14 ordinal responses. Higher scores indicated poorer OHQOL.

The dental health component (DHC) and the esthetic health component (AHC) of

the index of orthodontic treatment need (IOTN) (Brook and Shaw, 1989) were used to

assess malocclusion severity and orthodontic esthetic impairment, respectively (Feu et al,

2010). The IOTN-AHC scores range from 1 to 10 and the IOTN-DHC scores range from

1-5.Subjects with IOTN-AHC scores greater than 5 were considered to have an esthetic

orthodontic treatment need and subjects with IOTN-DHC scores greater than 3 were

considered to have an objective orthodontic treatment need (Mandall et al,2005).

The data were analyzed using simple and multiple stepwise regression analyses

(Feu et al, 2010). Chi-square tests of symmetry and t tests were also used to evaluate the

effects of esthetic impairment, malocclusion severity, sex, age, and socioeconomic status

on OHRQoL. Simple and multiple logistic regression analysis showed that subjects who

sought orthodontic treatment reported worse OHQOL as compared to the subjects in the

comparison group (P< 0.001). In addition, the children in the orthodontic group had more

severe malocclusions as shown by the IOTN (P = 0.003) and greater esthetic impairment,

both when analyzed by the orthodontist (P = 0.008) and by self-perception (P < 0.0001).It

was found that adolescents from the orthodontic group were 3.1 times as great to have

negative impacts on their quality of life. Also, children with severely compromised

esthetics or higher esthetic score (IOTN-AC examiner scores) were 3.9 times as great to have negative impacts, independent of other variables. Thus, it was concluded that adolescents who sought orthodontic treatment had more negative OHRQOL than those who did not seek orthodontic treatment. The study also concluded that severely compromised esthetics was a better predictor of poor OHRQOL than seeking orthodontic treatment (Feu et al, 2010).

Though some studies suggest poor dental esthetics to be a predictor for poor OHRQoL, however, it is also important to realize the impact that an individual's self-esteem can have on her OHRQoL. High self-esteem may boost a person's confidence in general and give them a more positive outlook towards life. Such a person may not be as affected by their appearance as someone with a low self-esteem, as individuals with low self-esteem tend to be more self-conscious and apprehensive of their looks and personality. People with low self-esteem may be more bothered by their facial and dental appearance as well.

In 2008, a group of researchers from Canada (Agou et al) conducted a cross-sectional study of children aged 11 to 14 years to assess the impact of self-esteem on the oral-health-related quality of life of children with malocclusion. The study participants (192) were recruited using a convenient consecutive sampling approach at the Faculty of Dentistry, University of Toronto, in Canada (Agou et al, 2008). The subjects filled out self-administered questionnaires: the CPQ11-14 and the self-esteem subscale of the child health questionnaire (CHQ-CF87), before the treatment. Other covariates that were recorded included: age, sex, and ethnic background.

The CPQ 11-14 (discussed in detail previously) is a child OHRQoL instrument that consists of 37 items, grouped into 4 domains: oral symptoms (OS), functional limitations (FL), emotional well-being (EW), and social well-being (SW) (Jokovic et al, 2002). The self-esteem (SE) sub-domain of the CHQ-CF87 was used to measure the SE of the participants in the study. The CHQ-CF87 is an 87-item child form designed for adolescents aged 10 to 17 years (Landgraf, Abetz, and Ware, 1996). It is a widely used and validated, generic self-report health related quality of life instrument. It includes 10 multi-item scales and 2 single-item questions (Landgraf, Abetz, and Ware, 1996). The SE sub-domain of the CHQ-CF87 is a 14-item measure that captures the following dimensions of SE: satisfaction with school and athletic ability, looks or appearance, ability to get along with others and family and perception of life overall (Landgraf and Abetz, 1997). The responses are given on a 5-point Likert-type scale (very satisfied to very unsatisfied) with higher scores representing a better quality of life. The clinical need for orthodontic treatment was determined using the Dental Aesthetic Index (DAI). The DAI scores range from 13 (most acceptable) to 100 (least acceptable) and can be categorized into 4 malocclusion severity levels: 13 to 25, minor or none; 26 to 31, definite; 32 to 35, severe; and 36 and over, handicapping.

The data were analyzed using descriptive statistics, bivariate analyses, and multiple regression models (Agou et al, 2008). It was found that children with low SE had significantly higher total CPQ11-14, OS, FL, EW, and SW domain scores than children with high SE ($P < 0.001$), even though they had similar malocclusions, as suggested by the DAI scores. Also, the Pearson correlation between the overall CPQ11-14 and SE scores was significant (r = –0.43, $P < 0.01$), indicating a moderate negative

association between the two scales. The regression model showed that approximately 17% of the total variance in CPQ11-14 scores could be attributed to SE alone. Also, when the CPQ 11-14 subscales were analyzed individually, it was found that the contribution of the main effect of SE was most pronounced for the EW and SW subscales. Thus, it was concluded that the impact of malocclusion on the quality of life is substantial in children with low self-esteem. However, the lack of temporality limited the confidence in establishing the direction of association in this study (Agou et al, 2008).

A longitudinal investigation was later undertaken by Agou et al to assess the OHRQOL outcomes in orthodontics while controlling for individual psychological characteristics (Agou et al, 2011). The specific objective of this investigation was to analyze the effect of psychological well-being (PWB) on reported OHRQOL in 11- to 14-year-old children receiving orthodontic as compared to a sample of untreated waiting-list controls. . It was hypothesized that children with better psychological well-being (PWB) would experience fewer negative OHRQOL impacts, irrespective of their orthodontic treatment status. The study sample comprised of 199 subjects at baseline and 118 subjects at follow-up. The treatment subjects and the control subjects were recruited from the University of Toronto dental clinics. A 2-group before-and-after design was used to assess changes in OHRQOL after orthodontic treatment. The clinical severity of the malocclusion was determined by using the Dental Aesthetic Index (DAI). Other covariates such as age and sex were also recorded.

All subjects completed self-administered questionnaires: the child perception questionnaire (CPQ11-14) and the PWB subscale of the child health questionnaire years (Landgraf and Abetz, 1997), both at baseline (T1) and follow-up (T2) (Agou et al, 2011).

The fixed appliance therapy treatment lasted for 26 months on average and the T2 data were collected at the first retention check appointment for the treatment subjects. Follow-up data for the control subjects was collected after an equivalent time interval as the treatment subjects. The data of the original and the retained subjects for both the groups were contrasted and it was found that the subjects lost to follow-up did not influence the distribution of the variables.

The treatment subjects had significantly better OHRQOL scores at follow-up but the results were significantly modified by each subject's PWB status ($P < 0.01$) (Agou et al,2011). In addition, multivariate analysis showed that PWB contributed significantly to the variance in CPQ11-14 scores (26%), whereas the amount of variance explained by the treatment status alone was relatively small (9%). Thus, it was concluded that PWB plays a mediator role when evaluating OHRQOL outcomes in children undergoing orthodontic treatment. Also, the study concluded that children with better psychological well-being were more likely to report better OHRQOL, regardless of their orthodontic treatment status. However, more research needs to be done with larger samples, to confirm this finding (Agou et al, 2011). Similar findings have been reported by a recent study by researchers in New Zealand, suggesting psychosocial characteristics to be important contributors to OHRQoL in adolescents (Foster Page et al, 2011).

However, there is mixed evidence on the association between orthodontic treatment/ malocclusion factors and its impact on adolescents' OHRQoL. Some studies have concluded that there isn't any association between malocclusion and OHRQoL. Taylor et al (2009) studied the effects of malocclusion and its treatment on the quality of life of adolescents. They used an observational, cross-sectional study design with a

longitudinal component. They collected clinical as well as self-reported data from 293

participants aged 11 to 14 years. These children were recruited from two sites: the

University of Washington School of Dentistry (UW) and the Odessa Brown Children's

Clinic (OBCC), a community health clinic in the Seattle area. At both the sites, the

patients were recruited from the orthodontic and pediatric dentistry clinics. The

orthodontic participants from OBCC were part of a larger randomized clinical trial

(RCT).

The participants were classified into three groups: pre-comprehensive orthodontic

(n = 93), post-interceptive orthodontic (n = 44), and non-orthodontic comparison (n =

156) (Taylor et al, 2009). The pre-comprehensive group included patients who needed

orthodontic treatment but had not yet started it. They were recruited both from the UW

Orthodontic Graduate Clinic and from the RCT at OBCC. The pre-comprehensive group

patients answered questionnaires before the start of orthodontic treatment. The second

group i.e. the post-interceptive group included patients who were evaluated as needing

orthodontic treatment and had already completed it before entering the study. All

participants in this group were recruited from the RCT and they answered questionnaires

at a recall appointment at least 1 month after active orthodontic treatment. The third

group i.e. the non-orthodontic comparison group included pediatric dental participants

from the UW Graduate Pediatric Dental Clinic (72) and OBCC (84).

Dental esthetics and occlusion assessments were evaluated using the Index of

Complexity, Outcome, and Need [Daniels and Richmond, 2000].The participants

completed three Quality of Life (QoL) questionnaires: the Youth Quality of Life (for

general QoL assessment), Children's Oral Health-Related Quality of Life (to assess

OHRQoL), and Treatment Expectations and Experiences (to evaluate participants'
expectations to change specific aspects of their life as a treatment outcome). It was found
that the overall QoL and OHRQoL were in general high in this population. No
differences were found in OHRQoL or overall QoL among the three groups. Also, there
were no differences in these measurements between the university and community health
clinics. Thus, it was concluded that malocclusion and orthodontic treatment do not appear
to affect general QoL or OHRQoL to a measurable degree. It is possible that the available
QoL measures are not sensitive enough for measuring the impact of improved
malocclusion (Taylor et al, 2009).

Section Summary

The review of literature on malocclusion and orthodontic treatment seeking
suggests that majority of orthodontic treatment is sought for esthetic reasons (Arrow et al,
2009; Kiyak H, 2008; Phillips and Beal, 2009). The desire for orthodontic treatment is
driven by an individual's self-perception of her facial/dental esthetics and it may be more
of an individual's felt need than a normatively defined need. In many cases it is assumed
that orthodontic treatment will lead to improvements of oral function and esthetics, which
in turn will lead to improved psychological and social well-being (Tsakos G., 2008;
Phillips and Beal, 2009;Kenealy et al,2007).

In the past few years, there has been a growing recognition that the focus of oral
health care delivery must expand to include more subjective and patient-based outcomes
such as quality of life (QoL). As a result of this shift to more patient-based outcomes,
OHRQoL is increasingly being reported as an outcome of orthodontic treatment. A
systematic review which assessed the association between orthodontic treatment need and

OHRQoL concluded that there is a modest association between the presence of

malocclusion/orthodontic treatment need and OHRQoL (Liu, McGrath, and Hagg, 2009).

Adolescents who have recently received orthodontic treatment are more likely to have

fewer oral health impacts than those not treated or still undergoing orthodontic treatment

(de Oliviera and Sheiham, 2004). Also, some researchers have concluded that

psychosocial characteristics such as self-esteem are also important contributors to

OHRQoL in adolescents. It appears that they may be even more important than

sociodemographic or clinical characteristics (Foster Page et al, 2011).

However, there is mixed evidence on the association between malocclusion (or

orthodontic treatment) and its impact on OHRQoL of adolescents. Some researchers have

concluded that malocclusion and orthodontic treatment does not appear to affect

OHRQoL (Taylor et al, 2009) while some found no significant long-term effects (Arrow

et al,2009).Therefore, longitudinal studies are necessary to determine validity,

responsiveness and minimal clinically important difference.

Other qualitative methods/ assessments besides QOL
(Web-based digital imaging studies)

In a study conducted by MacPherson et al (2005), teenagers' perceptions of dental

fluorosis were assessed using digital simulation and web-based testing. This digital image

simulation model placed teeth within their facial context and also established the

influence of the viewing distance on teenagers' perceptions of fluorosis. The web-based

questionnaire showed 30 photographs, displaying four levels of fluorosis, in addition to

fluorosis-free, at five different 'distances'. Teenage pupils (n = 217) were then asked to

rate the acceptability of the appearances and point out if they would wish treatment for each such appearance. It was found that even at D4 (i.e. the farthest distance of viewing), when the central incisors measured only 8 mm on-screen, 50% of subjects scored TF0 as 'acceptable', compared with only 20% at TF4. Thus the study concluded that teenagers can discriminate between various degrees of fluorosis. Also, it was concluded that more distant viewing of fluorosed teeth (within the overall context of the face), improves acceptability of the appearance.

Summary

Adolescents are more aware of tooth appearances and have higher expectations and concerns related to esthetics as compared to other age groups (Clark and Berkowitz, 1997). They have higher expectations from dental treatment (as compared to people of other age groups), either esthetic or orthodontic, as they expect it to improve their self-esteem and boost their confidence (Tung and Kiyak, 1999). Therefore, some studies have focused on assessing their esthetic perceptions (MacPherson et al, 2005). But few studies have been done to assess the oral health-related quality of life in this age group.

The review of literature in this area points toward the significance of using QOL measures in assessing the impact of oral health status in individuals. This can aid in better understanding of their oral health perspective and the impact of their condition on their quality of life. By use of such a tool, oral health providers can tailor the treatment plan based on individual perceptions and expectations. Apart from this, studies assessing the OHRQoL of adolescents can also be valuable in guiding oral health policy. Therefore, it is important to focus more research in this age group in the U.S., where not much work has been done to assess the OHRQoL of adolescents.

Gaps in Literature

Even though OHRQoL has gained a lot of importance in past years there are only a few published studies that are based in the United States. The Pub Med database was searched by using different keywords, but not many studies were found that assessed OHRQOL of adolescents in the U.S. (especially for the 15- 21 year age group).The studies in this age group were done mainly in other parts of the world like Australia, Brazil and Europe. Although some studies have been done in the U.S. to assess the OHRQoL, most of these have been conducted in other age groups besides adolescents; therefore, they may not be valid for this age group. Thus, it will be worthwhile to conduct a similar study in a population of U.S. adolescents. It will aid in better understanding of the impact of oral conditions like dental caries, malocclusion, and fluorosis on the OHRQoL of these individuals, and thus, aid in better treatment planning.

Assessment of the impact of oral conditions on the OHRQoL of children is important because oral diseases can hinder their future development, academic performance, and achievements apart from compromising their current functioning and psychosocial wellbeing (Barbosa, 2013).

Though it would be ideal to conduct a longitudinal evaluation of the assessment of the OHRQoL of adolescents but due to time constraints and the high cost involved in such a design it may not be very feasible. A cross-sectional analysis to assess the OHRQoL of adolescents is a more realistic option and yet provides valuable information for guiding future research in this area. Secondary data analysis of the data collected in the IFS at the 17-year time point would provide an excellent opportunity to study this age

group and fill the gap in the present knowledge of the factors that impact the OHRQoL of

U.S. adolescents.

CHAPTER III

MATERIAL AND METHODS

Overview

The aim of this thesis was to perform secondary analyses concerning the oral-health-related quality of life (OHRQoL) of adolescents from data collected as part of the Iowa Fluoride Study (IFS), which is an ongoing prospective cohort study. Specifically, analysis was conducted to assess the impacts of dental caries, enamel fluorosis, non-fluoride opacities, and malocclusion on the oral health-related quality of life (OHRQoL) of the IFS participants at the 17-year old time point.

The adolescent participants and an accompanying parent were asked to each complete a questionnaire in order to collect information regarding the perceptions of OHRQoL of the adolescents [Jokovic et al (2002, 2006), Locker et al (2005)]. The development and validation of these questionnaires has been discussed in detail in the literature review section of this thesis.

The OHRQoL instrument used in our study has been adapted and modified slightly from the OHRQoL instrument used previously by Do and Spencer in an Australian study [Do and Spencer (2007)]. Both the parent and the child questionnaire consist of four domains or subscales, namely: oral symptoms, functional limitations, emotional well-being, and social well-being. (These have been discussed in detail in previous sections of this thesis) In order to assess the OHRQoL, four domain scores were calculated by adding the impact frequencies for the Likert-type responses to the domain-specific questions in the questionnaire. The total or composite OHRQoL score then was computed by adding these four domain scores (note: questions 1-11 were general esthetic

perception questions and were not used for computing the OHRQoL score). In addition to the composite score, a global rating of oral health assessment was done both by parent and adolescent to assess the OHRQoL of the adolescents. The data were analyzed cross-sectionally at the 17-year old time point for the Iowa Fluoride Study participants.

(The detailed description of the questionnaires is discussed in other sections and the questionnaires have been included in the appendix section of this thesis).

<u>General Iowa Fluoride Study Procedures</u>

Population studied

The study was a part of an ongoing prospective cohort study, the Iowa Fluoride Study, in which subjects were recruited at birth from the post-partum wards of eight hospitals in eastern Iowa, from March 1992 to February 1995 [Levy et al (2006)]. The subjects had dental examinations at approximately ages 5, 9, 13, and 17 years (still in progress) [Levy et al (2006)]. During the recruitment process, the following were assessed: the parents' ages and educational backgrounds, their family income, and whether the child was first born [Levy et al (2004)].

IRB approval/ consent

Approval was received from the University of Iowa Institutional Review Board for all procedures. Also, consent was obtained from the parents before beginning the study and assent was obtained from the parents and the children prior to each examination. The IRB approval was first received in 1991 and the IRB reviews and re-approves the projects at least annually, as well as when any changes are made to the study protocol. The University of Iowa requires all graduate students/researchers to

complete the online IRB training (CITI) and obtain IRB approval before beginning data analysis.

Dental examinations

Dental examinations for the IFS were carried out by one of the five trained and calibrated dentist examiners, with the help of portable equipment and halogen lights. Out of these five trained and calibrated examiners, only three did the 17-year old time point dental examinations. The examiners assessed dental caries, non-fluoride opacities, dental fluorosis, and hypoplasia in all the participants.

For the 17-year old examinations, subjects were invited either to the University of Iowa or else the team went to one of the two remote locations (Waterloo, IA and Des Moines, IA) to conduct clinical examinations. The appointments were about 3 hours long and the participants (both the adolescent and one of their accompanying parents) also completed the OHRQoL questionnaires during this time (personal communication with IFS staff, April 1, 2012).

Dental impressions also were made for the adolescents (if not undergoing active orthodontic treatment) at the 17-year old examination in order to study dental arch growth and development and other occlusal characteristics. The dental casts were poured by the IFS staff at the site of the examination. The Dental Aesthetic Index (DAI) (Cons et al, 1986) was used to assess occlusal characteristics using the dental casts.

Russell's criteria

Russell's criteria were used to differentiate fluorosis from non-fluoride opacities [Russell (1961) and Warren et al (2001)]. Fluorosis was differentiated from "white spot" carious lesions based on color, texture, demarcation, and relationship to the gingival

margin [Levy et al (2006)].According to Russell's criteria, fluorosis is generally not well-defined, it often blends in with normal enamel, and is usually distributed symmetrically in the mouth [Russell (1961) and Warren et al (2001)]. Non-fluoride opacities on the other hand have a defined shape, are clearly differentiated from adjacent normal enamel, are often in the middle of the tooth surface, and are more randomly distributed in the mouth [Russell (1961), Warren et al (2001), Lawson et al (2008)].

Dental fluorosis

The teeth were dried slightly with gauze and fluorosis was scored using the Fluorosis Risk Index (Pendrys, 1990; Levy, 2006), assessing four zones per tooth (occlusal tip/incisal edge, incisal third, middle third, and cervical third) on all teeth (personal communication with IFS staff). However, for the purpose of this thesis and for defining the variables, only the six anterior teeth and 4 zones per tooth were included in the statistical analyses, so there were 6 x 4 = 24 total surfaces. FRI scores are defined below in Table 3-1.

Non-fluoride opacities

For assessing non-fluoride opacities, separate tooth-level opacity scores were used to score the teeth, in addition to the dental fluorosis scoring [Levy et al (2004)]. Table 3-2 shows the non-fluoride opacity scoring used. Although FRI score 7 is used to score opacities in the Fluorosis Risk Index, however in FRI, fluorosis takes precedence if both fluorosis and opacities appear on the same tooth surface. Therefore, in this study, a more global opacity scoring was used (described in Table 3-2) and separate tooth-level opacity scores were used to score the entire tooth.

Table 3-1. Definitive Fluorosis and Fluorosis Risk Index score definitions.

Definitive fluorosis	FRI score	Definition
No	0	no visible fluorosis on any zone, or
	1	only white striations on less than half of each zone
Yes	2	half or more of any zone exhibiting white striations, or
	3	any zone with pitting, staining, or deformity

Note: FRI score 7 is used to score opacities in the Fluorosis Risk Index. In FRI, fluorosis takes precedence if both fluorosis and opacities appear on the same tooth surface.

Table 3-2. Non-fluoride opacity scoring and definitions.

Non-fluoride opacity score	Definition
0	No opacity
1	Non-fluoride opacity
2	Hypoplasia
3	Both non-fluoride opacity and hypoplasia
9	Unable to score

Dental Aesthetic Index

The DAI is an estimate of the social acceptability of an individual's dental appearance. The DAI rating is based on the measurement of 10 occlusal traits related to

the appearance of an individual In order to calculate the DAI score, each of the 10 occlusal traits is multiplied by an appropriate weight and a constant is added to the composite weighted sum of these ten traits. The scores can range from 13 (most acceptable) to 100 (least acceptable). The DAI scores can be categorized into four malocclusion severity and treatment need levels: 13 to 25 (for minor or no malocclusion, no or slight treatment needed); 26 to 30 (definite malocclusion, elective orthodontic treatment); 31 to 35 (severe malocclusion, highly desirable orthodontic treatment); and 36 and over (handicapping malocclusion, orthodontic treatment highly recommended) (Cons et al, 1986, 1989; Estioko et al, 1994; Jenny and Cons, 1996).The components of the DAI and their regression coefficients (or weights) are listed in Table 3-3.

Occlusal characteristics

The occlusal characteristics recorded as part of the clinical examination were: molar relationship, vertical jaw relationship, transverse jaw relationship, anterior-posterior jaw relationship, and missing anterior teeth. Also, alginate impressions were taken from most of the subjects and dental casts were made. A calibrated dental student scored the dental casts using the DAI, in order to assess the occlusion. The occlusal characteristics recorded at the clinical examination are shown in Table 3-4.

Dental caries

The subjects were also examined for dental caries on all the teeth, as part of the intra-oral examination. Dental caries was assessed only on the basis of clinical examination and no radiographs were taken. Caries was recorded as cavitated lesions, non-cavitated lesions, or arrested caries. A scoring system was developed as part of the

IFS to record dental caries (included in the Appendix section of this thesis). In addition,

sealants and restorations were also recorded.

Table 3-3. Dental Aesthetic Index components, regression coefficients and their weights.

Dental Aesthetic Index Components	Regression coefficients (Rounded weights)
Missing visible teeth (incisor, canine, or premolar teeth in maxillary and mandibular arches)	6
Crowding	1
Spacing	1
Midline diastema in mm.	3
Largest anterior irregularity in mm. (maxillary)	1
Largest anterior irregularity in mm. (mandibular)	1
Anterior maxillary over-jet in mm.	2
Anterior mandibular over-jet in mm.	4
Vertical anterior open-bite in mm.	4
Anterior-posterior molar relation	3
Constant	13
Total	DAI score (Rounded)

Table 3-4. Occlusal characteristics recorded in clinical examination and their
 description.

Occlusal Characteristic	Variable type	Description
Molar relationship	Categorical-nominal	Class I/ II/ III
Vertical jaw relationship	Categorical-nominal	Within Normal Limits(WNL) Open Deep
Transverse jaw relationship	Categorical-dichotomous	Within normal limits Cross-bite
Anterior-Posterior jaw relationship	Categorical-nominal	Within Normal Limits(WNL) Crossbite >4mm overjet
Missing Anterior teeth	Categorical - Dichotomous	Yes/ No

Data entry

The OHRQoL questionnaires and dental exam data were entered using Verity®
TeleForm® Software, which scans the completed questionnaires and enters information
into a database. All data were subsequently verified by a research assistant.

Questionnaires

The OHRQoL questionnaires were originally developed by Locker and Jokovic in
Canada and our version was adapted and modified slightly from the questionnaires used
by Do and Spencer in Australia [Jokovic et al (2002, 2006), Locker et al (2005), Do and
Spencer (2007)]. Do and Spencer's study was nested in a larger population based study of
the South Australian (SA) school dental service (SDS) population, the Child Oral Health
Study [Do and Spencer (2007)]. The detailed development and evaluation of these
questionnaires has been discussed earlier in the literature review section of this thesis.

As the intent was to replicate the study conducted by Do and Spencer [Do and Spencer (2007)] in a U.S. population, minor modifications were made to the wording of the original questionnaires used by Do and Spencer, in order to make them more appropriate for mid-west U.S. participants (personal communication with Dr. Levy, April 11, 2012). The original Do and Spencer questionnaires, as well as the modified versions used in our study, have been included in Appendix section of this thesis. The modifications made to the original questionnaire have been highlighted.

The first section of the questionnaire in the original Do & Spencer study, as well as in this study, consists of some general questions (i.e., questions 1-11 included). The next few sections include the core questions, which fall under the four domains/subscales (i.e., oral symptoms, functional limitations, emotional well-being, and social well-being) used to assess the OHRQoL. These are presented in Table 3-5.

The Parent Perception Questionnaire (PPQ) used in our study (oral health questionnaire – Parent) consisted of 58 items, while the Child Perception Questionnaire (CPQ or oral health questionnaire – teen) consisted of 48 items. The impact frequency Likert scores were calculated partially for the four domains or subscales of the OHRQoL questionnaires: oral symptoms, functional limitations, emotional well-being and social well-being [Do and Spencer (2007)]. The CPQ and PPQ items used Likert-type scales and the response options included: "Never" = 0; "Once or twice" = 1; "Sometimes" = 2; "Often"= 3; and "Very often" = 4. The scores were calculated for the four domains and overall OHRQoL scores of CPQ and PPQ were also calculated [Do and Spencer (2007)]. For the overall scores, all the responses to the items in the four domains were summed up, with lower scores reflecting better OHRQoL [Do and Spencer (2007)].

Table 3-5. Questions included in the four domains/subscales of the CPQ/PPQ
questionnaires.

Domain/ Subscale	Number of questions	Question Numbers		Subscale Items
		CPQ	PPQ	
Oral Symptoms	5	Q12, Q13, Q14, Q15, Q16	Q12, Q13, Q14, Q15, Q16	Pain Bleeding Sores Bad Breath Food caught in teeth
Functional Limitations	7	Q17, Q18, Q19, Q20, Q22, Q23, Q25	Q17, Q18, Q19, Q20, Q21, Q22, Q23	Breathe through mouth Take longer to eat a meal Have trouble sleeping Difficult to chew or bite food Difficult to say words Difficult to eat foods you like Difficult to eat hot/cold foods
Emotional Well-Being	8	Q27, Q29, Q30, Q31, Q32, Q33, Q34, Q35	Q25, Q26, Q27, Q33, Q34, Q35, Q36, Q42	Felt irritable/ frustrated Shy/embarrassed Concerned what other people think Worried not as good-looking Worried that different Upset Nervous or afraid Not as healthy
Social Well-Being	10	Q36, Q37, Q39, Q40, Q41, Q42, Q44, Q46, Q47, Q48	Q28, Q29, Q30, Q31, Q32, Q37, Q38, Q39, Q40, Q43	Missed school Hard to pay attention in school Not wanting to speak/read aloud Avoided activities Not wanting to talk to people Avoided smiling/laughing Not wanting to spend time with others Teased Left out Others asked questions

In addition, both the parents and the adolescents were administered a global oral health rating (GOHR) quality of life question, which uses a scale that extends from 0 to 100, where 0 represents the worst health state that one can imagine and 100 represents "perfect" health. This question has been included in Appendix section of this thesis. The participants (both parents and adolescents) were given specific instructions to mark the scale with a vertical line to indicate a score (GOHR). The instructions given in the questionnaire were:

> "*On the scale below, please rate the impact of "how your teeth look and feel" on your quality of life in performing usual daily activities such as eating, speaking, exercising, studying, working (if applicable), and social interactions, and on your overall physical and mental well-being, including the level of comfort, pain, self-esteem, anxiety, or depression.*"

The parent GOHR question was modified to ask the parent to rate the overall impact of 'how their teenager's teeth look and feel' on their teenager's quality of life in performing various activities.

Validity and reliability

Jokovic et al (2002) examined the validity and reliability of the CPQ_{11-14} in a clinical convenience sample of 123 children recruited from among pediatric dentistry, orthodontic, and craniofacial patients in Toronto. Test-retest reliability was assessed in a subgroup of these children (n = 65), two weeks after administering the first questionnaire to all 123 children in the study sample (Jokovic et al, 2002). It was found that the mean CPQ_{11-14} scores were highest for oro-facial (31.4), lower for orthodontic (24.3), and lowest for pedodontic (23.3) patients (Jokovic et al, 2002). Also, it was found that there were significant associations between the CPQ_{11-14} score and global ratings of oral health

($p < 0.05$) and overall well-being ($p < 0.01$) (Jokovic et al, 2002). The Cronbach's alpha and intraclass correlation coefficient for the CPQ_{11-14} were 0.91 and 0.90, respectively (Jokovic et al, 2002). Thus, it was stated that the CPQ_{11-14} is valid and reliable (Jokovic et al, 2002).

However, the validity and reliability of the CPQ_{11-14} was not tested in other populations besides the convenience sample in the study by Jokovic et al (2002). Due to the lack of such studies with more representative samples, the performance of the CPQ_{11-14} remained questionable and could not be generalized to child populations which exhibit the full distribution of clinical presentations. Due to the possible bias associated with clinical samples, it is important to validate measures such as CPQ_{11-14} at the population level (Locker, 2000). Clinical populations may sometimes give a misleading picture of the utility of such measures (Locker, 2000).

The internal consistency of the CPQ_{11-14} and the construct validity against the global ratings of oral health and overall well-being were evaluated and shown to be acceptable in a population-based cross-sectional study in New-Zealand (Foster Page et al, 2005). A random sample ($N = 430$) of 12- and 13-year old New Zealanders completed the CPQ_{11-14} and were examined for malocclusion (Dental Aesthetic Index) and dental caries (Foster Page et al, 2005). The construct validity was found to be acceptable, showing higher overall scores among children with more severe malocclusion or with greater dental caries experience (Foster Page et al, 2005). It was found that the children in the worst 25% of the DMFS distribution had higher CPQ_{11-14} scores overall and for each of the four domains in the questionnaire (Foster Page et al, 2005). Thus, the study concluded

that the instrument has consistency and validity in measuring OHRQoL of children in a general population.

No separate analyses of the validity and reliability of the quality of life questionnaires were done in the IFS.

<div align="center">Operational definitions</div>

<div align="center">Oral Health-Related Quality of Life</div>

Based on the questionnaires used in our study, there are two ways to define the OHRQoL, either by using the composite score or by using the global oral health rating (GOHR) question. These are described below:

Domain score

The impact frequency Likert scores were calculated for the four domains or subscales of the OHRQoL questionnaires: oral symptoms, functional limitations, emotional well-being and social well-being [Do and Spencer (2007)].

The composite score (or overall scale score)

It was calculated by adding the impact frequencies for the Likert-type responses to the items in the four domains (that comprise of the entire questionnaire), with lower scores reflecting better OHRQoL [Do and Spencer (2007)].

The Global Oral Health Rating question

It was also used to assess the OHRQoL of the adolescents. The Global Oral Health Rating uses a scale that extends from 0 to 100, where 0 represents the worst health state that one can imagine and 100 represents "perfect" health. The participants (both

parents and adolescents) were given specific instructions to mark the scale with a vertical line to indicate a score (Iowa Fluoride Study Questionnaire).

Dental fluorosis

Dental fluorosis was defined in two ways: i) primary definition, and ii) secondary definition. These have been explained below:

Primary fluorosis definition

It was defined at the person level as having *one* or more maxillary anterior teeth with a FRI score of 2 or 3 for definitive fluorosis (assessing four zones, i.e., incisal edge, incisal third, middle third, and cervical third on each of the 6 maxillary anterior teeth).

Secondary fluorosis definition

It was defined at the person level as having *two* or more maxillary anterior teeth with a FRI score of 2 or 3 for definitive fluorosis (assessing four zones, i.e., incisal edge, incisal third, middle third, and cervical third on each of the 6 maxillary anterior teeth).

Dental caries

Dental caries was defined at the person-level as having cavitated caries lesions (D_2FS) anywhere in the entire mouth. Person-level D_2FS scores were calculated as the sum of decayed (D_2/cavitated lesion level) and filled (F) surfaces. Three categories were defined: category 1/$D_2FS=0$, category 2/$D_2FS=1-4$, and category 3/$D_2FS\geq5$.

Non-fluoride opacities

The scoring categories for each tooth included: 0, 1, 2, 3, and 9, which makes it a categorical variable. For data analysis purposes, these were collapsed into two categories,

i.e., whether a non-fluoride opacity was present or not, thus making it a dichotomous/ binary variable. Categories 0 and 2 were collapsed into a new category, 'No', i.e., if no non-fluoride opacity was present. Categories 1 and 3 were collapsed into a new category, 'Yes', i.e., if a non-fluoride opacity was present. Teeth with scores of '9' were excluded. The tooth level results were then combined into a person level variable, and each person was 'Yes' (one or more non-fluoride opacities), 'No' (no non-fluoride opacity), or excluded (if any score of '9'). So, the definition used was at the person level for opacities on any of the maxillary anterior teeth.

Occlusal characteristics

Table 3-6 shows the DAI score categories and their respective treatment need levels.

Table 3-6. DAI score categories and treatment need levels*

DAI Score	Treatment Need
13- 25	Normal or minor malocclusions with no or slight treatment need
26-30	Definite malocclusions with treatment elective
31-35	Severe malocclusions with treatment highly desirable
≥ 36	Very severe or handicapping malocclusions with treatment considered very important

*Source: Joanna Jenny, Naham C. Cons, Comparing and contrasting two orthodontic indices, the Index of Orthodontic Treatment Need and the Dental Aesthetic Index, American Journal of Orthodontics and Dentofacial Orthopedics, Volume 110, Issue 4, October 1996, Pages 410-416.

Demographic variables

Adolescent's sex

The sex of the participant adolescent was male or female, based on the recruitment questionnaire.

Parent's educational level

Parent's educational level was recorded as some high school, high school diploma (or GED), some college, 4-year college degree, and post-graduate or professional degree, based on the 2007 demographics questionnaire. For the purpose of this thesis, some categories were collapsed and parent's education level was defined as: i) some high school, high school diploma (or GED), ii) some college, iii) 4-year college degree or higher.

Family income level

The annual family income level was recorded as less than $20,000, $20,000-$39,999, $40,000-$59,999, $60,000-$79,999, and $80,000 or more, based on the 2007 demographic information questionnaire. For the purpose of this thesis, some categories were collapsed and the family income level was defined as: i) less than $40, 000, ii) $40,000-$79,999, and iii) $80,000 or more. These categories were used for reporting univariate and bivariate results. Since the upper and the middle income categories were very similar in regard to their OHRQoL assessments, they were combined into one category, so as to focus more on the difference between the low income and the higher income groups. Therefore, for multivariable analyses, a new binary variable called 'low income' was created and defined as: i) low income = yes, if family income $\leq$ $39,999, and ii) low income = no, if family income $\geq$ 40,000.

Race/ethnicity

     Race/ethnicity was defined as "Non-Hispanic White" or "others", based on the family background assessment at age11. The "other" category includes Black, Asian, Hispanic, Native American, and Mixed race subjects.

<center>Sample size</center>

     The data collection process was ongoing at the time of these thesis analyses, but only a small number of additional subjects were being accrued per month. All data available as of January 1, 2013 were included in the thesis study sample, resulting in a sample size of 394 adolescent-parent pairs.

<center>Thesis-specific methods</center>

<center>Sample size</center>

     Adolescents undergoing active orthodontic treatment were excluded from the analyses as orthodontia was not our variable of interest, due to the transient nature of active orthodontic treatment. There were 21 adolescents in our sample who were excluded from the analyses as they were undergoing active orthodontic treatment at the time of 17-year time point clinical examination in the IFS, resulting in an essential effective sample size of n = 373 (n= 394 total-21 undergoing active orthodontic treatment). This effective sample size was used for all univariate and bivariate analyses.

     However, due to missing values for other variables in the multivariable analyses for 27 subjects (18 missing information on family income, 8 missing orthodontic treatment experience, and 1 missing crossbite and overjet), the final sample for the regression models had 346 subjects instead of 373.

Median Dental Aesthetic Index score imputation

The DAI scores were available only for 235 adolescents. Therefore, the primary multivariable analysis using conditional median regression was done on these 235 adolescents. However, due to missing values for other variables in the multivariable analyses for 13 subjects (9 missing low income, 3 missing past orthodontic treatment, and 1 missing crossbite/overjet), the final sample for the regression models had 222 subjects instead of 235.

The median DAI score of 22 was imputed for the remaining 124 adolescents (346-222), in order to gain a larger sample size (resulting in an expanded sample size of n=346) for assessing the effect of the other independent variables on the OHRQoL composite score. Thus, this resulted in two sample sizes for multivariable analyses:

1. Main analytical sample (including subjects with DAI evaluation only, n=235)

2. Expanded sample size (with median DAI score imputation, n=346)

Research questions

The main question addressed in this thesis was how the oral-health-related quality of life of 17 year old adolescents is related to the presence of oral conditions such as dental caries, dental fluorosis, malocclusion, and non-fluoride enamel opacities. For the purpose of this study, fluorosis was assessed using the Fluorosis Risk Index [Pendrys (1990)].

Another question addressed in this thesis was how the parents' perceptions of the oral-health-related quality of life of their 17 year old adolescent is related to the presence of selected oral conditions like dental fluorosis, malocclusion, and non-fluoride enamel

opacities. This thesis also assessed the agreement between parents and their adolescent children in rating the OHRQoL of the adolescents. The research questions and the hypotheses are listed below:

Research question I

Aim

What are the relationships between the oral-health-related quality of life of 17 year old Iowa adolescents and the presence of selected oral conditions?

Hypotheses

1. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of caries experience.

2. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of dental fluorosis.

3. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of malocclusion.

Research question II

Aim

What are the relationships between the parents' perceptions of the oral health-related quality of life of their 17 year old adolescents and the presence of selected oral conditions?

Hypotheses

1. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of caries experience.

2. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of dental fluorosis.

3. The oral health-related-quality-of-life (OHRQoL) of 17-year-olds is related to the presence of malocclusion.

Research question III

Aim

What are the relationships between the OHRQoL of 17 year old adolescents and their parents' perceptions of their OHRQoL?

Hypotheses

1. Adolescent OHRQoL scores and GOHR are positively correlated with their parent's scores/rating.

 a. The composite scores of the OHRQoL questionnaires for parents and adolescents are positively correlated (Spearman Correlations; primary dependent variable = composite score).

 b. The four domain/subscale scores for parents and adolescents are positively correlated (Spearman Correlation; secondary dependent variables = 4 domains)

 c. The global oral health rating for parents and their adolescent children are positively correlated (Spearman Correlation; secondary dependent variable = GOHR).

2. Adolescents' and parents' OHRQoL scores and GOHR differ.

 a. Adolescents have higher CPQ scores (domains and composite scores) and thus poorer oral health-related quality of life estimates compared to their parents' perceptions of the adolescents' OHRQoL.

i) The composite scores (primary dependent variable) of the OHRQoL questionnaires for adolescents are higher than those for parents.

ii) The Oral Symptoms domain scores of the OHRQoL questionnaires for adolescents are higher than those for parents.

iii) The Functional Limitations domain scores of the OHRQoL questionnaires for adolescents are higher than those for parents.

iv) The Emotional Well-being domain scores of the OHRQoL questionnaires for adolescents are higher than those for parents.

v) The Social Well-being domain scores of the OHRQoL questionnaires for adolescents are higher than those for parents.

b. The global ratings of oral health (secondary dependent variable) are lower for adolescents than those for their parents (i.e., adolescents have poorer oral health-related quality of life estimates compared to their parents).

Variables and inclusion criteria

Dependent / outcome variables

The primary dependent variable was the OHRQoL composite score, and the secondary dependent variable was the global oral health rating question. The CPQ and PPQ item responses were used to calculate domain scores and composite CPQ and PPQ scores. The global oral health rating question (which uses a visual analogue scale of 0 – 100, reflecting worst to excellent oral health) was used as another indicator of OHRQoL.

Table 3-7. Table summarizing the source, type, and description of independent variables.

Independent variable	Source	Type	Description/Details
Fluorosis	Clinical examination	Dichotomous	*Primary fluorosis definition:* Having one or more maxillary anterior teeth with a FRI score of 2 or 3. *Secondary fluorosis definition:* Having two or more maxillary anterior teeth with a FRI score of 2 or 3.
Non-fluoride opacities	Clinical examination	Categorical	*No fluoride opacity present (No)* Original categories 0 & 2 were collapsed *Fluoride opacity present (Yes)* original categories 1 & 3 were collapsed *Excluded from analysis* Category 9
Occlusal characteristics :			
Molar relationship	Clinical examination	Categorical-nominal	Class I/ II/ III
Anterior cross-bite	Clinical examination	Dichotomous	Yes/No Derived from original variable 'anterior-posterior jaw relationship', described earlier.
Posterior cross-bite	Clinical examination	Dichotomous	Yes/No Derived from original variable 'transverse jaw relationship', described earlier.
Open-bite	Clinical examination	Dichotomous	Yes/No Derived from original variable 'vertical jaw relationship, described earlier.
Over-jet > 4 mm (excess over-jet)	Clinical examination	Dichotomous	Yes/No Derived from original variable 'anterior-posterior jaw relationship', described earlier.
Dental caries experience (D$_2$FS)	Clinical examination	Categorical	Category 1:D$_2$FS=0 Category 2: D$_2$FS=1-4 Category 3:D$_2$FS=5+

Table 3-7 Continued.

DAI score	Dental casts	Dichotomous	DAI score13 to 30: (Normal or minor malocclusions with no or slight treatment need; Definite malocclusions with treatment elective) DAI score$\geq$ 31: (Severe malocclusions with treatment highly desirable; Very severe or handicapping malocclusions with treatment considered very important)

Independent / explanatory variables

The independent variables included dental fluorosis, non-fluoride opacities, dental caries, and malocclusion. Other covariates, such as demographic data for race/ethnicity, parent's education, family income level, and sex of the participant were also available for analyses. Some of these demographic data were collected again in 2007, as part of the IFS. The independent variables, their source of collection, type, and description are presented in Table 3-7.

In addition to the independent variables, covariates such as race/ethnicity, parent's education, family income level, and sex of the participant were also available for analysis. The covariates, their source, type, and description are presented in Table 3-8.

Other covariates that were analyzed included: BMI, birth weight, whether the adolescent participant was the first child or not, history of bleaching teeth, history of any orthodontic treatment, and history of medical conditions like attention deficit hyperactivity disorder (ADHD), anxiety, depression, musculoskeletal disorder, diabetes, and developmental disorder.

Table 3-8. Table summarizing the source, type, and description of the covariates analyzed.

Covariate	Source	Type	Description/ Details
Mother's Education Father's Education	2007 questionnaire	Categorical-ordinal	Some high school H.S. diploma/GED Some college 4-year college degree Graduate/professional degree
Family Income	2007 questionnaire	Categorical-ordinal	< $20,000 $20,000 - $39,999 $40,000-$59,999 $60,000-$79,999 $80,000 or more
Race/ethnicity	Family Background and Assessment (child age11)	Categorical - dichotomous	Non-Hispanic White Others (Asian, Black, Mixed, Hispanic White)
Adolescent's gender	Recruitment questionnaire	Categorical - dichotomous	Male Female

Statistical methods and data analysis

The data were entered using Verity® TeleForm® Software, which scans the completed questionnaires and enters information into a database. The data were converted into a SAS format data set. The SAS 9.3 software (SAS Institute Inc., Cary, NC, USA) was used for all data analyses. A p-value of less than 0.05 was set as the criterion for statistical significance.

Univariate analyses

Descriptive analyses were conducted to get an overview of all the variables. The frequency distributions were generated and outliers were assessed.

Bivariate analyses

Bivariate analyses were conducted to study the relationships between the dependent variables and the independent variables. The Wilcoxon rank-sum test, Wilcoxon signed-rank test, Kruskal-Wallis test, and Spearman correlation tests were used. The two indicators of OHRQoL were compared between children and parents grouped by caries experience, fluorosis scores, non-fluoride opacities, DAI categories, gender, and orthodontic factors in bivariate analyses.

Specific research questions and the types of analyses done

Tables 3-9 and 3-10 show the dependent variables, the independent variables and their types, and the specific bivariate analyses done for Research questions I and II, respectively.

Table 3-9. Research question I: dependent variables, independent variables, and the types of bivariate analyses done.

Dependent Variable	Independent Variable	Type of Independent Variable	Type of Analysis
CPQ total/ Composite Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical	Kruskal-Wallis test
Global Oral Health Rating	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI	Dichotomous	Wilcoxon Rank Sum test

Table 3-9. Continued

	Dental Caries	Categorical-nominal	Kruskal-Wallis test
Oral Symptoms Domain Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical-nominal	Kruskal-Wallis test
Functional Limitations Domain Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
Emotional Well-being Domain	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test

Table 3-9. Continued

	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
Social Well-being Domain Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level		Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test

Table 3-10. Research question II: dependent variables, independent variables, and the types of bivariate analyses done.

Dependent Variable	Independent Variable	Type of Independent Variable	Type of Analysis
PPQ Total/ Composite Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
Global Oral Health Rating	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test

Table 3-10. Continued

	Missing Anterior teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
Oral Symptoms Domain Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
Functional Limitations Domain Score	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical- ordinal	Kruskal-Wallis test
	Fluorosis	Dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test

Table 3-10. Continued

Emotional Well-being Domain Score	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
Social Well-being Domain Score	Dental Caries	Categorical-ordinal	Kruskal-Wallis test
	Fluorosis	dichotomous	Wilcoxon Rank Sum test
	Non-fluoride Opacities	Dichotomous	Wilcoxon Rank Sum test
	Anterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Posterior Cross-bite	Dichotomous	Wilcoxon Rank Sum test
	Open-bite	Dichotomous	Wilcoxon Rank Sum test
	Overjet > 4 mm	Dichotomous	Wilcoxon Rank Sum test
	Missing Anterior Teeth	Dichotomous	Wilcoxon Rank Sum test
	DAI level	Dichotomous	Wilcoxon Rank Sum test
	Dental Caries	Categorical-ordinal	Kruskal-Wallis test

Multivariable analyses

The primary dependent variables were the parent (PPQ) and adolescent (CPQ) composite OHRQoL scores, and the secondary dependent variables were the 'Global Oral Health Rating' question responses for both parents and adolescents. Thus, the multivariable median regression models were generated for overall CPQ and PPQ scores and for the GOHR of parents and adolescents (four models: two for children and two for parents). The clinical indicators of oral health, i.e., dental caries, dental fluorosis, anterior cross-bite, overjet > 4 mm, and DAI category, were included as independent variables in multivariable models for the OHRQoL indicators together with other demographic/socioeconomic indicators as control variables, such as adolescent's gender and family/household income. All of these variables were retained in the multi-variable analyses and no model trimming procedure was performed to achieve a more parsimonious model, as all of the above-mentioned variables were considered as theoretically important/significant in assessing the impact on OHRQoL of an adolescent. However, a p-value ≤ 0.05 was considered as statistically significant for the analyses.

Justification for choosing the independent variables to be
included in the multivariable analyses
Gender

Gender was included in the multivariable analyses as it was hypothesized that male and female participants might differ on the assessment of their OHRQoL. Female participants can tend to be more critical of their tooth appearance and thus have higher expectations for their tooth appearance or could be less satisfied with the esthetic perceptions of their teeth. Thus, gender was included in all four of the multivariable

models (dependent variable = CPQ, PPQ, child GOHR, and parent GOHR) to study any variations in the OHRQoL based on gender differences.

Family income

Family income is an important social characteristic that can determine an individual's ability to seek necessary or esthetic dental treatment. Thus, it can affect an individual's OHRQoL either favorably or adversely, depending on their availability of resources. For example, an individual with higher family income may be able to afford routine dental check-ups and preventive dental therapy, thus avoiding pain and discomfort that may be associated with dental diseases such as dental caries, gingivitis, and periodontitis. In addition, for individuals suffering from malocclusion, resource availability could be instrumental in determining their ability to undergo orthodontic treatment, which can be expensive. Untreated malocclusion could adversely affect the OHRQoL of an individual, especially adolescents, as they could be more concerned about their esthetic appearance, as compared to other age groups. For these reasons, family income was included as a covariate in all the multivariable models used to predict the OHRQoL of an individual

Dental caries

Dental caries is often associated with pain and discomfort and can thus affect the psychosocial well-being of an individual The CPQ/PPQ tool used to assess OHRQoL in this study consists of four domains: oral symptoms, functional limitation, emotional well-being, and social well-being. Dental caries can affect any or all of these four domains, as caries can be associated with pain, discomfort, difficulty in chewing food, lack of concentration, absence from school/work, poor performance, decreased esthetic

perception of teeth, poor social interactions, and low self-esteem. Thus, dental caries can be an important predictive factor for assessing OHRQoL and, therefore, was included in all four multivariable models (dependent variable = CPQ, PPQ, child GOHR, and parent GOHR).

Dental fluorosis

Dental fluorosis occurs due to the hypomineralization of tooth enamel. This can lead to discoloration of the teeth. Mild and very mild fluorosis can cause teeth to look whiter, and therefore, it can improve esthetic perceptions of teeth, thereby leading to better OHRQoL. On the other hand, moderate and severe fluorosis can cause more noticeable tooth discoloration and in some cases even loss of function, thus leading to decreased esthetic perception and poor OHRQoL. Therefore, depending on the severity of dental fluorosis, the OHRQoL of an individual can be shifted to either end of the spectrum. Thus, dental fluorosis was included in all four multivariable models (dependent variable = CPQ, PPQ, child GOHR, and parent GOHR).

DAI score

The DAI score was included in the multivariable analyses as it is an estimate of the social acceptability of an individual's dental appearance (occlusion). The DAI rating is based on the measurement of 10 occlusal traits related to the appearance of an individual. The scores can range from 13 (most acceptable) to 100 (least acceptable) (Cons et al, 1986, 1989; Estioko et al, 1994; Jenny and Cons, 1996). Therefore, it reflects that how acceptable an individual's dental appearance is to other people. In this manner, it can aid in predicting the OHRQoL of an individual, as a person's social well-being and emotional well-being could be affected by how other people perceive their dental

appearance. In addition, DAI rating also reflects the severity of malocclusion (minor or no malocclusion, definite malocclusion, severe malocclusion, and handicapping malocclusion), as well as the treatment need levels corresponding to the perceived severity of malocclusion (ranging from 'no or slight treatment needed' to 'orthodontic treatment highly recommended') (Cons et al, 1986, 1989; Estioko et al, 1994; Jenny and Cons, 1996). The severity of an individual's malocclusion can in turn affect their oral symptoms and cause functional limitations, thereby affecting their OHRQoL. For these reasons, DAI score/ rating was considered as an important independent variable and was included in all of the multivariable models (two models each for parents and adolescents).

Jaw relationships (anterior cross-bite and overjet > 4mm)

These occlusal characteristics were recorded as part of the clinical examination. They were included in the multivariable models as they reflect the clinical assessment of an individual's occlusion, specifically in the anterior teeth that are more visible, and thus can affect the appearance of the front teeth, thereby affecting the OHRQoL of an individual These clinical occlusal characteristics were included in the multivariable models despite the presence of DAI rating in the models. Whereas DAI rating reflects the social acceptability of an individual's dental appearance, the clinical occlusal characteristics reflect the assessment of the occlusion based on clinical acumen. The decision to include these occlusal characteristics in the multivariable models was also guided by the statistically significant bivariate analyses ($P \leq 0.15$).

Orthodontic treatment

Subjects undergoing active orthodontic treatment were excluded from the analyses, as due to its transient nature, active orthodontic treatment was not our variable

of interest. However, past orthodontic treatment was included as an independent variable in all multivariable analyses, as orthodontic treatment can improve an individual's dental appearance, thereby enhancing their dental esthetic perceptions and positively affecting their OHRQoL.

<div align="center">Quantile regression</div>

Quantile regression (Koenker and Bassett,1978) is a type of semi-parametric regression analysis that extends the concept of quantile in univariate analysis to regression analysis and aims to estimate regression relationships specific to a particular percentile or quantile of the outcome variable (Koenker and Hallock,2001; Choi et al,2012). It is a flexible and robust method, as it doesn't make any distributional assumptions about the error term in the model. Median regression is a special case of quantile regression where the constant is the median of the sample and the conditional value of the median is modeled as a function of the regressors (Koenker and Hallock, 2001).

Quantile regression analysis can be performed using common statistical software (e.g., PROC QUANTREG procedure in SAS; QUANTREG package in R; QREG procedure in STATA). For the purpose of this thesis, the PROC QUANTREG procedure in SAS version 9.3 was used to generate the multivariable median regression models. The QUANTREG procedure in SAS estimates a single quantile regression function and estimates the standard errors using the asymptotic variance-covariance approximation (SAS online manual). It models the effects of covariates on the conditional quantiles. Thus, in median quantile regression, the sum of the absolute deviations (error terms) around the median are minimized. The following syntax was used to fit a simple linear model for the 50th percentile of the dependent variable:

```
PROC QUANTREG data= xyz algorithm = simplex CI= resampling (Nrep=1000)

seed 123;

Model CPQ = female lowincome fluorosis caries DAIscore crossbite overjet

PastOrtho/diagnostics cutoff=3 quantile= 0.5;

Run;
```

The MODEL statement in the PROC QUANTREG procedure in SAS specifies a simple linear regression model with CPQ/PPQ as the response variable Y and the independent variables as the covariates Xi. The option QUANTILE=0.5 requests that the regression quantile function $Q(0.5|X = x) = x' \beta (0.5)$ is to be estimated by solving:

$$\beta\text{-hat } (0.5) = \operatorname{argmin}_{\beta \in R^z} \sum_{i=1}^{n} \rho 0.5 \left(y_i - x'_i \beta \right)$$

<u>Simplex method</u>

Optimization of the median regression equation in QUANTREG uses the simplex algorithm method of Barrodale and Roberts (1973). The simplex method is a two-stage iterative process that reduces computation time (as compared to the general simplex method) and is suitable for datasets with fewer than 50 covariates and 5,000 observations (SAS online manual). The regression coefficients were estimated using the default settings of the simplex algorithm.

<u>Resampling</u>

Confidence intervals for regression parameters were estimated using the resampling method – a bootstrap approach designed to provide robust estimates (SAS online manual). The resampling method can be computationally challenging, but is

feasible for smaller data sets (< 20 variables) (SAS online manual). The QUANTREG

resampling method uses a Markov chain marginal bootstrap (MCMB) technique

introduced by He and Hu (2002). By specifying the option CI=RESAMPLING, the

QUANTREG procedure also calculates standard errors, t-values, and p-values of

regression parameters using the MCMB resampling method (SAS online manual).

Rationale for using quantile regression in our study

Quantile regression was used in this study because it provides a more

comprehensive picture of the effect of the independent variables on the response variable.

The dependent variables (i.e., OHRQoL scores) in our study were skewed toward better

OHRQoL. Therefore, median regression (a special form of quantile regression) was used

for multivariable analyses because it describes the changes in the center of the

distribution. As the median is insensitive to outliers in univariate analysis, similarly,

median regression is also insensitive to outliers (Choi et al, 2012).

Thus, using median regression allowed us to estimate the effect of a one unit

change in the predictor variables on the conditional *median* of the response variable. In

contrast, using linear regression, we could have estimated the effect of a one unit change

in the predictor variables on the conditional *mean* of the response variable.

Sensitivity analysis

In order to assess the sensitivity of the multivariable analyses with the main

analytical sample, two additional regression models were generated for comparison with

the primary model. These comparison models were generated using: i) ordinary least

squares regression on the main analytical sample, and ii) conditional median regression

on a sample with expanded sample size (the sample size was increased by imputing

median DAI scores for those who were missing DAI evaluations

CHAPTER IV

RESULTS

Introduction

The findings from this study are presented in this chapter in the following

sections: 1) Demographic data, 2) Dental exam findings, 3) Descriptive data for

OHRQoL questionnaires and esthetic perceptions questionnaires for adolescents and their

parents, 4) Bivariate analyses, and 5) Multivariable analyses. The following non-

parametric tests were used for the bivariate analyses: Wilcoxon Rank Sum tests,

Wilcoxon Sign Rank tests, Spearman Correlations and Kruskal-Wallis tests. The

explanations pertaining to when each test was used have been presented in the Methods

section (Chapter III) of this thesis. Conditional median regression, a special form of

quantile regression, was used for all multivariable analyses.

Demographics

The descriptive statistics for demographic characteristics of the adolescent

participants (n = 374) and their parents presented in Table 4-1 show that 54.3% of the

adolescent participants and 92.1% of the parents who completed the OHRQoL

questionnaires were female. The study sample was comprised mostly of non-Hispanic

whites (95.7%) and all other race/ethnicities (i.e., Black, Asian, Hispanic, and Native

American) accounted for only 4.3% of the study sample. Most of the parents in this study

were well-educated, with about 51% of mothers and 41% of fathers having a 4-year

college degree or more and about 40% more of mothers and about 30% more of fathers

having some college education or a 2-year college degree, as of 2007.

The sample was comprised mainly of adolescents from middle to high socio-economic status families. About 49% of the subjects were from families with annual family income in 2007 greater than $80,000, 38% had annual family income from $40,000 to $ 79,999, and about 13% belonged to families with less than $40,000 annual income. About 45% of children in the study sample were the first born child in their family.

<div align="center">Dental examination findings</div>

The findings from the dental examinations are summarized in this section, including information about dental caries experience, fluorosis, non-fluoride opacities, orthodontic characteristics, and malocclusion. Table 4-2 shows the descriptive analysis of dental characteristics of the subjects. Thirty-seven percent of the adolescents were caries-free (no caries experience at the cavitated lesion level, i.e., D_2FS), which reflects the relatively low dental disease burden in the sample. Twenty-seven percent of adolescents had more than five tooth surfaces with cavitated caries experience (D_2FS). The overall mean $\pm$ SD decayed (cavitated) or filled surfaces (D_2FS) value was 3.55 $\pm$ 5.05. About 85% of the participants had no non-cavitated lesions on their six maxillary anterior teeth, about 9% had one to three, and about 6% had four or more non-cavitated lesions on their six maxillary anterior teeth.

Dental exams at age 17 showed that about 22% of the adolescents had definitive fluorosis on one or more maxillary anterior teeth (maximum Fluorosis Risk Index (FRI) score = 2 or 3), including seven subjects who had severe fluorosis (maximum FRI score = 3). The frequency distribution for non-fluoride enamel opacities on the six maxillary anterior teeth (at the person-level) is also presented in Table 4-2. Only about 14% of the

subjects had one or more non-fluoride opacities present on one or more maxillary six anterior teeth.

Some of the orthodontic characteristics of the participants have also been listed in Table 4-2. Very few study participants had these types of malocclusion. Based on the assessment of occlusal characteristics at age 17, only 3.8% of participants each had an anterior cross-bite or posterior cross-bite, 2.8% had over-jet greater than 4 mm, and 3.0% had an open-bite. About 60% of participants had undergone some sort of orthodontic treatment previously, while about 5% were undergoing active orthodontic treatment. Also, about 25% of participants had had their teeth bleached.

Table 4-2 also shows the four DAI categories that were used to describe the level of malocclusion in the sample. The mean ± SD DAI was 22.29 ± 4.5. Based on Dental Aesthetic Index (DAI) scores, the large majority (about 90%) had DAI scores in the range of 13-25(considered representative of either minor or no malocclusion), 7% had DAI scores in the range of 26-30 (considered representative of definite malocclusion), 2.1% had DAI scores in the range of 31-35(considered representative of severe malocclusion), and only 1.3% had DAI scores greater than 36(considered representative handicapping malocclusion).

Table 4-1. Demographic characteristics of the subjects and their families.

Variable	Percentage	
Adolescent's sex	(N=373)	
Male	45.6	
Female	54.4	
Parent's sex	(N=367)	
Male	7.9	
Female	92.1	
Adolescent's race/ethnicity	(N=373)	
Non-Hispanic White	95.7	
Other	4.3	
Family income (2007)*	(N=355)	
< $40,000	13.0	
$40,000 - $79,000	38.0	
≥ $80,000	49.0	
Parent's educational Level (2007)*	Mother (N=363)	Father (N=362)
Some high school, HS diploma /GED	9.1	19.3
Some college education or 2-year college degree	40.2	29.8
4-year college degree or higher	50.1	41.2
Unknown	0.6	9.7
Age at dental visit (years)	(N=373)	
< 17.5	36.5	
17.5 to < 18	39.8	
18 to <18.5	15.7	
First born child	(N=373)	
Yes	56	
No	44	

* Based on the IFS 2007 demographics questionnaire.

Table 4-2. Dental examination findings.

Variable	Percentage
Caries experience (D_2FS whole mouth)	(N=373)
0	37.3
1-4	35.1
5+	27.6
Number of D_1S lesions on six maxillary anterior teeth	(N=373)
0	85.2
1-4	10.2
5+	4.6
Non-fluoride enamel opacities on six maxillary anterior teeth	(N=373)
Yes	14.0
No	86.0
Maximum FRI score on maxillary anterior teeth	(N=373)
0	48.0
1	30.0
2	20.0
3	2.0
Number of six maxillary anterior teeth with definitive fluorosis (FRI score 2/3)	(N=373)
0	83.4
1	4.3
2	5.9
3	2.1
4	2.4
5	1.1
6	0.8
Vertical jaw relationship	(N=372)
Normal	97.0
Open bite	3.0
Transverse relationship	(N=372)
Normal	96.0
Posterior crossbite	4.0
Anterior-posterior relationship	(N=372)
Normal	93.5
Crossbite	3.8
More than 4mm overjet	2.7
DAI score categories (description)	(N=373)
DAI 13-25 (minor or no malocclusion)	89.6
DAI 26-30 (definite malocclusion)	7.0
DAI 31-35 (severe malocclusion)	2.1
DAI >36 (handicapping malocclusion)	1.3

Other medical conditions

In addition to the dental findings, some other medical information was also obtained from the participants, such as information related to the presence of attention deficit hyperactivity disorder, anxiety, depression, musculoskeletal disease, diabetes, and developmental disorders. This information is presented in Tables 4-3 and 4-4.

Table 4-3 shows the distribution of Attention Deficit Hyperactivity Disorder (ADHD), anxiety, depression, and musculoskeletal disorders. Table 4-4 shows the distribution of diabetes and developmental disorders in the study participants. About 1% of participants suffered from diabetes, and about 1% had any developmental disorder.

Table 4-3. Distribution of Attention Deficit Hyperactivity Disorder (ADHD), anxiety, depression, and musculoskeletal disorders.

Condition	Frequency Distribution (%)		
	Current	None	Past
ADHD only	17 (4.3)	375 (95.2)	2(0.5)
ADHD/anxiety/depression	58 (14.7)	318 (80.7)	18 (4.6)
Musculoskeletal disorder	4 (1.0)	386 (98.0)	4 (1.0)

Table 4-4. Distribution of diabetes and developmental disorders.

Condition	Frequency Distribution (%)	
	Present	Absent
Diabetes	3 (0.8)	391 (99.2)
Any Developmental Disorder	3 (0.8)	361 (99.2)

Descriptive information for esthetic perceptions of

adolescents' front teeth and their OHRQoL

Table 4-5 and Table 4-6 show the distribution of the Likert-type scale rankings

for parents' and adolescents' perceptions of the adolescents' overall health and overall

well-being. In particular, these two questions ask the parents and the adolescents about

the health of adolescents' teeth, lips, mouth, jaws, and their effect on the life of the

adolescents. Table 4-5 shows the descriptive statistics for parents' and adolescents'

perception of the overall health of the adolescents' teeth, lips, mouth, and jaws.

Comparatively more parents (36.7%) than children (21.2%) rated the overall health of

adolescents' teeth ,lips, mouth, and jaws, as 'excellent', with many more parents and

children reporting very good overall oral health of the adolescents (45.4% and 48.8%

respectively).

Table 4-6 shows the descriptive statistics for parents' and adolescents' response to

the question, 'how much is the adolescent's overall well-being affected by the condition

of his/her teeth, lips, mouth, or jaws?' About 52% parents and about 45% adolescents

answered that the adolescents' overall well-being was 'not at all' affected by the condition of their teeth, lips, mouth, or jaws.

Tables 4-7 to 4-16 show the distributions of the Likert-type scale rankings for parents' and adolescents' perceptions about the appearance of the adolescent's teeth. Table 4-7 shows the descriptive statistics for parents' and adolescents' perceptions of the color of the adolescents' teeth. More parents found the color of their adolescents' teeth to be 'very attractive' as compared to the adolescents themselves.

Among adolescents, about 12% adolescents rated their teeth as 'very attractive', about 34% as 'somewhat attractive', 43% as 'just ordinary', about 10% as 'somewhat unattractive', and only one percent as 'very unattractive'. Among parents, about 29% rated their adolescents' teeth as 'very attractive', 27% as 'very attractive', 27% as 'somewhat attractive', 37% as 'just ordinary', seven percent as 'somewhat unattractive', and only about one percent as 'very unattractive'.

Table 4-8 shows the descriptive statistics for parents' and adolescents' desire to change the color of the adolescents' teeth. More adolescents (about 23%) than parents (about nine percent) answered 'definitely yes' to their 'desire to change the color of the adolescents' teeth'. Also, about 40% of adolescents answered 'probably yes' to their 'desire to change the color of their teeth'. This may be because adolescents are more critical of the color of their teeth as compared to their parents.

Table 4-5. Descriptive statistics for parents' and adolescents' perceptions of the overall oral health of the adolescents.

	Frequency distribution (%)	
Perceptions of the overall oral health of the adolescent	Child	Parent
Excellent	82 (21.2)	135 (36.7)
Very Good	182 (48.8)	167 (45.4)
Good	93 (24.9)	57 (15.5)
Fair	12 (3.2)	9 (2.5)
Poor	4 (1.1)	0 (0)

Table 4-6. Descriptive statistics for parents' and adolescents' perceptions of the extent to which the overall life of the adolescents is affected by their oral health.

	Frequency distribution (%)	
How much does the condition of adolescents' teeth, lips, mouth, or jaws affect their life overall?	Child	Parent
Not at all	166 (44.5)	190 (51.8)
Very little	131 (35.1)	119 (32.4)
Somewhat	52 (13.9)	32 (8.7)
A lot	18 (4.8)	18 (4.9)
Very much	6 (1.6)	8 (2.2)

Table 4-7. Descriptive statistics for parents' and adolescents' perception of the color of the adolescents' teeth.

Color of teeth	Frequency distribution (%)	
	Child	Parent
Very attractive	46 (12.4)	108 (29.3)
Somewhat attractive	126 (33.9)	99 (26.9)
Just ordinary	160 (43.0)	132 (35.9)
Somewhat unattractive	36 (9.7)	26 (7.1)
Very unattractive	4 (1.1)	3 (0.8)

Table 4-8. Descriptive statistics for parents' and adolescents' desire to change the color of the adolescents' teeth.

Desire to change the color of the adolescents' teeth	Frequency distribution (%)	
	Child	Parent
Definitely yes	85 (22.8)	34 (9.2)
Probably yes	149 (39.9)	82 (22.3)
Neutral	62 (16.6)	101 (27.5)
Probably no	59 (15.8)	94 (25.5)
Definitely not	18 (4.8)	57 (15.5)

Table 4-9 shows the descriptive statistics for parents' and adolescents' perception of the shape of the adolescent's teeth. More parents (about 45%) than adolescents (about 23%) found the shape of the adolescents' teeth to be 'very attractive'. Among

adolescents, about 35% found the shape of their teeth to be 'somewhat attractive', about 35% as 'just ordinary', and about six percent and 0.5% as 'somewhat unattractive' and 'very unattractive' respectively. Among parents, about 27% found the shape of their adolescents' teeth to be 'somewhat attractive', about 25% as 'just ordinary', and about 3% and 0.5% as 'somewhat unattractive' and 'very unattractive' respectively.

Table 4-10 shows the descriptive statistics for parents' and adolescents' desire to change the shape of the adolescent's teeth. About 14% of adolescents answered that they probably wanted to change the shape of their teeth as compared to six percent of parents who expressed their desire to change the shape of their adolescents' teeth. On the other hand, about 72% of parents and about 55% of adolescents answered either 'probably no' or 'definitely not' to their desire to change the shape of the adolescents' teeth.

Table 4-9. Descriptive statistics for parents' and adolescents' perception of the shape of the adolescents' teeth.

	Frequency distribution (%)	
Shape of adolescents' teeth	Child	Parent
Very attractive	86 (23.1)	167 (45.4)
Somewhat attractive	131 (35.1)	100 (27.2)
Just ordinary	130 (34.9)	90 (24.5)
Somewhat unattractive	24 (6.4)	9 (2.5)
Very unattractive	2 (0.5)	2 (0.5)

Table 4-10. Descriptive statistics for parents' and adolescents' desire to change the shape of the adolescents' teeth.

	Frequency distribution (%)	
Change Shape	Child	Parent
Definitely yes	18 (4.8)	13 (3.5)
Probably yes	51 (13.7)	22 (6.0)
Neutral	95 (25.5)	67 (18.2)
Probably no	116 (31.2)	119 (32.3)
Definitely not	92 (24.7)	147 (40.0)

Table 4-11 shows the descriptive statistics for parents' and adolescents' perceptions of the extent of malocclusion of the adolescent's front teeth. About 73% of adolescents found their teeth to be 'not crooked at all', while about 80% of parents thought that their adolescent's teeth were 'not crooked at all'.

Table 4-12 shows the descriptive statistics for parents' and adolescents' desire to straighten the adolescent's front teeth. Adolescents and their parents did not differ much on their 'desire to straighten the adolescents' teeth'.

Table 4-13 shows the descriptive statistics for parents' and adolescents' perceptions of the extent of staining of the adolescent's front teeth. About 33% of adolescents and about 45% of parents thought that the adolescents' teeth were 'not at all stained'. About 60% of adolescents and about 51% of parents thought that the adolescents' teeth were 'just slightly stained'.

Table 4-11. Descriptive statistics for parents' and adolescents' perceptions of the extent of malocclusion of the adolescents' front teeth.

	Frequency distribution (%)	
Front teeth	Child	Parent
Very crooked	0 (0)	2 (0.5)
Substantially crooked	9 (2.4)	4 (1.1)
A little bit crooked	88 (23.6)	68 (18.5)
Not crooked at all	276 (73.4)	294 (79.9)

Table 4-12. Descriptive statistics for parents' and adolescents' desire to straighten the adolescents' front teeth.

	Frequency distribution (%)	
Straighten teeth	Child	Parent
Definitely yes	20 (5.4)	18 (4.9)
Probably yes	44 (11.8)	31 (8.4)
Neither yes or no (neutral)	63 (16.9)	71 (19.3)
Probably no	93 (24.9)	76 (20.7)
Definitely not	153 (41.0)	172 (46.7)

Table 4-13. Descriptive statistics for parents' and adolescents' perceptions of the extent of staining of the adolescent's front teeth

	Frequency distribution (%)	
Teeth Stained	Child	Parent
Very badly stained	1 (0.3)	4 (1.1)
Badly stained	23 (6.2)	11 (3.0)
Just slightly stained	224 (60.2)	188 (51.4)
Not at all stained	124 (33.3)	163 (44.5)

Table 4-14 shows the descriptive statistics for parents' and adolescents' perceptions of whether the adolescent 'can make his/her teeth look clean when he/she tries hard to brush them'. About 35% of adolescents and about 44% of parents thought that the adolescents' teeth looked clean when he/she tries hard to brush them.

Table 4-14. Descriptive statistics for parents' and adolescents' perceptions of whether the adolescent 'can make his/her teeth look clean when he/she tries hard to brush them'.

	Frequency distribution (%)	
Look clean	Child	Parent
Yes	131 (35.1)	162 (44.1)
Almost	132 (35.4)	127 (34.6)
Not quite	91 (24.4)	59 (16.1)
Definitely not	19 (5.1)	9 (2.5)
Did not try	-	10 (2.7)

Tables 4-15 and 4-16 show the descriptive statistics for parents' and adolescents' satisfaction with the adolescent's teeth. About 83% of adolescents and parents were either satisfied or very satisfied with the appearance of the adolescents' teeth.

Table 4-15. Descriptive statistics for adolescents' satisfaction with the appearance of their front teeth.

Adolescents' satisfaction with appearance of front teeth	Frequency distribution (%)
Very satisfied	89 (23.9)
Satisfied	221 (59.3)
Somewhat dissatisfied	55 (13.9)
Dissatisfied	11 (2.9)

Table 4-16. Descriptive statistics for parents' satisfaction with the appearance of their adolescents' front teeth.

Parents' satisfaction with appearance of adolescents' front teeth	Frequency distribution (%)
Very satisfied	145 (39.5)
Satisfied	159 (43.3)
Neutral	38 (10.3)
Dissatisfied	21 (5.7)
Very dissatisfied	4 (1.1)

Table 4-17 shows the descriptive statistics for parents' and adolescents' perceptions of the adolescents' oral health-related quality of life (OHRQoL) and global oral health rating (GOHR). Among adolescents, the mean scores for the four domains of the Child Perception Questionnaire (CPQ), i.e., oral symptoms, functional limitations, emotional well-being, and social well-being, were 4.1, 1.3, 2.4, and 0.9, respectively (higher scores suggest worse OHRQoL). Among parents, the mean scores for the four

domains of the Parent Perception Questionnaire (PPQ), i.e., oral symptoms, functional

limitations, emotional well-being, and social well-being, were 4.4, 2.7, 1.6, and 1.6

respectively (higher scores suggest worse OHRQoL). The mean composite scores for

CPQ and PPQ were 8.7 and 10.3, respectively (higher scores suggest worse OHRQoL);

whereas the mean GOHR scores for adolescents and parents was 86.6 and 91.2,

respectively (higher scores suggest better OHRQoL).

Table 4-17. Descriptive statistics for parents' and adolescents' perceptions of the
adolescents' OHRQoL (N=373).

	Adolescents		Parents	
Domains	Median Score (25th %ile, 75th %ile)	Mean (SD)	Median Score (25th%ile, 75th%ile)	Mean (SD)
Oral symptoms	4 (2,6)	4.1 (2.6)	3 (1,6)	4.4 (5.1)
Functional limitations	0 (0,2)	1.3 (2.2)	0 (0,4)	2.7 (5.2)
Emotional well-being	1 (0,3)	2.4 (4.2)	0 (0,1)	1.6 (4.2)
Social well-being	0 (0,1)	0.9 (2.2)	0 (0,1)	1.6 (5.2)
Total/ composite score	6 (3,12)	8.7 (8.2)	5 (2,11)	10.3 (15.4)
Global oral health rating	90 (80,95)	86.6 (12.2)	95 (88,98)	91.2 (11.5)

Bivariate analyses

Table 4-18 shows the bivariate analyses of OHRQoL composite score of

adolescents (CPQ total score) and parents (PPQ total score) with various independent

variables. The following variables were significant at the $P \leq 0.15$ significance level in bivariate analyses for adolescents: sex, family income, father's education level, low birth weight, fluorosis (two or more teeth with FRI score 2/3), dental caries, anterior cross-bite, active orthodontic treatment, any orthodontic treatment, dental caries, and current ADHD/anxiety/depression.

Female participants tended to have higher CPQ composite scores as compared to male participants ($P = 0.005$), thus suggesting less favorable OHRQoL in females as compared to males. Participants belonging to families with higher income tended to have lower CPQ composite scores as compared to participants belonging to families with lower income ($P = 0.02$). This suggests that higher income group participants tended to have better OHRQoL as compared to their counterparts from lower income groups. The CPQ composite score tended to be higher (suggesting worse OHRQoL) in those adolescents whose father's education level was less than 4-year college degree as compared to those whose father's education level was greater than or equal to 4-year college degree ($P = 0.14$). Adolescents with dental fluorosis (two or more teeth with FRI score 2/3) tended to have lower CPQ composite scores (suggesting better OHRQol) as compared to adolescents who did not have dental fluorosis. Adolescents who had an anterior cross-bite tended to have higher CPQ composite scores (suggesting worse OHRQoL) as compared to those without anterior cross-bites ($P = 0.07$). Adolescents undergoing active orthodontic treatment tended to have higher CPQ composite scores (suggesting worse OHRQoL) as compared to those who were not undergoing active orthodontic treatment ($P < 0.001$). Adolescents who had undergone any orthodontic treatment in the past tended to have lower CPQ composite scores (suggesting better

OHRQoL) as compared to those who had not undergone any orthodontic treatment in the past. Adolescents with more dental caries (D_2FS lesions) tended to have higher CPQ composite scores (suggesting worse OHRQoL) as compared to those with lesser dental caries (D_2FS lesions) (P = 0.04).

The following variables were significant at the $P \leq 0.15$ significance level in bivariate analyses for the parents: family income, single-mom, low birth weight, fluorosis (One or more teeth with FRI score 2/3), overjet > 4mm, missing anterior teeth, DAI score, active orthodontic treatment, and current ADHD/anxiety/depression.

Parents who had higher annual family income tended to have lower PPQ composite scores (suggesting better OHRQoL of their children) as compared to parents with lower family income (P < 0.001). The PPQ composite scores tended to be higher (suggesting worse OHRQoL) for parents whose children had dental fluorosis (one or more teeth with FRI score 2/3) as compared to parents whose children did not have dental fluorosis (P =0.07). The PPQ composite scores tended to be higher (suggesting worse OHRQoL) for parents whose children had overjet > 4mm as compared to parents whose children did not have overjet > 4mm (P = 0.06).). The PPQ composite scores tended to be higher (suggesting worse OHRQoL) for parents whose children had any of their six anterior teeth missing, as compared to parents whose children did not have any of their six anterior teeth missing (P = 0.05). The PPQ composite scores tended to be higher (suggesting worse OHRQoL) for parents whose children had higher DAI scores (DAI $\geq$ 31) as compared to those who had lower DAI scores (DAI= 13-30) (P = 0.02). The PPQ composite scores tended to be higher (suggesting worse OHRQoL) for parents whose

children were undergoing active orthodontic treatment as compared to those whose children were not undergoing active orthodontic treatment (P = 0.004).

Table 4-19 shows the bivariate analyses of the Global Oral Health Rating (GOHR) measure of the OHRQoL of adolescents (assessed by both adolescents and parents) with various independent variables. The following variables were significant at the P ≤ 0.15 significance level in bivariate analyses for adolescents: family income, father's education level, single mom, low birth weight, DAI score, active orthodontic treatment, any orthodontic treatment, and any bleaching. The following variables were significant at the P ≤ 0.15 significance level in bivariate analyses for parents: family income, mother's education, low birth weight, anterior cross-bite, DAI score, active orthodontic treatment, any orthodontic treatment, dental caries, and current ADHD/anxiety/depression.

Participants belonging to families with higher income tended to have higher GOHR scores (suggesting better OHRQoL) as compared to participants belonging to families with lower income (P= 0.06). Adolescents with lower DAI scores (13-30) tended to have higher GOHR scores (suggesting better OHRQoL) as compared to those with higher DAI scores (≥ 31) (P = 0.05). Adolescents undergoing active orthodontic treatment tended to have lower GOHR scores (suggesting worse OHRQoL) as compared to adolescents who were not undergoing active orthodontic treatment (P = 0.004). Adolescents who had undergone any orthodontic treatment in the past tended to have higher GOHR scores (suggesting better OHRQoL) as compared to those who had not undergone any past orthodontic treatment (P = 0.03).

Table 4-18.Bivariate analyses of OHRQoL composite score of adolescents (CPQ total score) and parents (PPQ total score) with various independent variables (N=373).

Dependent Variable	Independent Variable	Type of Independent Variable	Adolescent			Parent		
			N	Median (25%, 75%)	P-value[i]	N	Median (25%, 75%)	P-value[i]
OHRQoL Composite Score (CPQ/PPQ)	Sex	Male	179	6 (3,11)	**0.005**	180	6 (2,14)	0.24
		Female	214	7.5 (4,13)		208	6 (2,14)	
	Family income	< $40,000	49	8 (4,14)	**0.02**	48	9.5 (2,23)	**<0.001**
		$40,000 to $79,000	144	8 (4,15.5)		144	7.5 (2.5,17)	
		≥ $80,000	181	6 (3,10)		179	4 (1,7)	
	Mother's education level	≥ 4-year college degree	193	6 (4,12)	0.96	191	5 (2,11)	0.26
		< 4-year college degree	187	7 (3,13)		187	6 (2,15)	
	Father's education level	≥ 4-year college degree	155	6 (3,10)	**0.14**	154	4.5 (2,10)	0.22
		< 4-year college degree	189	7 (3,13)		187	5 (2,14)	
	Single-mom	No	344	6 (3,12)	0.37	341	5 (2,11)	**0.10**
		Yes	37	8 (3,15)		37	9 (2,15)	

Table 4-18 Continued.

Low birth weight	< 2.5 kg	14	10.5 (6,15)	**0.07**	13	9 (8,20)	**0.02**
	> = 2.5 kg	379	6 (3,12)		375	5 (2,11)	
Fluorosis (Flu1plus[ii])	No	330	7 (3,12)	0.29	327	5 (2,11)	**0.07**
	Yes	63	5 (3,10)		61	7 (3,16)	
Fluorosis (Flu2plus[iii])	No	346	7 (3,12)	**0.09**	342	5 (2,11)	0.32
	Yes	47	5 (3,9)		46	7 (2,12)	
Non-fluoride opacities	No	340	6 (3.5,12)	0.42	335	5 (2,11)	0.80
	Yes	53	7 (3,11)		53	5 (2,11)	
Anterior cross-bite	No	376	6 (3,12)	**0.07**	371	5 (2,11)	0.41
	Yes	15	10 (5,17)		15	10 (1,23)	
Posterior cross-bite	No	377	6 (3,12)	0.34	372	5 (2,11)	0.81
	Yes	15	8 (3,20)		15	9 (0,20)	
Open-bite	No	379	6 (3,12)	0.33	374	5 (2,11)	0.23
	Yes	12	5 (2,10)		12	6.5 (2.5,39)	
Overjet > 4 mm	No	380	6 (3,12)	0.35	376	5 (2,11)	**0.06**
	Yes	11	9 (5,11)		10	9 (5,31)	
Missing anterior teeth	No	382	6 (3,12)	0.60	377	5 (2,11)	**0.05**
	Yes	11	8 (3,30)		11	8 (5,29)	
DAI score	DAI 13-30	220	6 (3,12)	0.33	219	5 (2,11)	**0.02**

Table 4-18. Continued.

		DAI ≥ 31	14	7 (5,22)		14	10 (5,24)	
	Active orthodontic treatment	No	372	6 (3,12)	**<0.001**	367	5 (2,11)	**0.004**
		Yes	21	15 (9,20)		21	11 (4,32)	
	Any orthodontic treatment	No	153	8 (4,13)	**0.06**	152	5 (2,11)	0.77
		Yes	231	6 (3,11)		228	5 (2,11)	
	Any bleaching	No	287	6 (3,12)	0.60	284	5 (2,11)	0.68
		Yes	97	7 (4,12)		96	6 (2,11)	
	Current ADHD/anxiety/depression	No (none and past)	336	6 (3,11)	**<0.001**	331	5 (2,11)	**0.09**
		Yes (current)	57	10 (6,19)		57	7 (2,14)	
	Dental caries (D_2FS)	$D_2FS = 0$	145	6 (3,9)	**0.04**	143	5 (1,10)	0.25
		$D_2FS = 1$-4	141	6 (4,13)		140	6 (2,14.5)	
		$D_2FS = 5$-40	107	8 (3,13)		105	6 (2,14)	

[i] Wilcoxon Rank Sum test for 2-level variables and Kruskal-Wallis test for 3 levels or more.

[ii] One or more teeth with FRI score 2/3.

[iii] Two or more teeth with FRI score 2/3.

Table 4-19.Bivariate analyses of global oral health rating (GOHR) of adolescents and parents with various independent variables (N=373).

Dependent Variable	Independent Variable	Type of Independent Variable	Adolescent GOHR			Parent GOHR		
			N	Median (25%, 75%)	P-value[i]	N	Median (25%, 75%)	P-value[i]
Global Oral Health Rating question	Sex	Male	177	90 (80,95)	0.39	177	95 (90,98)	0.24
		Female	207	90 (80,95)		204	95 (85,98)	
	Family Income	< $40,000	49	85 (75,95)	**0.058**	47	90 (80,98)	**0.02**
		$40,000 to $79,000	140	90 (80,95)		142	95 (85,98)	
		≥ $80,000	176	95 (90,98.5)		176	95 (90,98.5)	
	Mother's Education level	≥ 4- year college degree	187	90 (80,95)	0.41	189	95 (90,99)	**0.02**
		< 4-year college degree	185	90 (80,95)		183	90 (85,98)	
	Father's Education level	≥ 4- year college degree	151	90 (85,95)	**0.03**	153	95 (90,98)	0.22
		< 4-year college degree	185	89 (80,95)		183	95 (88,98)	
	Single-mom	No	336	90 (80,95)	**0.11**	336	95 (90,98)	0.63
		Yes	37	85 (75,95)		36	95 (82.5,99)	
	Low birth weight	< 2.5 kg	370	90 (80,95)	**0.05**	368	95 (90,98)	**0.07**
		> = 2.5 kg	14	82.5 (80,88)		13	90 (85,95)	

Table 4-19. Continued.

	Fluorosis (Flu1plus[ii])	No	322	90 (80,95)	0.69	322	95 (88,98)	0.82
		Yes	62	90 (80,95)		59	95 (90,98)	
	Fluorosis (Flu2plus[iii])	No	338	90 (80,95)	0.83	336	95 (90,98)	0.94
		Yes	46	90 (80,95)		45	95 (85,99)	
	Non-fluoride Opacities	No	331	90 (80,95)	0.51	328	95 (88,98)	0.46
		Yes	53	90 (80,95)		53	95 (90,97)	
	Anterior Cross-bite	No	369	90 (80,95)	0.29	365	95 (90,98)	**0.07**
		Yes	13	85 (75,95)		15	90 (60,99)	
	Posterior Cross-bite	No	368	90 (80,95)	0.20	366	95 (90,98)	0.69
		Yes	15	85 (65,95)		14	95 (85,98)	
	Open-bite	No	370	90 (80,95)	0.72	368	95 (90,98)	0.74
		Yes	12	92 (77.5,99.5)		12	95 (82.5,99)	
	Overjet > 4 mm	No	371	90 (80,95)	0.63	370	95 (90,98)	0.29
		Yes	11	90 (85,95)		10	91 (85,97)	
	Missing Anterior Teeth	No	373	90 (80,95)	0.23	370	95 (90,98)	0.20
		Yes	11	80 (75,95)		11	90 (80,99)	
	DAI Score	DAI 13-30	216	90 (80,95)	**0.05**	217	95 (90,98)	**0.02**

Table 4-19. Continued.

		DAI $\geq$ 31	13	80 (63,90)		14	87 (65,95)	
Active Orthodontic treatment	No	365	90 (80,95)	**0.004**	361	95 (90,98)	**0.005**
	Yes	19	80 (75,86)		20	85 (81,91)	
Any orthodontic treatment	No	149	88 (80,95)	**0.03**	150	90 (87,98)	**0.03**
	Yes	226	90 (80,95)		223	95 (90,99)	
Any Bleaching	No	282	89.5 (80,95)	**0.03**	278	95 (88,98)	0.18
	Yes	93	90 (83,97)		95	95 (90,99)	
Current ADHD/Anxiety/Depression	No (none and past)	329	90 (80,95)	0.21	327	95 (90,98)	**0.007**
	Yes (current)	55	87 (75,95)		54	90 (80,98)	
Dental Caries (D$_2$FS)	D$_2$FS = 0	142	90 (80,95)	0.23	142	95 (90,99)	**0.002**
	D$_2$FS = 1-4	137	90 (80,95)		136	95 (90,98.5)	
	D$_2$FS = 5-40	105	90 (80,95)		103	90 (85,97)	

[i] Wilcoxon Rank Sum test for 2-level variables and Kruskal-Wallis test for 3 levels or more.

[ii] One or more teeth with FRI score 2/3.

[iii] Two or more teeth with FRI score 2/3.

Table 4-20 shows the Spearman correlations between fluorosis scores and OHRQoL measures (i.e., CPQ/PPQ and GOHR-teens/parents). None of the Spearman correlations were significant at $P \leq 0.05$.

Table 4-20. Spearman correlations between fluorosis scores
 (assessed on 6 maxillary anterior teeth) and OHRQoL measures
(CPQ/PPQ and GOHR) (N=373)

	Adolescent	Parent
	Rho*	Rho
CPQ/PPQ composite score	-0.02 P=0.62	0.09 P=0.07
GOHR	-0.0004 P=0.99	0.007 P=0.89

*Spearman's rho is the coeffIcient's name

Table 4-21 shows the correlations between subscales, the overall CPQ/PPQ

scores, and the global oral health ratings for adolescents and parents. The OHRQoL

subscales (except global oral health rating) are scored with higher responses

corresponding to lower quality. As expected, many significant correlations were found.

The Spearman correlations for parents' and adolescents' OHRQoL scores and ratings

were positively correlated, with social well-being and global oral health ratings being

significantly correlated.

Table 4-21. Matrix of correlations among adolescents' and parents' CPQ/PPQ domain scores, composite score, and Global Oral Health Rating (N=374).

	Subscale	Oral Symptoms	Functional Limitations	Emotional Well-Being	Social Well-Being	Composite Score	Global Oral Health Rating
				Adolescent			
Parent	Oral Symptoms	0.23 P<0.001	0.20 P=0.001	0.11 P=0.03	0.17 P=0.001	0.25 P<0.001	-0.07 P=0.20
	Functional Limitations	0.20 P<0.001	0.24 P<0.001	0.14 P=0.007	0.17 P=0.001	0.25 P<0.001	-0.12 P=0.02
	Emotional Well-Being	0.13 P=0.01	0.15 P=0.00	0.34 P<0.001	0.30 P<0.001	0.31 P<0.001	-0.22 P<0.001
	Social Well-Being	0.11 P=0.04	0.18 P<0.001	0.23 P<0.001	0.38 P<0.001	0.30 P<0.001	-0.17 P=0.001
	Composite Score	0.24 P<0.001	0.23 P<0.001	0.21 P<0.001	0.26 P<0.001	0.33 P<0.001	-0.12 P=0.02
	Global Oral Health Rating	-0.18 P<0.001	-0.14 P=0.006	-0.26 P<0.001	-0.23 P<0.001	-0.29 P<0.001	0.44 P<0.001

Spearman Correlation Coefficients, Prob > |r| under H0: Rho=0

Table 4-22 shows the comparison of adolescents' and parents' composite scores and Global Oral Health Ratings. Adolescents had higher scores than parents for the emotional well-being domain whereas parents scored higher for the functional limitations domain of the OHRQoL questionnaire (rated higher as lower OHRQoL). On the other hand, adolescents scored lower for the GOHR (rated higher as better OHRQoL) as

compared to their parents.

Table 4-22. Comparison of adolescents' and parents' composite scores and
Global Oral Health Ratings (N=374).

Dependent variable	Wilcoxon Sign Rank	P-value	Result
Functional limitations	-4036.0	<0.0001	parent >adolescent
Oral symptoms	1843.5	0.26	NS
Emotional well-being	4912.0	<0.0001	adolescent > parent
Social well-being	226.5	0.64	NS
Composite score	1022.0	0.56	NS
Global oral health rating	-12287.0	<0.0001	Parent > adolescent

Multivariable analyses

The multivariable models were developed using two different sample sizes, as

follows:

1. Main analytical model: using the main analytical sample (i.e., with DAI measurement

   only, n = 222).

   a. Primary dependent variable = CPQ (rated higher as worse)

   b. Primary dependent variable =PPQ (rated higher as worse)

   c. Secondary dependent variable = GOHR-adolescent (rated higher as better)

d. Secondary dependent variable = GOHR-parent (rated higher as better)

2. Comparison model: using an expanded sample (i.e., with median DAI score

imputation, n=346).

a. Primary dependent variable = CPQ (rated higher as worse)

b. Primary dependent variable =PPQ (rated higher as worse)

c. Secondary dependent variable = GOHR-adolescent (rated higher as better)

d. Secondary dependent variable = GOHR-parent (rated higher as better)

Multivariable analyses for primary dependent variables-

CPQ and PPQ scores

Multivariable analyses for primary dependent variable CPQ

score (i.e., OHRQoL composite score for adolescent)

Model 1: Main analytical sample (with DAI measurement,

n= 222)

 Table 4-23 shows the multivariable analysis for OHRQoL composite score for

adolescents (CPQ) for the 222 children with DAI scores. The independent variables

included in the model were: adolescent's sex, annual family income, dental fluorosis,

dental caries experience (D_2FS), DAI score, anterior cross-bite, overjet > 4mm, and past

orthodontic treatment. The following variables were statistically significant at the $P \leq 0.05$

level: sex, dental caries, and DAI score. The estimates show the direction for change of

conditional medians. For example, girls had higher median CPQ estimates (suggesting

worse OHRQoL) as compared to boys (P = 0.04), adolescents with D_2FS scores

(cavitated caries experience) of zero (P = 0.006) and one to four (P = 0.03) had lower

median CPQ estimates (suggesting better OHRQoL) as compared to adolescents with higher (5+) D_2FS scores, and adolescents with higher DAI scores had higher median CPQ estimates (suggesting worse OHRQoL) as compared to adolescents with lower DAI scores (P = 0.02). In terms of the magnitude of the differences, the parameter estimates for all the statistically significant variables (at P ≤ 0.05) in the model have been interpreted below:

Being a girl was associated with a 1.98 units increase in the conditional median of the CPQ score (P = 0.03), keeping all other variables in the model fixed. Similarly, being in the $D_2FS=0$ category (category 1) was associated with a decrease of 3.17 units in the conditional median of the CPQ score (P = 0.006) compared with being in the $D_2FS \geq 5$ (category 3), and a one unit increase in the DAI score was associated with a 0.29 units increase in the conditional median of the CPQ score (P = 0.02) (higher score suggesting worse OHRQoL).

Model 2: Expanded sample with median DAI score imputation (n=345)

Model 2 used an expanded sample size by imputing median DAI scores for those subjects who were missing DAI evaluation (discussed previously in Chapter 3).Table 4-24 shows the multivariable analysis for OHRQoL composite score for adolescents (CPQ) on the expanded sample size (n=345). The independent variables included in the model were: adolescent's sex, annual family income, dental fluorosis, dental caries (D_2FS), DAI score, anterior cross-bite, overjet > 4mm, and past orthodontic treatment. The following variables were statistically significant at the P ≤ 0.05 level: sex, dental caries, and DAI score (with imputed median DAI score for those missing DAI rating). The estimates

show the direction for change of conditional medians. For example, girls had higher median CPQ estimates (suggesting worse OHRQoL) as compared to boys (P = 0.004), adolescents with D_2FS scores of zero (i.e., no cavitated caries experience present) had lower median CPQ estimates (suggesting better OHRQoL) as compared to adolescents with D_2FS scores of 5+ (P = 0.006), and adolescents with higher DAI scores had higher median CPQ estimates (suggesting worse OHRQoL) as compared to adolescents with lower DAI scores (P = 0.02). In terms of the magnitude of the differences, the parameter estimates for all the statistically significant variables (at P ≤ 0.05) in the model have been interpreted below:

Being a girl was associated with 2.04 units increase in the conditional median of the CPQ score (P = 0.004), keeping all other variables in the model fixed. Similarly, being in the $D_2FS=0$ category (category 1) was associated with a 1.87 units decrease in the conditional median of the CPQ score (P = 0.04) compared with being in the $D_2FS \geq 5$ (category 3), and a one unit increase in the median imputed DAI score was associated with a 0.29 units increase in the conditional median of the CPQ score (P = 0.02).

Table 4-23. Multivariable analysis for OHRQoL composite score (CPQ) for adolescents (using the main analytical sample i.e., with DAI measurement only, n= 222*)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	1.74	3.07	-4.31	7.80	0.57	0.57
Sex	1	1.98	0.93	0.15	3.82	2.13	**0.03**
Family Income	1	-0.44	1.64	-3.69	2.80	-0.27	0.78
Fluorosis	1	-0.25	1.67	-3.56	3.05	-0.15	0.88
Dental caries							
$D_2FS = 0$	1	-3.17	1.14	-5.43	-0.92	-2.78	**0.006**
$D_2FS = 1\text{-}4$	1	-2.72	1.19	-5.07	-0.37	-2.29	**0.02**
$D_2FS = 5\text{-}40$	0	0.00	0.00	0.00	0.00	.	.
DAI score	1	0.29	0.12	0.04	0.53	2.36	**0.02**
Anterior cross-bite	1	4.68	4.03	-3.27	12.64	1.16	0.24
Overjet > 4mm	1	-2.60	3.71	-9.93	4.72	-0.70	0.48
Past Orthodontic treatment only	1	-0.26	0.98	-2.20	1.68	-0.27	0.79

*One subject was missing information on OHRQoL score (CPQ), so the number of observations used in the regression were 221.

Table 4-24. Multivariable analysis for OHRQoL composite score (CPQ) for adolescents (using the expanded sample with imputed median DAI scores, n = 346*)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	0.80	3.04	-5.17	6.78	0.26	0.79
Sex	1	2.04	0.70	0.65	3.44	2.89	**0.004**
Family income	1	-0.17	1.38	-2.89	2.55	-0.12	0.90
Fluorosis	1	-0.24	0.86	-1.93	1.45	-0.28	0.77
Dental caries							
$D_2FS=0$	1	-1.87	0.90	-3.66	-0.09	-2.07	**0.04**
$D_2FS = 1$-4	1	-1.12	1.02	-3.14	0.89	-1.09	0.27
$D_2FS = 5$-40	0	0.00	0.00	0.00	0.00		.
DAI score							
Measured/imputed DAI score	1	0.29	0.12	0.05	0.53	2.40	**0.02**
No DAI measured	1	-0.41	0.77	-1.93	1.11	-0.53	0.59
Anterior cross-bite	1	4.29	2.65	-0.93	9.52	1.61	0.11
Overjet > 4mm	1	-1.75	2.41	-6.50	2.99	-0.73	0.47
Past orthodontic treatment only	1	-0.70	0.88	-2.44	1.02	-0.80	0.42

*One of the subjects was missing information on OHRQoL score (CPQ), so the number of observations used in the regression analysis were 345.

Sensitivity analysis

In order to assess the sensitivity of the multivariable analyses of the primary

analytical sample using conditional median regression (i.e., model 1), two comparison

regression models were generated: i) using conditional median regression on an expanded

sample size by imputing median DAI scores for those who were missing DAI evaluation (i.e., model 2, n=345), and ii) using ordinary least squares regression on the main analytical sample (i.e., model 3, n=222). The comparisons among the three models have been shown in Table 4-25. Table 4-25 summarizes the statistically significant variables across the three models. It can be seen that dental caries ($D_2FS = 0$), sex, and DAI score were statistically significant in all three models, while dental fluorosis was not significant in any of the models.

Table 4-25.Comparison Table/ Sensitivity Analysis.

Variable	Main Analytical Model [estimate (p-value]	Comparison Models [estimate (p-value]	
	Model 1[i] *(n = 222)*	*Model 2[ii]* *(n = 345)v*	*Model 3[iii]* *(n = 222)*
Sex	1.98 (**0.04**)	2.04 (**0.004**)	2.24 (**0.046**)
Fluorosis	- 0.25 (0.88)	-0.24 (0.77)	0.41 (0.80)
Dental caries ($D_2FS = 0$)	- 3.17 (**0.006**)	-1.87 (**0.04**)	-1.58 (**0.02**)[iv]
Dental caries ($D_2FS = 1$-4)	-2.72 (**0.03**)	-1.12 (0.27)	
DAI Score	0.29 (**0.02**)	0.29 (**0.02**)	0.27 (**0.02**)

[i] Using conditional median regression on the main analytical sample.

[ii] Using conditional median regression on the expanded sample, i.e., with median DAI score imputation.

[iii] Using ordinary least squares regression on the main analytical sample.

[iv] Treating dental caries as a continuous variable.

[v] Median DAI was imputed for n = 374 subjects, but due to missing data the regression analyses resulted in n=345 for the two comparison models.

Two-way interactions

Table 4-26 shows the two-way interactions for all independent variables in the multivariable models, using the main analytical sample (with DAI measurement only, n=222), and the extended sample (with imputed median DAI scores, n=345). For the multivariable model using the primary analytical sample, none of the two-way interactions were significant at $P \leq 0.05$. However, for the multivariable model using the extended sample size (n=345), there were some statistically significant two-way interactions.

For the multivariable model using the extended sample size, the following two-way interactions were significant ($P \leq 0.05$): i) between sex and fluorosis ($P = 0.04$), ii) between sex and past orthodontic treatment ($P = 0.02$), and iii) between low income and past orthodontic treatment ($P = 0.04$). However, different results were achieved when more than one two-way interaction was included in the model, although singly they were each significant. When all three independently significant two-way interactions ($P \leq 0.05$) for the expanded sample size (with imputed DAI scores) were included jointly in the multivariable model, only the interaction between sex and past orthodontic treatment remained statistically significant. The other two independently significant two-way interactions, i.e., the interaction between low income and past orthodontic treatment, and the interaction between sex and fluorosis were not statistically significant in the model including all of the three two-way interactions at the same time.

Table 4-26. Two-way interactions for all independent variables in the multivariable model using the main analytical sample (primary model) and the extended sample (comparison model)

Variable Name	Interaction	P-Value	
		Primary model (n=222)	Comparison model (n=345)
Sex	Sex *Low income	0.47	0.80
	Sex * Fluorosis	0.44	**0.036**
	Sex * Caries (D$_2$FS)	0.93	0.74
	Sex * DAI score	0.48	0.47
	Sex * Anterior crossbite	0.64	0.56
	Sex * Overjet>4mm	0.9	0.49
	Sex * Past orthodontic	0.29	**0.02**
Family income	Family income *Fluorosis	0.54	0.62
	Family income* Caries (D$_2$FS)	0.55	0.62
	Family income*DAI score	0.095	0.09
	Family income*Anterior crossbite	0.46	0.53
	Family income* overjet>4mm[1]	-	0.85
	Low income *Past orthodontic	0.30	**0.047**
Fluorosis	Fluorosis*Caries (D$_2$FS)	0.68	0.95
	Fluorosis *DAI score	0.75	0.74
	Fluorosis *Anterior crossbite	0.79	0.82

Table 4-26. Continued.

	Fluorosis *Overjet>4mm	1.00	0.84
	Fluorosis *Past orthodontic	0.44	0.73
Dental caries (D_2FS)	Caries*DAI score	0.98	0.98
	Caries *Anterior crossbite	0.62	0.80
	Caries *Overjet>4mm	0.97	0.83
	Caries*Past orthodontic	0.87	0.13
DAI score	DAI score*Anterior crossbite	0.80	0.78
	DAI score*Overjet>4mm	0.81	0.81
	DAI score*Past orthodontic	0.70	0.70
Anterior cross-bite	Anterior crossbite*overjet>4mm[ii]	-	-
	Anterior crossbite * Past orthodontic [iii]	-	-
Overjet > 4mm	A_P4mmoverjet* Past orthodontic[iv]	-	-

[i] None of the subjects had both low income and overjet > 4mm.

[ii] None of the subjects had both anterior cross-bite and overjet > 4mm.

[iii] None of the subjects had both anterior cross-bite and past orthodontic treatment only.

[iv] None of the subjects had both overjet > 4mm and past orthodontic treatment only.

Figure 4-1 illustrates the effects of the interaction between sex and past orthodontic treatment on the median CPQ estimates for adolescents (P=0.02). Having had previous orthodontic treatment affected the median CPQ estimates of male subjects differently than it affected the median CPQ estimates of female subjects. For females, there was a substantial decrease in the median CPQ estimate (lower CPQ suggests better OHRQoL) for those who had past orthodontic treatment compared to those who did not. This suggests that undergoing orthodontic treatment substantially improved the OHRQoL in females. For males, there was an increase in the median CPQ estimate of much smaller magnitude.

On the other hand, the magnitude of the difference between male and female median CPQ estimates was much greater for the group of adolescents who had not undergone past orthodontic treatment as compared to the group of adolescents who had undergone orthodontic treatment. Females who had not undergone orthodontic treatment in the past had substantially higher median CPQ estimates, and thus poorer OHRQoL, as compared to their male counterparts who had not undergone past orthodontic treatment. For those who had received previous orthodontic treatment, there was very little difference between female and male median CPQ estimates.
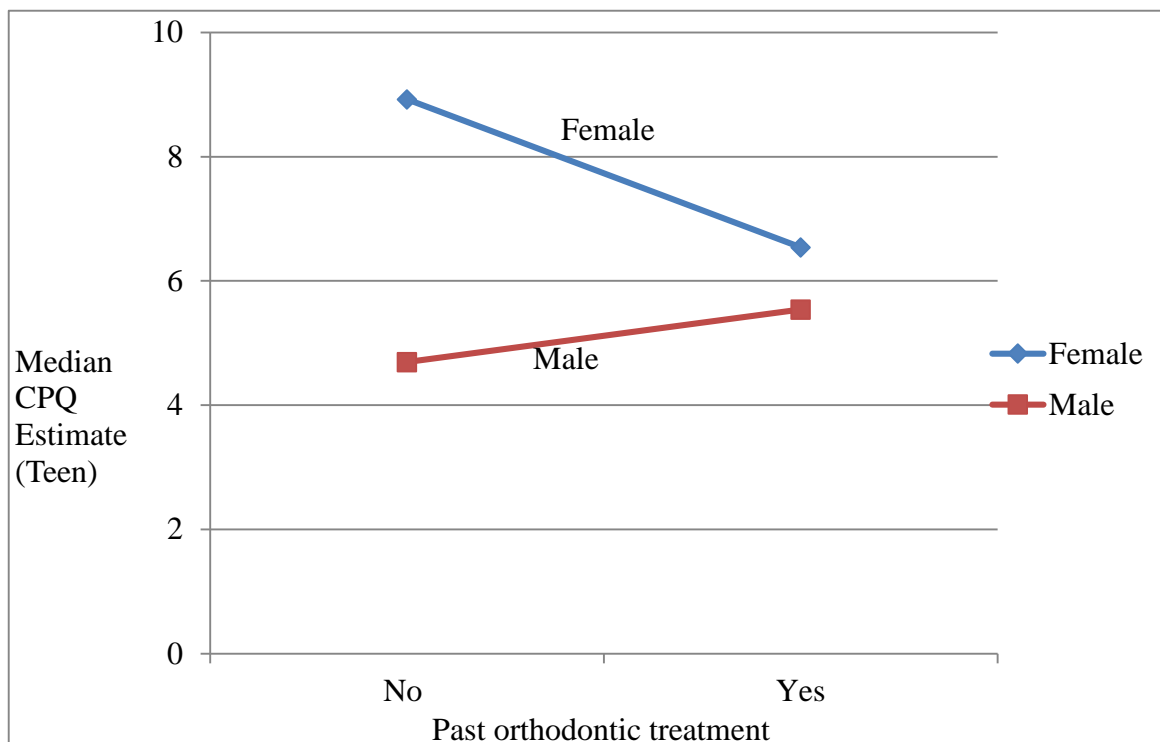
Figure 4-1. Interaction between sex and orthodontic treatment experience

Figure 4-2 illustrates the effects of the interaction between low income and past orthodontic treatment on the median CPQ estimates for adolescents (P=0.047). There was little effect of orthodontic treatment on the median CPQ estimate of adolescents from high income families, while there was a pronounced effect for low income families. In other words, adolescents from low income families who underwent orthodontic treatment in the past had substantially lower median CPQ estimates as compared to adolescents from low income families who did not undergo orthodontic treatment in the past. This suggests that undergoing orthodontic treatment in the past improved the OHRQoL of low income adolescents. On the other hand, for those without previous orthodontic treatment,

there was little difference in the median CPQ estimates for adolescents from low income families vs. adolescents from high income families. However, for those with previous orthodontic treatment, high income adolescents had substantially higher median CPQ estimates.
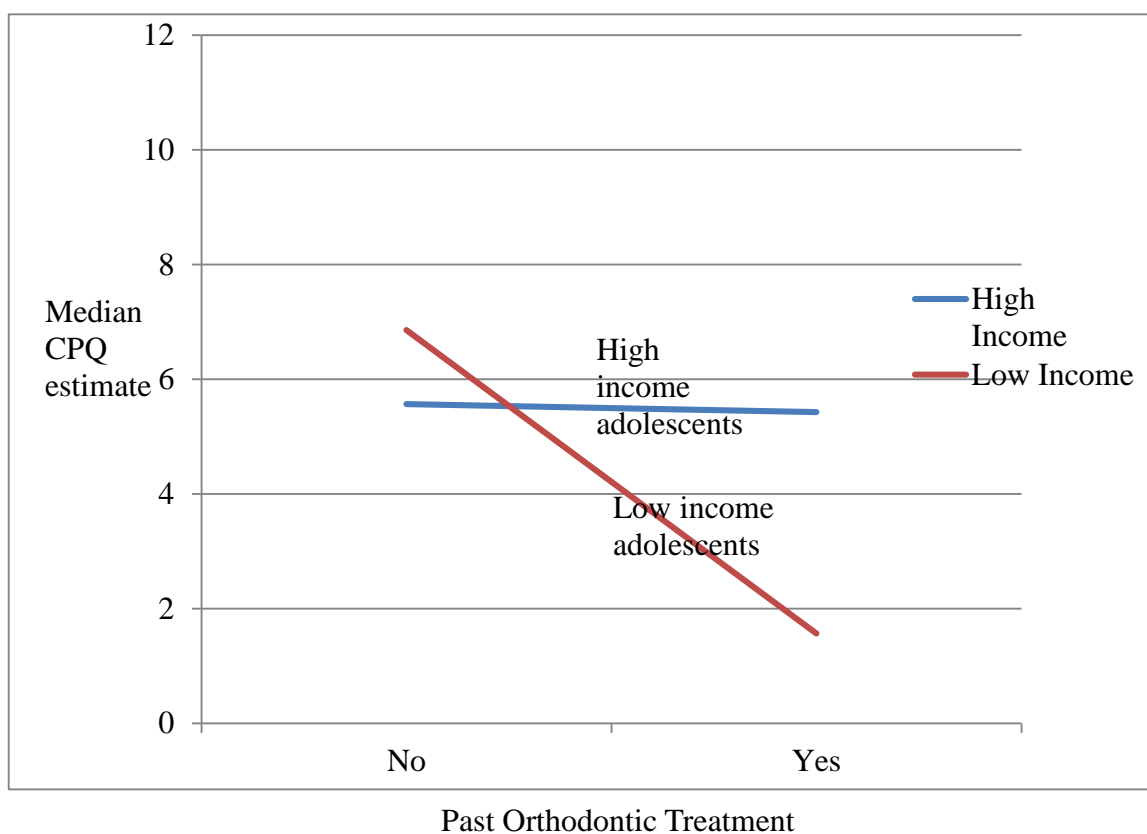
Figure 4-2.Interaction between income and orthodontic treatment experience

Figure 4-3 illustrates the effects of the interaction between sex and dental fluorosis status (having one or more maxillary anterior teeth with a FRI score of 2 or 3,

explained previously in chapter 3) of the adolescent subjects. Male subjects who did not

have dental fluorosis had lower median CPQ estimates (suggesting better OHRQoL) as

compared to female subjects who did not have dental fluorosis.
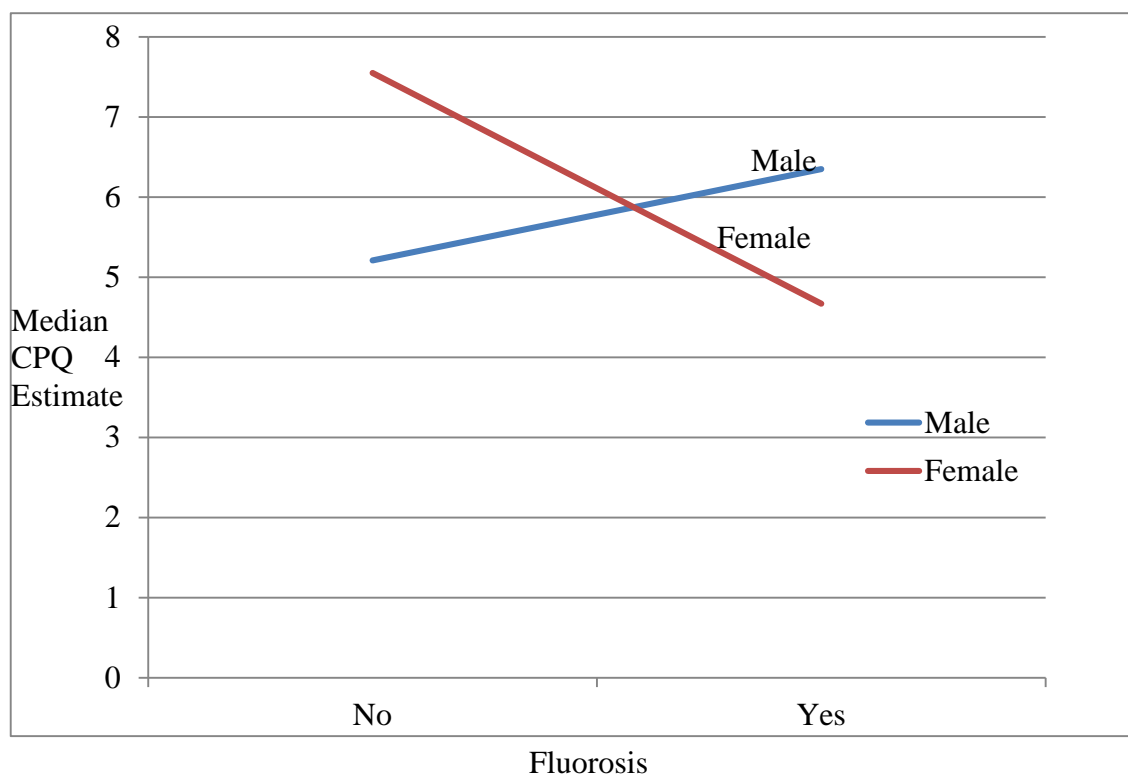
Figure 4-3. Interaction between variables sex and dental fluorosis

On the other hand, females who had dental fluorosis had lower median CPQ

estimates (suggesting better OHRQoL) as compared to males who had dental fluorosis.

Thus, females who had dental fluorosis tended to have better OHRQoL than males who

had dental fluorosis, whereas females who did not have dental fluorosis tended to have

poorer OHRQoL than males who did not have dental fluorosis. Also, males who did not

have dental fluorosis had slightly lower median CPQ estimates as compared to males

who had dental fluorosis. Therefore, for males, not having dental fluorosis led to slightly

better OHRQoL. While on the other hand, for females, having dental fluorosis led to substantially lower median CPQ estimates and thus, better OHRQoL.

Justification for including only one two-way interaction in final model:

Including the three statistically significant two-way interactions in the regression model at the same time diminished their effects. As a result, no pair of these interactions was jointly significant, nor were all three together significant. To further explore this, we looked at how the interaction effects overlapped and found out that the groups of subjects defining the interactions overlapped substantially in some cases.

Table 4-27 is an explanatory table that shows the frequency distribution for all the groups represented in Table 4-28, i.e., females with fluorosis and past orthodontic treatment, females with fluorosis and no past orthodontic treatment, males with fluorosis and past orthodontic treatment, males with fluorosis and no past orthodontic treatment.

Table 4-28 shows the frequency distribution for the 'sex*fluorosis' interaction by 'sex*orthodontic treatment experience' interaction. Of the 28 female fluorosis subjects, 23 were also past orthodontic treatment subjects; hence, the interaction effects will be determined by mostly the same subjects. Therefore, we decided to include only the most significant interaction effect in the final model (i.e., sex*orthodontic treatment experience). Thus, we did not want to add the sex by fluorosis interaction on top of the (more significant) sex by orthodontic treatment experience interaction in the final model.

Table 4-27. Explanatory table for frequency distribution of all the groups
represented in Table 4-28

		Females with orthodontic treatment experience		Males with orthodontic treatment experience	
		Yes	No	Yes	No
Fluorosis	Yes	23	5	16	15
	No	107	63	65	70

Table 4-28. Frequency table for 'sex*fluorosis' interaction by 'sex*orthodontic
 treatment experience' interaction

Sex*fluorosis interaction	Sex*orthodontic treatment experience interaction		
	Females with previous orthodontic treatment only	All Others**	Total
Females with fluorosis only	23	5	28
All Others*	107	229	336
Total	130	234	364

*Includes all males (with/without fluorosis) and females without fluorosis.

**Includes all males (with/without previous orthodontic treatment) and females without
  previous orthodontic treatment.

Table 4-29 shows the frequencies for 'sex*orthodontic treatment experience'

interaction by 'income*orthodontic treatment experience' interaction. Of the 15 low

income subjects with previous orthodontic treatment, 12 were females. Therefore, 12 out

of 15 subjects in these two groups overlapped. Thus, we did not want to add the

'income*orthodontic treatment experience' interaction on top of the (more significant)

'sex*orthodontic treatment experience' interaction in the final model.

Table 4-29. Frequency table for 'sex*orthodontic treatment experience' by 'income* orthodontic treatment experience'

Sex*orthodontic treatment experience interaction	Income*orthodontic treatment experience interaction		
	Low income subjects with previous orthodontic treatment only	All Others**	Total
Females with previous orthodontic treatment only	**12**	112	124
All Others*	3	220	223
Total	**15**	332	347

*Includes all males (with/without previous orthodontic treatment) and females without previous orthodontic treatment.

**Includes all high income subjects and low income subjects without previous orthodontic treatment.

Final regression model for adolescents

Table 4-30 summarizes the final regression model[±] for adolescents including the

interaction term. The dependent variable was the OHRQoL composite score for

adolescents (CPQ). The independent variables included: sex, family income, dental

fluorosis, dental caries (D_2FS/cavitated lesions), DAI score, anterior cross-bite, overjet,

and past orthodontic treatment. The independent variables that were statistically

significant at P≤0.05 included: sex, dental caries, DAI score, and anterior cross-bite. The interaction between sex and orthodontic treatment experience was also statistically significant at P≤0.05.

The parameter estimates for family income and fluorosis were close to zero. This implies that there is no effect of family income and fluorosis on the conditional median of the CPQ score. In fact, income and fluorosis did not have any significant effect on the dependent variable in the previous model without the interaction term as well (see Table 4-24).

Final regression equation

The final regression equation (including the interaction term) was:

CPQ score = - 0.23 + 4.23 (sex, 1= female) + 0.00 (family income, 1= low income) + 0.00 (fluorosis) -1.85 (Dental caries, category for D_2FS= 0) -1.85 (Dental caries, category for D_2FS =1-4) + 0.31 (DAI) + 4.69 (anterior cross-bite, 1= yes) – 2.00 (overjet, 1= yes) + 0.85 (orthodontic treatment experience, 1= yes) – 3.23 (sex *orthodontic treatment experience).

Table 4-30. Final regression model$^{\pm}$ for adolescents including the interaction term

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-Value	Pr > |t|
Intercept	1	-0.23	2.95	-6.04	5.58	-0.08	0.93
Sex	1	4.23	1.17	1.92	6.54	3.60	**0.0004**
Family income	1	0.00**	1.39	-2.74	2.74	0.00	1.00
Fluorosis*	1	0.00**	0.82	-1.62	1.62	0.00	1.00
Dental caries							
D$_2$FS category1 (D$_2$Fs=0)	1	-1.85	0.90	-3.62	-0.07	-2.04	**0.04**
D$_2$FS category2 (D$_2$FS= 1-4)	1	-1.85	0.95	-3.71	0.02	-1.95	**0.052**
D$_2$FS category3 (D$_2$FS= 5-40)	0	-	-	-	-	-	-
DAI score							
Measured/imputed DAI score	1	0.31	0.12	0.07	0.54	2.61	**0.01**
No DAI measured	1	-0.54	0.78	-2.07	0.99	-0.69	0.48
Anterior cross-bite	1	4.69	2.36	0.06	9.33	1.99	**0.047**
Overjet > 4mm	1	-2.00	2.40	-6.73	2.73	-0.83	0.41
Orthodontic treatment experience	1	0.85	1.01	-1.15	2.84	0.84	0.40
Sex*orthodontic treatment experience	1	-3.23	1.39	-5.96	-0.50	-2.33	**0.02**

$^{\pm}$Using expanded sample size with imputed median DAI scores (n=345).

* Definitive fluorosis (FRI score of 2 or 3) in one or more maxillary anterior teeth.

**Rounded to two decimal places.

In order to explain the interaction, we used the model estimates (from the regression output) for the interaction variables (sex and orthodontic treatment experience), while assigning median values for all other independent variables. Table 4-31 shows the median values for all the independent variables included in the regression model.

The medians for the non-interaction variables were: a) family income (median = not low income, parameter estimate = 0.00); b) fluorosis (median = no fluorosis, parameter estimate = 0.00); c) dental caries (median = D_2FS category 2/D_2FS= 1-4); d) DAI score (median = 22, parameter estimate = 0.31); e) no DAI measured (median = DAI measured, parameter estimate = -0.54); f) anterior cross-bite (median = no, parameter estimate = 4.69); and g) overjet > 4mm (median = no overjet > 4mm, parameter estimate = -2.00).

As the medians for family income, fluorosis, no DAI measured, anterior cross-bite, and overjet were all zero, their estimates did not contribute to the regression equation. The variables with non-zero medians were: a) dental caries/D_2FS = 1-4 category (median = category 2, parameter estimate = -1.85, effect = 1*-1.85 for being in category 2), and b) DAI score (median = 22, parameter estimate = 0.31, effect = 22*0.31). Thus, the total median and intercept effects were:

CPQ score = -0.23 + 4.23 (sex, 1= female) -1.85 (D_2FS category 2, from dental caries) + 0.31 (DAI, median score =22) + 0.85 (orthodontic treatment experience, 1= yes) – 3.23 (sex *orthodontic treatment experience).

Table 4-31. Median values for the independent variables included in the regression model.

Variable	Categories	Median
Dental caries	o Category 1: $D_2FS = 0$ (0) o Category 2: D2FS = 1-4 (1) o Category 3: D2FS = 5+ (2)	1.00 (or category 2)
Sex	o Female =1 o Male =0	1.00
Family Income	o Low income = 1 o Others = 0 (i.e., middle and high income)	0.00
Fluorosis	o Fluorosis = 1 (if definitive fluorosis present in one or more of the maxillary six anterior teeth) o Fluorosis = 0 (if definitive fluorosis present in any of the maxillary six anterior teeth)	0.00
DAI score	o $13 \leq$ DAI score ≤ 30 o DAI score ≥ 31	22.00
No DAI measured	o No DAI measured = 1 (if DAI measurement was missing and median DAI score of 22 was imputed) o No DAI measured = 0 (if DAI measurement was done on the cast)	0.00
Anterior cross-bite	o Yes = 1 o No = 0	0.00
Overjet > 4mm	o Yes = 1 o No = 0	0.00
Orthodontic treatment experience (in the past)	o Yes = 1 o No = 1	1.00

<u>Net effect of variable orthodontic treatment experience when</u>

<u>considering the main effects and interaction terms jointly in the</u>

<u>model</u>

The full effect of the variable 'orthodontic treatment experience', when

considering the main effect and the two-way interaction between 'orthodontic treatment

experience' and 'sex', can be summarized by using median values for all other

independent variables in the final model. Table 4-32 shows the median CPQ estimates for

males and females with and without previous orthodontic treatment.

Table 4-32. Median CPQ estimates for males and females with and without
 previous orthodontic treatment

Previous orthodontic treatment	Male	Female
No	4.74	8.97
Yes	5.59	6.59

The interaction effect can be explained as:

a) For males, having received previous orthodontic treatment was associated with

an increase of 0.85 units (5.59-4.74) in the median CPQ estimate (suggesting worsening

of OHRQoL).

b) For females, having received previous orthodontic treatment was associated with a decrease of 2.38 units (6.59-8.97) in the median CPQ estimate (suggesting improvement in OHRQoL).

Alternatively, the interaction can be explained as:

For subjects with previous orthodontic treatment, the median CPQ estimates for females were 1 unit higher (less desirable) than for males (6.59-5.59). On the other hand, for subjects without past orthodontic treatment, median CPQ estimates of females were 4.23 units higher (less desirable) than males (8.94-4.74).

Multivariable analyses for primary dependent variable PPQ
score (i.e., OHRQoL composite score for parents)

Model 1: Main analytical sample (with DAI measurement,
n = 222)

Table 4-33 shows the multivariable analysis on the main analytical sample, using the OHRQoL composite score for parents (PPQ) as the dependent variable. Like in the previous models, the independent variables included were: adolescent's sex, annual family income, dental fluorosis, dental caries (D_2FS), DAI score, anterior cross-bite, overjet > 4mm, and past orthodontic treatment. None of the variables were statistically significant at P≤ 0.05.

Model 2: Expanded sample with median DAI score

imputation (n=345)

Table 4-34 shows the multivariable analysis for OHRQoL composite score for

parents (PPQ), using the expanded sample size (with median DAI score imputation,

n=345). The independent variables included in the model were: adolescent's sex, annual

family income, dental fluorosis, dental caries (D_2FS), DAI score, anterior cross-bite,

overjet > 4mm, and past orthodontic treatment. This model shows that those adolescents

whose DAI scores were not measured (no DAI measured, n=122) were different from

those adolescents who had their DAI scores measured. This difference is reflected in the

PPQ scores of the parents. The median PPQ score estimates were significantly lower for

parents whose adolescent children did not have DAI scores measured as compared to the

median PPQ score estimates of parents whose adolescent children had their DQAI scores

measured (P=0.03).

Multivariable analyses for secondary dependent variables-

GOHR of parents and adolescents

Multivariable analyses for secondary dependent variable GOHR-teens

(i.e., Global Oral Health Rating of adolescents)

Model 1: Main analytical sample (with DAI measurement, n = 222)

Table 4-35 shows the multivariable analysis on the main analytical sample, using

the GOHR for adolescents (rated higher as better) as the dependent variable. The

independent variables included in this model were the same as in the previous models,

i.e., adolescent's sex, annual family income, dental fluorosis, dental caries (D_2FS), DAI

score, anterior cross-bite, overjet > 4mm, and past orthodontic treatment. However, none of the independent variables were statistically significant at P ≤ 0.05.

Model 2: Expanded sample with median DAI score

imputation (n=345)

Table 4-36 shows the multivariable analysis on the expanded sample, using the GOHR for adolescents (rated higher as better) as the dependent variable and the same independent variables as used in the previous models. None of the independent variables were statistically significant at significance level P ≤ 0.05.

Multivariable analyses for secondary dependent variable

GOHR-parents (i.e., Global Oral Health Rating of parents)

Model 1: Main analytical sample (with DAI measurement,

n = 222)

Table 4-37 shows the multivariable analysis on the main analytical sample, using the GOHR for parents (rated higher as better) as the dependent variable and the same independent variables as used in the previous models. The only independent variable that was statistically significant (P ≤ 0.05) in this model was the DAI score (P = 0.02).

The estimates in the model show the direction for change of conditional medians. Therefore, parents whose adolescent children had higher DAI scores had lower median GOHR estimates (suggesting worse OHRQoL of their children) as compared to parents whose adolescent children had lower DAI scores (P = 0.02). In terms of the magnitude of the difference, a one unit increase in the DAI score of the adolescents was associated with

a 0.62 units decrease in the conditional median of the parents' GOHR of their children (P = 0.02).

Model 2: Expanded sample with median DAI score

imputation (n=345)

Table 4-38 shows the multivariable analysis on the expanded sample, using the GOHR for parents (rated higher as better) as the dependent variable and the same independent variables as used in previous models. Dental caries and DAI score were statistically significant at $P \leq 0.05$. Being in the $D_2FS = 0$ category (for adolescents) was associated with a 3.64 units increase in the GOHR scores of the parents (P = 0.02) and being in the $D_2FS = 1$-4 category (for adolescents) was associated with a 3 units increase in the GOHR of the parents (P = 0.04) (suggesting better OHRQoL) as compared to the GOHR scores of parents, whose children were in the $D_2FS = 5+$ category. Also, parents of adolescents with higher DAI scores had lower median GOHR estimates (suggesting worse OHRQoL) as compared to parents of adolescents with lower DAI scores (P = 0.04).

Table 4-33. Multivariable analysis for OHRQoL composite score (PPQ) for parents (using the main analytical sample with DAI measurement only, n=222)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	-1.40	3.39	-8.08	5.28	-0.41	0.68
Sex	1	0.00	1.01	-1.99	1.99	0.00	1.00
Family Income	1	2.73	1.86	-0.95	6.41	1.46	0.14
Fluorosis	1	3.26	2.03	-0.75	7.28	1.60	0.11
Dental caries							
$D_2FS = 0$	1	-0.80	1.23	-3.24	1.64	-0.65	0.52
$D_2FS = 1-4$	1	0.33	1.40	-2.44	3.11	0.24	0.81
$D_2FS = 5-40$	0	0.00	0.00	0.00	0.00	.	.
DAI score	1	0.27	0.14	-0.01	0.54	1.88	0.06
Anterior cross-bite	1	7.33	4.47	-1.48	16.15	1.64	0.10
Overjet > 4mm	1	2.20	6.68	-10.97	15.37	0.33	0.74
Orthodontic treatment experience	1	0.86	1.16	-1.43	3.16	0.74	0.46

* One subject was missing information n OHRQoL score (PPQ), so 221 observations were used in the regression analysis.

Table 4-34. Multivariable analysis for OHRQoL composite score (PPQ) for parents (using the expanded sample with imputed median DAI scores, n = 345)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	0.00	3.34	-6.57	6.57	0.00	1.00
Sex	1	-0.00	0.84	-1.66	1.66	-0.00	1.00
Family income	1	2.61	1.75	-0.82	6.04	1.50	0.13
Fluorosis	1	2.19	1.43	-0.61	5.00	1.54	0.12
Dental caries							
$D_2FS=0$	1	-1.09	1.08	-3.23	1.04	-1.01	0.31
$D_2FS = 1\text{-}4$	1	-0.29	1.14	-2.54	1.96	-0.25	0.80
$D_2FS = 5\text{-}40$	0	0.00	0.00	0.00	0.00	.	.
DAI score							
Measued/imputed DAI score	1	0.22	0.14	-0.05	0.50	1.58	0.11
No DAI measured	1	-2.22	1.00	-4.19	-0.25	-2.22	0.03
Anterior cross-bite	1	5.29	4.34	-3.25	13.83	1.22	0.22
Overjet > 4mm	1	3.09	5.94	-8.60	14.79	0.52	0.60
Orthodontic treatment experience	1	1.35	0.95	-0.51	3.22	1.42	0.15

Table 4-35. Multivariable analysis for GOHR for adolescents (using the main analytical sample with DAI measurement only, n= 222)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	96.59	5.60	85.54	107.63	17.24	< 0.0001
Sex	1	-2.00	1.63	-5.22	1.22	-1.22	0.22
Family income	1	-3.12	3.25	-9.52	3.29	-0.96	0.34
Fluorosis	1	-3.88	2.31	-8.43	0.67	-1.68	0.09
Dental caries							
$D_2FS=0$	1	0.53	1.94	-3.30	4.36	0.27	0.78
$D_2FS = 1\text{-}4$	1	3.29	2.26	-1.16	7.75	1.46	0.15
$D_2FS = 5\text{-}40$	0	0.00	0.00	0.00	0.00	.	.
DAI score	1	-0.35	0.24	-0.82	0.11	-1.49	0.14
Anterior cross-bite		-0.23	12.32	-24.53	24.06	-0.02	0.98
Overjet > 4mm		4.59	9.23	-13.62	22.79	0.50	0.62
Orthodontic treatment experience		2.12	1.79	-1.43	5.66	1.18	0.24

Table 4-36. Multivariable analysis for GOHR for adolescents (using the expanded sample with imputed median DAI scores, n = 345)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	95.29	4.86	85.73	104.85	19.61	< 0.0001
Sex	1	-0.00	1.25	-2.45	2.46	-0.00	1.00
Family income	1	-3.47	3.19	-9.74	2.80	-1.09	0.28
Fluorosis	1	-0.00	1.40	-2.75	2.75	-0.00	1.00
Dental caries							
$D_2FS=0$	1	0.35	1.46	-2.51	3.22	0.24	0.81
$D_2FS = 1-4$	1	1.41	1.59	-1.73	4.55	0.88	0.38
$D_2FS = 5-40$	0	0.00	0.00	0.00	0.00	.	.
DAI score							
Measured/imputed DAI Score	1	-0.35	0.21	-0.76	0.06	-1.69	0.09
No DAI measured	1	1.06	1.34	-1.58	3.69	0.79	0.43
Anterior cross-bite	1	-1.53	9.16	-19.54	16.48	-0.17	0.87
Overjet > 4mm	1	4.06	4.28	-4.36	12.48	0.95	0.34
Orthodontic treatment experience	1	1.41	1.35	-1.24	4.07	1.05	0.29

Table 4-37.Multivariable analysis for parents' GOHR (using the main analytical sample i.e., with DAI measurement only, n= 222)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	106.50	6.55	93.59	119.41	16.26	< 0.0001
Sex	1	-0.62	1.53	-3.63	2.38	-0.41	0.68
Family income	1	-2.12	2.63	-7.31	3.06	-0.81	0.42
Fluorosis	1	-0.87	1.92	-4.65	2.90	-0.46	0.65
Dental caries							
$D_2FS=0$	1	0.62	2.17	-3.65	4.89	0.29	0.77
$D_2FS = 1\text{-}4$	1	3.00	1.84	-0.64	6.64	1.63	0.11
$D_2FS = 5\text{-}40$	0	0.00	0.00	0.00	0.00	.	.
DAI score	1	-0.62	0.28	-1.17	-0.08	-2.25	**0.02**
Anterior cross-bite	1	-24.50	13.74	-51.59	2.59	-1.78	0.08
Overjet > 4mm	1	6.87	8.01	-8.91	22.66	0.86	0.39
Orthodontic treatment experience	1	-0.25	1.74	-3.69	3.19	-0.14	0.89

Table 4-38. Multivariable analysis for parents' GOHR (using the expanded sample with imputed median DAI scores, n = 345)

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		t-value	Pr > |t|
Intercept	1	103.27	5.89	91.67	114.87	17.52	< 0.0001
Sex	1	-0.36	0.99	-2.33	1.60	-0.36	0.72
Family income	1	-0.91	2.52	-5.87	4.06	-0.36	0.72
Fluorosis	1	-1.00	1.14	-3.24	1.24	-0.88	0.38
Dental caries							
$D_2FS=0$	1	3.64	1.57	0.55	6.72	2.32	**0.02**
$D_2FS = 1\text{-}4$	1	3.00	1.43	0.19	5.81	2.10	**0.04**
$D_2FS = 5\text{-}40$	0	0.00	0.00	0.00	0.00		.
DAI score							
Measured/imputed DAI Score	1	-0.54	0.26	-1.06	-0.03	-2.09	**0.04**
No DAI measured	1	0.7	1.16	-1.56	3.01	0.63	0.53
Anterior cross-bite	1	-4.91	11.24	-27.01	17.19	-0.44	0.66
Overjet > 4mm	1	0.36	4.92	-9.32	10.04	0.07	0.94
Orthodontic treatment experience	1	1.36	1.51	-1.60	4.33	0.90	0.37

CHAPTER V

DISCUSSION

<u>Overview</u>

The primary objective of this study was to assess the impact of dental conditions

such as dental caries, dental fluorosis, and malocclusion (as indicated by DAI scores) on

the OHRQoL of adolescents. In addition, adolescents' and parents' perceptions on dental

esthetics were also assessed.

This study was a secondary analysis of cross-sectional survey data obtained from

the Iowa Fluoride Study participants at the 17-year time point of the study. The results

from this study indicated that dental caries experience and malocclusion (as indicated by

DAI score) were associated with lower OHRQoL of adolescents. Also, females were

found to be more critical of their OHRQoL. In general, adolescents were found to be

more critical of their OHRQoL as compared to parents.

Demographic characteristics

About 54% of the adolescent participants were female and about 46% were male.

The majority of the study participants were non-Hispanic whites (95.5%) and all other

races/ethnicities together (i.e., Black, Asian, Hispanic, and Native American) accounted

for only 4.5% of the study sample. Thus, this sample was not representative of all the

racial and ethnic backgrounds (i.e., Black, Asian, Hispanic, and Native American).

Most of the study participants belonged to middle to high socio-economic status

families. About 49% of the subjects were from families with annual family income

greater than $80,000, 38% had annual family income from $40,000 to $ 79,999, and 13%

belonged to families with less than $40,000 annual income. Therefore, about half of the

participants had family income greater than $80,000, while the median household income for the United States was $51,371 in 2012 (Census ACS survey, 2012). Also, most of the parents in this study were well-educated, with about 51% of mothers and about 41% of fathers having a 4-year college degree or more.

Study sample

Of the 550 adolescents who participated in the study at age 13, 395 returned for the 17-year time point examination, thus indicating a fairly high retention rate of about 72%. However, 21 adolescents were excluded from the analyses as they were undergoing active orthodontic treatment at the time of age 17 clinical examination. These subjects were excluded from the analyses as orthodontia was not our variable of interest, due to the transient nature of active orthodontic treatment. This resulted in an effective sample size of n = 374 (n= 395 total-21 undergoing active orthodontic treatment).

Univariate results

About 60% of the participants had undergone some sort of orthodontic treatment previously, whereas according to the third National Health and Nutrition Examination Survey (NHANES III), the prevalence of orthodontic treatment in U.S. non-Hispanic White young adults was 30% in 1994. Also, about 37% of the adolescents were caries-free (cavitated lesion level), which reflects the relatively low dental disease burden in the sample. This can be attributed to increased awareness about oral health and the high socio-economic status of the Iowa Fluoride Study participants as compared to the U.S. general population.

As a large percentage of the participants had undergone orthodontic treatment in the past, only 6% of the adolescents had DAI scores greater than 31, considered

representative of severe or handicapping malocclusion). The large majority (83%) had DAI scores in the range of 13-25 (considered representative of either minor or no malocclusion), and 11% had DAI scores in the range of 26-60 (considered representative of definite malocclusion).

Cavitated caries experience (D_2FS) was observed among 63% of adolescents, with about 27% having more than five tooth surfaces with caries experience (D_2FS). The mean D_2FS was 3.55. According to the NHANES (collected between 1999 and 2004) data regarding dental caries in U.S. adolescents, the prevalence of caries in permanent teeth (DMFT) among non-Hispanic White adolescents aged 12-19 years was about 58% and the mean DFS was 4.32.

Fluorosis assessment on the adolescents' maxillary anterior teeth showed that approximately 22% of the 374 adolescents examined had definitive fluorosis (maximum FRI score = 2 or 3) on one or more maxillary anterior teeth. Among these 22%, seven subjects had severe fluorosis (FRI score = 3) with pitting and staining on at least one maxillary anterior tooth. The national prevalence of dental fluorosis was 40.7% and the prevalence of moderate and severe fluorosis was 3.6% in in adolescents aged 12-15, according to the NHANES data from 1999-2004 (Beltrán-Aguilar et al, 2010).

Only about 14% of the study subjects had one or more non-fluoride opacities present on one or more of their maxillary six anterior teeth and about 26 % reported any bleaching done on their teeth.

The CPQ and PPQ composite scores were used as the primary dependent variables in the multivariable models and the secondary dependent variables were the 'Global Oral Health Rating' question responses for both parents and adolescents. Among

adolescents, the highest mean values were recorded for the domain of oral symptoms (4.2), followed by emotional well-being (2.4), functional limitations (1.5), and social well-being (1.1). The mean composite scores for CPQ and PPQ were 8.7 and 10.3, respectively (higher scores suggest worse OHRQoL); the mean GOHR scores for adolescents and parents were 86.6 and 91.2, respectively (higher scores suggest better OHRQoL).

Based on the esthetic perceptions questions, more parents (29.3%) found the color of their adolescents' teeth to be 'very attractive' as compared to the adolescents themselves (12.3%). Also, about 40% of adolescents answered 'probably yes' to their 'desire to change the color of their teeth' as compared to about 22% of parents. This may be because adolescents are more critical of the color of their teeth as compared to their parents (Shulman et al, 2004; Kavand et al, 2012).

Bivariate results

Several statistical approaches were used to assess the impact of oral health conditions on the OHRQoL of adolescents. P-values below 0.15 were considered statistically significant. The Wilcoxon rank-sum test, Wilcoxon sign-rank test, Kruskal-Wallis test, and Spearman correlation tests were used. The two indicators of OHRQoL (i.e., composite score and rating) were compared between children and parents grouped by adolescents' sex, caries experience, fluorosis scores, non-fluoride opacities, DAI categories, gender, and orthodontic factors in bivariate analyses. Wilcoxon Rank-Sum tests were used to assess the relationships between OHRQoL indicators and oral conditions (dichotomous variables) such as: dental fluorosis, non-fluoride opacities, DAI score (DAI≤ 30 or DAI≥31), and other orthodontic factors. The Kruskal Wallis test was

used to assess the relationships between OHRQoL indicators and dental caries experience (categorical variable). The Wilcoxon Rank Sum test was used to compare and contrast adolescents' and parents' OHRQoL scores and ratings. Spearman correlations were used to study the correlations among the OHRQoL subscales of parents and adolescents.

Female participants tended to have higher CPQ composite scores as compared to male participants ($P = 0.005$), thus suggesting less favorable OHRQoL in females as compared to males. Also, participants belonging to families with higher income tended to have lower CPQ composite scores as compared to participants belonging to families with lower income ($P = 0.02$). This suggests that higher income group participants tend to have better OHRQoL as compared to their counterparts from lower income groups. This has been demonstrated in other studies as well.

Multivariable analyses

Introduction

In this section, the dependent variables, the independent variables, and the type of multivariable analyses used in our study will be discussed. In addition, the key findings will be compared and contrasted with findings from studies in the literature.

Dependent variables

The CPQ and PPQ composite scores were used as the primary dependent variables in the multivariable models and the secondary dependent variables were the 'Global Oral Health Rating' question responses for both parents and adolescents.

Independent variables

The clinical indicators that were included as independent variables in multivariable models for the OHRQoL were cavitated dental caries experience (three categories: i) category 1:$D_2FS = 0$, ii) category 2: $D_2FS = 1\text{-}4$, iii) category 3:$D_2FS = 5+$), fluorosis status (yes/no), DAI score (two categories: i) DAI ≤ 30, ii) DAI ≥ 31) , anterior crossbite, overjet $> 4mm$ (yes/no), and previous orthodontic treatment experience (yes/no), with socioeconomic indicators such as sex (male/female) and household income (low income/others) as control variables. All of these variables were considered as theoretically important in assessing the impact on OHRQoL of adolescents (Do and Spencer, 2007; Barbosa et al, 2013; Bastos et al, 2012; Castro et al, 2010; Arrow P, 2013; Martinis et al, 2012; Foster Page et al, 2005; Locker et al, 2007; Bernabe et al, 2008; Agou et al, 2008; O'Brien et al, 2006; Feu et al, 2010; Ukra et al, 2013). For this reason, they were all retained in the multi-variable analyses without performing any model selection procedure to achieve a more parsimonious model. The multivariable models were developed using two different sample sizes: the main analytical sample (including subjects with DAI evaluation only, n=222), and the expanded sample size (with median DAI score imputation, n=345).

Multivariable analyses using quantile regression

The multivariable analyses were conducted using quantile regression analysis (Koenker and Bassett, 1978), a semi-parametric regression analysis that estimates regression relationships specific to a particular percentile or quantile of the outcome variable and doesn't make any distributional assumptions (Koenker and Hallock, 2001; Choi et al, 2012). Quantile regression has the ability to provide a complete picture of the

covariate effect when a set of percentiles is modeled and, therefore, it can capture important features of the data that might be missed by models that average over the conditional distribution (SAS online manual).

For our data analyses, a special case of quantile regression, i.e., median regression, was used, as it describes the changes in the center of the distribution and is insensitive to outliers (Choi et al, 2012). In median regression, the effects of the covariates are modelled on the conditional median of the response variable, whereas ordinary least-squares (OLS) regression models the relationship between one or more covariates and the conditional mean of the response variable.

Handling missing data

Missing DAI values in our sample were replaced by imputing the median DAI score of 22 in order to gain a larger sample size and utilize the available data for other variables for analyses. Similar analytical strategy has been used in other OHRQoL research (Marshman et al, 2005). However, it is important to consider the fact that, since all the imputations were with the same value (median DAI=22), this method can underestimate the variance for DAI score (Haitovsky, 1968).

Sensitivity analyses using the two sample sizes, i.e., with and without median DAI imputation (N=222 and 345, respectively), showed similar patterns of results, although the two-way interactions were statistically significant only for the expanded sample. Therefore, the smaller sample size was used to interpret the main effects and the expanded sample size was used for interpreting the significant two-way interactions. In

the section below, the significant main effects are interpreted using the smaller sample size.

Key findings

Based on the conditional median regression model, adolescent's sex, cavitated dental caries experience (category 1:$D_2FS = 0$), and Dental Aesthetic Index (DAI) score were found to affect the OHRQoL of adolescents ($P \leq 0.05$).

Adolescent's sex

The influence of sex on adolescents' perceptions of OHRQoL was found to be statistically significant in our study. Based on the findings of our study, higher CPQ overall scores were associated with being female, with a 1.98 units increase in the conditional median of the CPQ score ($P = 0.03$). This suggests that females tend to be more sensitive to the positive and negative impacts on their OHRQoL and value it more than their male counterparts. This finding corroborates the results of other studies that have demonstrated higher impacts on the OHRQoL of females (Foster Page et al, 2005; Calis et al, 2009; Bos et al, 2010; Barbosa et al, 2013; Ukra et al, 2013). This also implies that female adolescents are more sensitive to the esthetic perceptions of their dental appearance as compared to males (Bianco et al, 2010). Also, according to McGrath and Bedi (2000), there are gender variations in the social and psychological impacts of oral health, with women perceiving oral health as having a greater impact on their quality of life than men.

However, Wong and coworkers (2011) found the OHRQoL in the social well-being domain for adolescent boys aged 12 years to be poorer than for girls of same age ($P<0.05$). The authors mentioned that there were no theoretical explanations available for

the difference and more research is needed to investigate this finding. Ukra et al (2013) also reported higher impacts in certain domains of the CPQ $_{11-14}$ for males. They found females to consistently report significantly poorer OHRQoL, except for the oral symptoms domain, where the scores were higher for the male participants. This could be due to the difference in how men and women perceive an impact on their OHRQoL.

Dental caries experience (D$_2$FS)

Dental caries was treated as a categorical variable in our analyses. Three categories were defined: category 1/D$_2$FS=0, category 2/D$_2$FS=1-4, and category 3/D$_2$FS≥5. Based on the conditional median regression model, being in the D$_2$FS=0 category (category 1) was associated with a decrease of 3.17 units in the conditional median of the CPQ score compared with being in the D$_2$FS≥5 (category 3), keeping all other variables in the model fixed (P = 0.006) (higher score suggesting worse OHRQoL). This implies that children who were in the no caries experience category (i.e., category1/D$_2$FS=0) tended to have better OHRQoL as compared to children who belonged to the higher caries category (i.e., category 3 or D$_2$FS≥5).

Similar findings were also reported in other studies. Some of the studies that found significant associations between dental caries and OHRQoL are discussed in the section below. However, caution must be exercised in comparing our results to other studies since direct comparisons cannot be made due to the different analytical approaches used in the studies. We used conditional median regression for our multivariable analyses, whereas none of the other studies that assessed OHRQoL used quantile regression or median regression (a special case of quantile regression).

Studies that found significant associations between dental

caries experience and OHRQoL

Similar findings were also reported by Do and Spencer in 8- to 13-year old

Australian children (Do and Spencer, 2007). The dependent variables included two

OHRQoL indicators: i) the mean overall CPQ/PPQ score, and ii) the percentage of

respondents who perceived their or their children's oral health as excellent or very good

(global oral health rating). Based on the bivariate analyses, the authors reported that as

caries experience increased, there was a gradual decrease in the proportion of respondents

(both parents and children aged 8-to 13-years) who perceived their/their children's oral

health as excellent or very good ($P < 0.05$). Also, the difference in the oral health

perception (for both parents and children aged 8-to 13-years) was significant between the

group without caries and the group with the highest caries experience (Chi-square,

pairwise comparison, *P* < 0.05) (Do and Spencer, 2007).

For multivariable analyses, three linear regression models were generated for the

overall CPQ/PPQ scores (one for parents and one each for children aged 8-10 years and

11-13 years) (Do and Spencer, 2007). In addition, two logistic regression models were

generated for the percentage of respondents who perceived their or their children's oral

health as excellent or very good (one for parents and one for all the children combined)

(Do and Spencer, 2007).

Based on the linear regression model, the authors reported higher caries

experience (having 3-4 surfaces with caries experience) to be significantly associated

with higher CPQ scores reported by 8- to 10-year old children (Do and Spencer, 2007).

Specifically, children (8-10 years old) with caries experience on 3-4 tooth surfaces were

3.36 times as great to have higher CPQ_{8-10} scores as compared to children (8-10 years old) who had no caries experience (unstandardized coefficient = 3.36, P<0.05). However, no significant associations were reported between caries experience and PPQ/CPQ_{11-14} scores (Do and Spencer, 2007), based on the linear regression models.

Furthermore, based on the logistic regression model, having 5+ tooth surfaces with caries experience was associated with significantly lower odds for parents to perceive their child's oral health as excellent or very good compared with the odds for parents whose children had no caries experience (Do and Spencer, 2007). For example, for parents whose children had 5+ tooth surfaces with caries experience, the odds for perceiving their child's oral health as excellent or very good were 0.32 times as great as compared to parents whose children had no caries experience (OR= 0.32, 95% CI: 0.19-0.53) (Do and Spencer, 2007).

Thus, caries experience was concluded to have a negative association with the OHRQoL of children (Do and Spencer, 2007). The authors stated that one possible explanation for this association could be that caries can cause pain and discomfort to the child and can also be stressful for the family due to the financial burden caused by the dental treatment (Do and Spencer, 2007).

Robinson et al (2005) also reported a significant association between lower OHRQoL and dental caries experience in 12-year old rural Ugandan children. They reported dental caries experience to be associated with higher CPQ_{11-14} total scores (P < 0.01), thus suggesting a negative association between dental caries experience and OHRQoL. For example, the mean CPQ_{11-14} total scores for children with caries experience (DMF>0) were higher (mean CPQ = 32.5, 95% CI: 27.5-37.5) as compared to

the mean CPQ_{11-14} total scores for children with no caries experience (mean CPQ=21.9, 95% CI: 18.2-25.6) (t-test P-value <0.01) (Robinson et al, 2005).

Barbosa et al (2013) also found a negative association between dental caries experience and the OHRQoL of 8- to 12-year old children in Brazil. Based on the multiple linear regression models, the authors reported higher number of decayed (β=0.245, P=0.017) and missing teeth (β=0.318, P=0.002) to be significantly associated with higher CPQ_{8-10} scores (suggesting worse OHRQoL), even after controlling for confounding factors. Thus, they concluded that children with more caries tend to rate their OHRQoL less favorably (Barbosa et al, 2013).

Similar findings were also reported by Castro et al (2011) among 11- to 12-year-old school children in Brazil. They found a significant association between dental caries and the OHRQoL (measured through the Child Oral Impacts on Daily Performance/Child-OIDP) (Gherunpong et al, 2004) of the 11- to 12-year-old study participants (Castro et al, 2011). In the logistic regression model, the Child-OIDP was associated with dental caries experience (DMFT + dmft > 0). Specifically, children with dental caries experience were 2.2 times as great to report poor OHRQoL as compared to children with no dental caries experience (OR=2.2, 95% CI: 1.1,4.5, P=0.03).

Studies that found no significant association between

dental caries experience and OHRQoL

Most of the studies assessing the impact of dental caries on the OHRQoL of children and adolescents have reported significant associations. However, there are a few studies that have reported no association between dental caries experience and OHRQoL of children or adolescents. Marshman et al (2005) reported no apparent relationships

between the DMFT and CPQ scores (Spearman correlation coefficient, r=0.09) among children aged 11 to 14 years old (n=89) in the U.K. The authors attributed the weak relationship between dental caries and the OHRQoL of the study participants to the low levels of caries in the sample. The mean DMFT of the sample was 1.25±2.75 and only 15% of children in this sample had untreated caries. The authors pointed out that the degree of impact of dental caries on the OHRQoL of children at such low levels could be too low for the CPQ_{11-14} to detect, given that the sample size of the study was also small.

Summary

The findings of our study on the association of caries with OHRQoL were similar to those reported in other studies (Arrow P, 2013; Barbosa et al, 2013; Bastos et al, 2012; Castro et al,2010; Do and Spencer, 2007; Martinis et al, 2012). This could be explained by the fact that dental caries is likely to cause pain, discomfort, dysfunction, inability to concentrate, and poor school attendance (Jackson et al, 2011; Krisdapong et al, 2013; Blumenshine et al, 2008). Thus, dental caries can have a negative impact on the life of an individual and can hamper their ability to succeed (Barbosa and Gavia˜o, 2008).

However, it must be noted that adolescents' attitudes toward their oral health in general can also impact their OHRQoL. For example, adolescents who do not value their oral health and are not much concerned about it might not be as affected by the impacts of oral conditions on their OHRQoL compared with adolescents who value their oral health more. Thus, it is possible that these underlying differences in attitudes toward oral health and oral health behaviors can act as confounding factors in assessing OHRQoL.

<u>DAI score</u>

Malocclusion was scored using the Dental Aesthetic Index (DAI) developed by

Cons et al (1986). DAI score was found to be significantly associated with the OHRQoL

of the adolescents. Based on the conditional median regression model, a one unit increase

in the DAI score was associated with a 0.29 units increase in the conditional median of

the CPQ score (P = 0.02).

<u>Studies that found significant association between DAI and</u>

<u>OHRQoL</u>

Do and Spencer (2007) also reported similar findings that suggested lower

OHRQoL to be associated with malocclusion. They reported that for both children (8- to

13-year-olds) and their parents, having a less socially acceptable dental appearance, as

measured by the DAI score of the children, was associated with lower odds of perceiving

excellent or very good oral health as compared to the odds for children with an

acceptable dental appearance (OR $_{children}$=0.57, 95% CI: 0.38-0.87; OR $_{parents}$=0.60, 95%

CI: 0.39-0.92). Furthermore, based on the multivariable linear regression model, children

(8- to 10-year-olds) who were in the higher DAI score category (DAI score=35+)

reported 4.78 units (unstandardized coefficient) higher CPQ$_{8-10}$ total score (suggesting

poorer OHRQoL) as compared to children in the lower DAI score category (DAI score

≤34) (P<0.001) (Do and Spencer, 2007).

A similar finding was also reported in a recent study that assessed the impact of

malocclusion on the OHRQoL in adolescents in New Zealand (Ukra et al, 2013). Based

on bivariate analyses, the authors reported that there was a distinct gradient in the mean

CPQ and domain scores across the categories of malocclusion severity, and adolescents

in the handicapping category of the DAI had the highest CPQ scores ($P \leq 0.001$, Kruskal Wallis test) and, thus, they concluded that severe malocclusion negatively impacts the OHRQoL of New Zealand adolescents (Ukra et al, 2013). Similarly, Locker et al (2007) and Bernabe et al (2008) also reported malocclusion to have a negative impact on the OHRQoL of children and adolescents.

Studies that found no significant association

A recent review of literature reported the association between malocclusion and OHRQoL to be controversial (Zhang et al, 2006). They reviewed literature relating to the impact of malocclusion and the treatment of malocclusion on the physical, social and psychological health (i.e. quality of life, QoL) of people suffering from malocclusion or undergoing orthodontic treatment. Some studies have reported no association between malocclusion and OHRQoL (Barbosa et al, 2009; Taylor et al, 2009).

Summary

Findings of strong and consistent associations between malocclusion and OHRQoL of adolescents have been reported in many recent studies (Foster Page et al, 2005; Do and Spencer, 2007; Locker et al, 2007; Bernabe et al, 2008; Agou et al, 2008; O'Brien et al, 2006; Feu et al, 2010; Ukra et al, 2013).

Dental fluorosis

No association of dental fluorosis with the OHRQoL of the adolescents was found in our study. This can be attributed to the low prevalence of severe fluorosis in our study sample. Only 7 subjects in our sample had severe fluorosis (FRI score=3) on one or more of their six maxillary anterior teeth. The prevalence of definitive fluorosis (on one or

more of the six maxillary anterior teeth) was 22%, but it was mostly mild. Other studies

with low prevalence of dental fluorosis also did not find statistically significant

associations between OHRQoL and dental fluorosis (Biazevic et al, 2008).

Interestingly, Do and Spencer (2007) reported that having a TF score (Thylstrup

and Fejerskov Index, Fejerskov et al, 1988) of 1 or 2 (indicative of very mild and mild

fluorosis) was associated with significantly lower CPQ scores (suggesting better

OHRQoL) among 11- to 13-year-old children and their parents compared with having no

fluorosis experience, after controlling for other factors. For example, the odds of

reporting lower CPQ scores (suggesting better OHRQoL) in children with TF score of 1

were about 6 times as great as compared to children with TF score of zero

(unstandardized coefficient= -5.93, P=0.01). Similarly, the odds of reporting lower CPQ

scores (suggesting better OHRQoL) in children with TF score of 2 were about 8 times as

great as compared to children with TF score of zero (unstandardized coefficient= -8.39,

P<0.01) (Do and Spencer, 2007).

Furthermore, based on the logistic regression model, the authors reported that for

children with TF score of 2, the odds for perceiving their oral health as excellent or very

good were 1.87 times as great as compared to the odds for perceiving excellent or very

good oral health by children with TF score zero (OR=1.87, 95% CI: 1.00-3.48, P<0.05).

The authors stated that one possible explanation for this finding could be that mild

fluorosis has an enhancing effect on the perception of attractiveness of tooth color,

though they acknowledged that a follow-up study is needed to reevaluate this finding (Do

and Spencer, 2007).

In contrast, dental fluorosis was found to be significantly associated with OHRQoL in populations where fluorosis severity was high (Astrom and Moshoto, 2002). For example, Astrom and Moshoto (2002) reported that the odds of being dissatisfied with oral condition and dental appearance in Tanzanian adolescents with severe dental fluorosis ($6 < TF \leq 9$) were about 3 times as great (oral condition: OR =2.8, 95% CI: 1.3-6.1; dental appearance: OR=3.1, 95% CI: 1.4-6.8) as compared to adolescents with no dental fluorosis (TF=0) (Astrom and Moshoto, 2002). This suggests that dental fluorosis can have a negative association with OHRQoL in populations where high severity of dental fluorosis is prevalent (TF score of 3 and higher).

Interaction between sex and orthodontic treatment

experience

Interestingly, the interaction between sex and past orthodontic treatment was found to be statistically significant (P=0.02) in our study (using the expanded sample size with imputed DAI scores). Though the interaction was significant in the regression model that utilized the expanded sample with DAI imputations, however, it should be noted that imputation was not used for any of the variables included in the interaction (i.e., sex and orthodontic treatment experience). One reason for the interaction to be significant in the model using imputed sample size could be the larger sample for the variables sex and orthodontic treatment experience that was utilized in the regression model.

Having had previous orthodontic treatment had a different effect on the median CPQ estimates of male and female subjects. There was a substantial decrease in the median CPQ estimate (lower CPQ suggests better OHRQoL) of female participants who had undergone orthodontic treatment in the past compared with those who did not. This

suggests that undergoing orthodontic treatment substantially improved the OHRQoL in females. For males, there was an increase in the median CPQ estimate of much smaller magnitude.

Also, the magnitude of the difference between male and female median CPQ estimates was much greater for the group of adolescents who had not undergone past orthodontic treatment as compared to the group of adolescents who had undergone orthodontic treatment. For example, females who had not undergone orthodontic treatment in the past had substantially higher median CPQ estimates as compared to their male counterparts. In contrast, male and female participants who had received previous orthodontic treatment, showed very little difference between their median CPQ estimates.

This could be due to the difference in how males and females perceive an impact on their OHRQoL. Also, it is possible that there is self-selection into orthodontic treatment. Females could be more aware of their appearance and have greater esthetic concerns compared to males. Therefore, they could be more likely to seek orthodontic treatment, as they might expect orthodontic treatment to boost their self-esteem and confidence. On the other hand, it is possible that most males seek orthodontic treatment only for severe malocclusion and many fewer for esthetic concerns solely.

Comparison of multivariable results for adolescents and
parents

Based on the parents' model, using the parents' perceptions of adolescents' OHRQoL (PPQ score) as the dependent variable, only DAI score was found to be significantly associated with higher PPQ total score (rated higher as worse OHRQoL). Similar findings were reported by Do and Spencer (2007) in Australia. Based on their

multivariable linear regression model, DAI was found to be significantly associated with higher PPQ scores (Do and Spencer, 2007). It is possible that parents perceive greater effects of malocclusion (as compared to other oral health conditions) on OHRQoL due to the time and financial resources spent on orthodontic treatment.

No significant findings were found in the adolescent model using the secondary dependent variable, i.e., Global Oral Health Rating, whereas in the parent model, dental caries and malocclusion (assessed using DAI score) were found to be significantly associated with parents' perceptions of their children's GOHR. This could be due to the problems related to adolescents' ability to conceptually understand the visual-analogue scale (VAS) method. Possibly, when responding to the GOHR question, adolescents do not take into account the multidimensional constructs related to oral health, as asked in the four subscales of the CPQ questionnaire. They may respond to the VAS based on any single construct related to OHRQoL, depending on their different thought processes at that moment. The VAS ranges from 0-100, with 0 being worst imaginable health and 100 being perfect health. Therefore, response to VAS depends on the subject's unique interpretation and can be relatively vague as compared to the more specific and structured questions on the CPQ. Furthermore, adolescents may lack the experiential grounding to comprehend the maximal descriptor (e.g., worst imaginable health) as compared to their parents.

In addition, based on the bivariate analyses, adolescents were found to be more critical of the emotional well-being domain of the OHRQoL questionnaire, compared with their parents. It is possible that adolescents' oral health status can adversely affect their emotional well-being. This could be due to several reasons, such as the stress of undergoing dental treatment, peer-pressure, and inability to perform well at school or work. Adolescents might not share these feelings with their parents and, thus, parents might not be fully aware of their children's emotional states.

On the other hand, parents were more critical of the functional limitations domain of the OHRQoL questionnaire as compared to the adolescents. One possible explanation for this could be that functional impairments and limitations might be more evident to the parents than is the emotional state of their children. For example, parents tend to be more concerned when their child is unable to eat or chew food due to a functional impairment, and they may even recall such incidents more than the children.

Study strengths

This study reported on the concurrently evaluated impact of dental fluorosis, caries, and malocclusion on the OHRQoL among children and their parents. Among the study's strengths is its utilization of a previously validated OHRQoL tool so as to enhance the understanding of the association between various oral health conditions and their influence on an individual's OHRQoL (Jokovic et al, 2002; Jokovic et al, 2006; Locker et al, 2007). This measure was used to complement conventional normative clinical measures of oral health. It must be acknowledged that subjective measures have some advantages over the clinical measures of oral health such as caries, fluorosis, and malocclusion indices. While individual clinical measures report on the clinician's measurement and/or judgment of the oral health condition of the individual, subjective measures assess the extent to which these conditions affect the perceptions of the individual's OHRQoL. Individual perceptions of oral health can vary from person to person and, therefore, different people could perceive their OHRQoL differently. However, subjective measures also have a disadvantage as they are self-reported and subject to recall bias.

Study limitations

Our study sample is not representative of the overall U.S. population and is narrow in focus, as it is limited only to Iowa adolescents. Therefore, neither is it representative of other age groups except adolescents aged 17 years, nor is it representative of people living in other geographic locations in the U.S. or across the world. Also, our study participants consisted mainly of middle to high income non-Hispanic Whites. Therefore, this study is not representative of other racial and ethnic backgrounds, as well as lower income groups. Due to these reasons, it is difficult to extrapolate the findings to other populations.

According to Fisher-Owens et al (2013), racial/ethnic disparities in children's oral health status and access are attributable largely to socioeconomic and health insurance factors. It is likely that our study participants are more concerned about their oral health compared to the general population, as they chose to stay in the longitudinal IFS since their recruitment in the early- to mid-1990s.

Another limitation of our study is that it was a cross-sectional analysis of secondary data collected in the IFS. Due to the cross-sectional nature of the study, no causality/temporal relationship can be inferred from these results. Also, the tool used to assess the OHRQoL of adolescents was a self-reported measure; therefore, there could be potential recall bias associated with the patient-reported outcome measure.

Due to the unavailability of DAI evaluation for 152 subjects, the median DAI score (of 22) was imputed in order to expand the sample size. However, this could have drawbacks such as bias, distorted correlations, and reduced variance (Haitovsky, 1968). Although sophisticated simulation techniques for imputation of missing data have been

reported in literature to be robust, their use was beyond our scope for this thesis analyses. These constraints mean that caution is required in interpretation of our study results.

Furthermore, it is important to acknowledge that certain household and individual characteristics, such as attitudes toward oral health, preventive behaviors, oral health regimen, and general attitude toward life, can vary from person to person and can influence an individual's OHRQoL. Since no information on attitudes and oral health behaviors was assessed in these secondary data analyses, these can possibly confound our findings. These constraints mean that caution is required in interpretation of our study results.

<div align="center">Future directions</div>

Additional research should be done with more diverse populations, regions, and cultures to better quantify these common impacts of oral health conditions on adolescents and parents. For instance, OHRQoL assessment in low SES populations and populations with more untreated dental caries can provide the opportunity to meaningfully assess the impact of untreated caries on the OHRQoL of people.

Other studies should also look in multivariable analyses at the relationships of the individual CPQ/PPQ domains with the clinical variables. In addition, different combinations of variables such as dental caries and dental fluorosis should be studied together, in order to more fully assess the joint effects, which could sometimes be missed while assessing interactions. It would also be interesting to assess both general HRQoL and OHRQoL at the same time, as it could enhance our understanding of the underlying behaviors that can affect OHRQoL.

The self-reported outcome measure OHRQoL can be used for studying treatment effectiveness in future. Systematic longitudinal research designs should use validated OHRQoL measures in order to assess changes in the OHRQoL over time in diverse populations and across disciplines (Sischo and Broder, 2011). This can help in better treatment planning and in evaluating self-perceived treatment effectiveness by the people who experience those oral conditions.

However, there is emerging evidence that psychological characteristics play an important role in predicting adolescents' OHRQoL (Agou et al, 2008, 2011; Baker et al, 2010). Children with better well-being have been found to report better OHRQoL, irrespective of their malocclusion or orthodontic status (Agou et al, 2011). Therefore, in order to fully understand the associations between clinical measures of oral health and OHRQoL of adolescents, it is important to consider the role played by the psychological characteristics of the adolescents. Thus, more research should be done to analyze these complex causal relationships.

<center>Clinical relevance</center>

Statistically significant changes over time may not be meaningful to patients (Jaeschke et al, 1989) and, thus, patient-centered subjective measures such as OHRQoL hold greater clinical relevance in assessing the impacts of oral health conditions, as well as the effectiveness of treatment procedures.

According to Cella and co-workers (2002), in order to determine the clinical significance of HRQoL data, attention should be given to overall group differences and individual assessments. This can have patient-oriented applications, especially for

adolescents, as they are at a unique stage in their lives where they begin to assert autonomy in decision-making.

Thus, assessments of their perceptions of their dental esthetics, as well as the impact of their oral conditions on their OHRQoL, can also guide the oral health professional in better treatment planning for the individual Also, as has been pointed out in the literature, these perceptions can vary for different individuals and, thus, their assessment can also aid in better allocation of resources, depending on the needs of the individual

CHAPTER VI

CONCLUSIONS

Our study involved secondary analyses of the oral health-related quality of life data collected in the Iowa Fluoride Study at the 17-year time-point. Both adolescents and their parents filled out questionnaires related to the assessment of the OHRQoL of the adolescents. In addition, adolescents also underwent clinical examination to assess dental caries, dental fluorosis, orthodontic characteristics, and non-fluoride opacities. Dental casts were also made with the assent of the participants. These casts were later used to estimate the social acceptability of the participants' dental appearance and assess their malocclusion severity, using the Dental Aesthetic Index (Cons et al, 1978). This study assessed the relationships between the OHRQoL of Iowa adolescents and the presence of selected oral conditions, such as dental caries, dental fluorosis, and malocclusion.

Based on the multivariable analyses, dental caries and malocclusion severity (reflected by DAI score) were the two oral conditions that were found to be significantly associated with poorer OHRQoL in adolescents. In addition, the influence of sex on adolescents' perceptions of OHRQoL was found to be statistically significant in our study and being female was associated with poorer OHRQoL.

The findings of our study corroborate the results of other investigations that have demonstrated significant associations between: i) dental caries and OHRQoL (Arrow P, 2013; Barbosa et al, 2013; Bastos et al, 2012; Castro et al,2010; Do and Spencer, 2007; Martinis et al, 2012); ii) malocclusion and OHRQoL (Foster Page et al, 2005; Do and Spencer, 2007; Locker et al, 2007; Bernabe et al, 2008; Agou et al, 2008; O'Brien et al,

2006; Feu et al, 2010; Ukra et al, 2013); and iii) sex and OHRQoL (Foster Page et al, 2005; Calis et al, 2009; Bos et al, 2010; Barbosa et al, 2013; Ukra et al, 2013).

Thus, oral conditions such as dental caries and malocclusion can be a source of stress and can have a negative impact on the life of an individual and can impede their ability to succeed. Females tend to be more sensitive to the negative impact of oral health conditions. Therefore, in order to better understand the impact of oral health conditions, subjective measures should be used in conjunction with normative measures or clinical measures of assessing oral health. This can help in better treatment planning and in providing optimal patient care, depending on the specific needs of the individual, and geared towards improving their quality of life on the whole and not just treating the clinical symptoms.

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APPENDIX

QUESTIONNAIRES

<div style="border:1px solid black; padding:10px; text-align:center">

CHILD ORAL HEALTH QUESTIONNAIRE

8-10 years

</div>

Hello,

Thanks for helping us with our study!

We are doing this study to understand better things that may happen to children because of their **teeth and mouth.**

PLEASE REMEMBER:

- Don't write your name on the questionnaire.
- This is **not a test** and there are no right or wrong answers.
- Answer as **honestly** as you can.
- **Don't talk to anyone** about the questions when you are answering them.
- **No one** you know will see your answers.
- Read each question **carefully** and think about the things that have happened to you in the **past 4 weeks**.
- Before you answer, ask yourself**: "Does this happen to me because of my teeth or mouth?"**
- Put an ⊠ in the box beside the answer that is **best** for you.
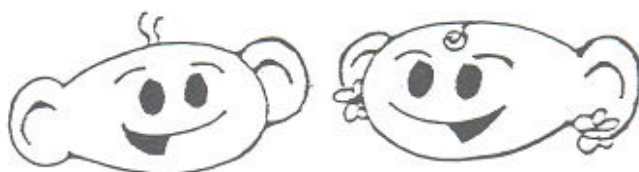
CHILD ORAL HEALTH QUESTIONNAIRE

11-14 years

Hello,

Thanks for agreeing to help us with our study!

This study is being done so that there will be more understanding about problems children may have because of their **teeth, mouth, lips and jaws**. By answering the questions, you will help us learn more about young people's experiences.

PLEASE REMEMBER:

- Don't write your name on the questionnaire
- This is **not a test** and there are no right or wrong answers
- Answer as **honestly** as you can. Don't talk to anyone about the questions when you are answering them. Your answers are **private**; no one you know will see them
- Read each question **carefully** and think about your experiences in the **past 3 months** when you answer
- Before you answer, ask yourself**: "Does this happen to me because of problems with my teeth, lips, mouth or jaws?"**
- Put an ⊠ in the box for the answer that is best for you
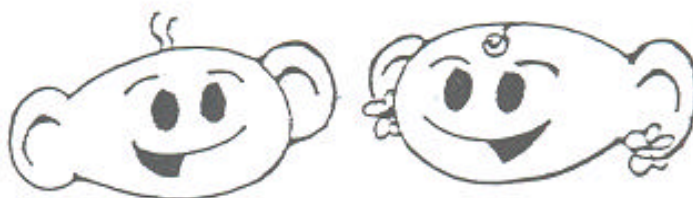
Today's date: _____/_____/_____
　　　　　　　　　　DAY　　MONTH　　YEAR

FIRST, A FEW QUESTIONS ABOUT YOU

1.　Are you a boy or a girl?

- ❑ Boy
- ❑ Girl

2.　When were you born?　_____/_____/_____
　　　　　　　　　　　　　　　DAY　　MONTH　　YEAR

3.　Would you say the <u>health</u> of your teeth, lips, jaws and mouth is:

- ❑ Excellent
- ❑ Very good
- ❑ Good
- ❑ Fair
- ❑ Poor

4.　How much does the condition of your teeth, lips, jaws or mouth affect your <u>life overall</u>?

- ❑ Not at all
- ❑ Very little
- ❑ Some
- ❑ A lot
- ❑ Very much

QUESTIONS ABOUT ORAL PROBLEMS

In the past 3 months, how often have you had:

5.   Pain in your teeth, lips, jaws or mouth?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

6.   Bleeding gums?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

7.   Sores in your mouth?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

8.   Bad breath?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day
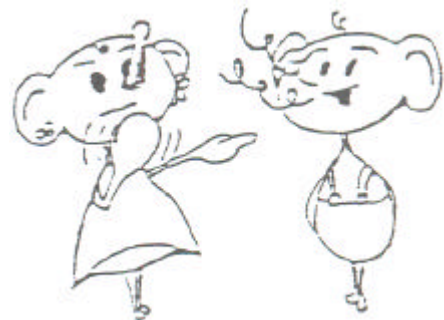
9.   Food stuck in or between your teeth?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

10.   Food stuck in the top of your mouth?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

For the next questions…
Has this happened because of your <u>teeth, lips, jaws or mouth?</u>

In the <u>past 3 months</u>, how often have you:

---

11.   Breathed through your mouth?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

12.   Taken longer than others to eat a meal?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

13. Had trouble sleeping?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

> **In the past 3 months, because of your teeth, lips, mouth or jaws, how often has it been:**

14. **Difficult to bite or chew food like apples, corn on the cob or steak?**

   ❑ Never
   ❑ Once or twice
   ❑ Sometimes
   ❑ Often
   ❑ Everyday or almost every day

15. **Difficult to open your mouth wide?**

   ❑ Never
   ❑ Once or twice
   ❑ Sometimes
   ❑ Often
   ❑ Everyday or almost every day

16. **Difficult to say any words?**

   ❑ Never
   ❑ Once or twice
   ❑ Sometimes
   ❑ Often
   ❑ Everyday or almost every day

17. **Difficult to eat foods you would like to eat?**

   ❑ Never
   ❑ Once or twice
   ❑ Sometimes
   ❑ Often
   ❑ Everyday or almost every day

18. **Difficult to drink with a straw?**

   ❑ Never
   ❑ Once or twice
   ❑ Sometimes
   ❑ Often
   ❑ Everyday or almost every day

19. Difficult to drink or eat hot or cold foods?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

<div align="center">

QUESTIONS ABOUT FEELINGS

</div>

Have you had the feeling because of your <u>teeth, lips, jaws or mouth</u>?
If you felt this way for <u>another reason,</u> answer 'Never'.

In the <u>past 3 months</u>, how often have you:

20. Felt irritable or frustrated?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

21. Felt unsure of yourself?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

22. Felt shy or embarrassed?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

In the past 3 months, because of your teeth, lips, mouth or jaws, how often have you:

23. **Been concerned what other people think about your teeth, lips, mouth or jaws?**

❏ Never
❏ Once or twice
❏ Sometimes
❏ Often
❏ Everyday or almost every day

24. **Worried that you are not as good-looking as others?**

❏ Never
❏ Once or twice
❏ Sometimes
❏ Often
❏ Everyday or almost every day
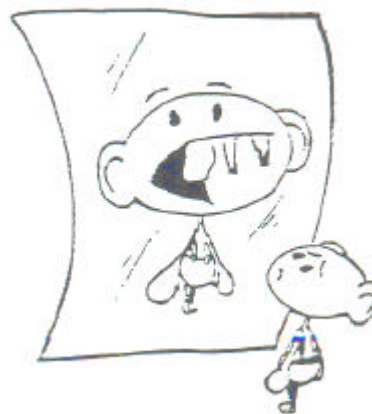
25. **Been upset?**

❏ Never
❏ Once or twice
❏ Sometimes
❏ Often
❏ Everyday or almost every day

26. **Felt nervous or afraid?**

❏ Never
❏ Once or twice
❏ Sometimes
❏ Often
❏ Everyday or almost every day

27. **Worried that you are not as healthy as others?**

❏ Never
❏ Once or twice
❏ Sometimes
❏ Often
❏ Everyday or almost every day

28. Worried that you are different than other people?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

QUESTIONS ABOUT SCHOOL

Have you had these experiences because of your <u>teeth, lips, jaws or mouth</u>? If it was for <u>another reason</u>, answer 'Never'.

In the <u>past 3 months</u>, how often have you:

29. Missed school because of pain, appointments, or surgery?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

30. Had a hard time paying attention in school?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

31. Had difficulty doing your homework?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

32. Not wanted to speak or read out loud in class?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

QUESTIONS ABOUT YOUR SPARE-TIME ACTIVITIES & BEING WITH OTHER PEOPLE

Have you had these experiences because of your <u>teeth, lips, jaws or mouth</u>? If it was for <u>another reason</u>, answer 'Never'.

In the <u>past 3 months</u>, how often have you:

33. Avoided taking part in activities like sports, clubs, drama, music, school trips?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

34. Not wanted to talk to other children?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

35. Avoided smiling or laughing when around other children?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

36. Had difficulty playing a musical instrument such as a recorder, flute, clarinet, trumpet?

❑ Never
❑ Once or twice
❑ Sometimes
❑ Often
❑ Everyday or almost every day

37. Not wanted to spend time with other children?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

38. Argued with other children or your family?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

> **In the past 3 months, because of your teeth, lips, mouth or jaws, how often have:**

39. Other children teased you or called you names?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

40. Other children made you feel left out?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

41. Other children asked you questions about your teeth, lips, jaws or mouth?

- ❑ Never
- ❑ Once or twice
- ❑ Sometimes
- ❑ Often
- ❑ Everyday or almost every day

THERE, IT'S FINISHED!

Just one more thing. To test how good this questionnaire is at giving us the information we need, we would like a group of children to complete it again.

Would you be willing to help us by completing another copy of the questionnaire soon? We would mail it to you in the next 2 weeks.

YES ❑
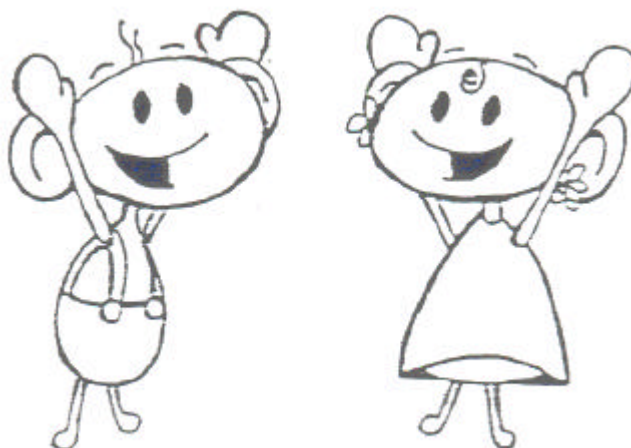
THANK YOU FOR HELPING US

FIRST, A FEW QUESTIONS ABOUT YOU

Today's date: _____/_____/_____
                    DAY   MONTH   YEAR

1. **Are you a boy or a girl?**

   ☐ Boy
   ☐ Girl

2. **When were you born?**   _____/_____/_____   **Age** _____
                                DAY   MONTH   YEAR

3. **When you think about your teeth or mouth, would you say that they are:**

   ☐ Very good
   ☐ Good
   ☐ O.K.
   ☐ Poor

4. **How much do your teeth or mouth bother you in your everyday life?**

   ☐ Not at all
   ☐ A little bit
   ☐ Some
   ☐ A lot

NOW A FEW QUESTIONS ABOUT YOUR TEETH AND MOUTH

How often have you had:

5.   Pain in your teeth or mouth in the past 4 weeks?

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

6.   Sore spots in your mouth in the past 4 weeks?

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

7.   Pain in your teeth when you drink cold drinks or eat hot foods in the past 4 weeks?

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

8.   Food stuck in your teeth in the past 4 weeks?

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

9.   Bad breath in the past 4 weeks?

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day
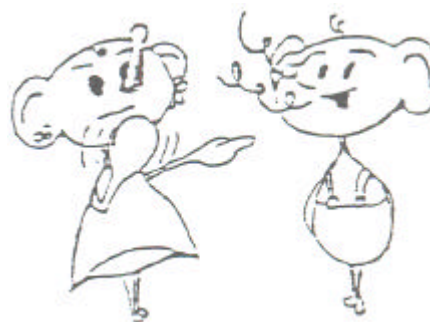
| **How often have you:** |

10. **Needed longer time than others to eat your meal because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

11. **Had a hard time biting or chewing food like apples, corn on the cob or steak because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

12. **Had trouble eating foods you would like to eat because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

13. **Had trouble saying some words because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

14. **Had a problem sleeping at night because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

SOME QUESTIONS ABOUT YOUR FEELINGS

How often have you:

15. Been upset because of your teeth or mouth in the past 4 weeks?

- ☐ Never
- ☐ Once or twice
- ☐ Sometimes
- ☐ Often
- ☐ Everyday or almost every day

16. Felt frustrated because of your teeth or mouth in the past 4 weeks?

- ☐ Never
- ☐ Once or twice
- ☐ Sometimes
- ☐ Often
- ☐ Everyday or almost every day

17. Been shy because of your teeth or mouth in the past 4 weeks?

- ☐ Never
- ☐ Once or twice
- ☐ Sometimes
- ☐ Often
- ☐ Everyday or almost every day

18. Been concerned what other people think about your teeth or mouth in the past 4 weeks?

- ☐ Never
- ☐ Once or twice
- ☐ Sometimes
- ☐ Often
- ☐ Everyday or almost every day

19. Worried that you are not as good-looking as others because of your teeth or mouth in the past 4 weeks?

- ☐ Never
- ☐ Once or twice
- ☐ Sometimes
- ☐ Often
- ☐ Everyday or almost every day
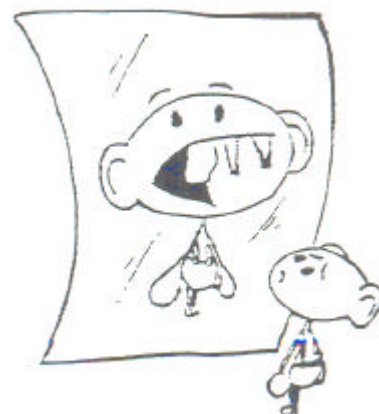
QUESTIONS ABOUT YOUR SCHOOL

How often have you:

20. **Missed school because of your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

21. **Had a hard time doing your homework because of your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

22. **Had a hard time paying attention in school because of your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

23. **Not wanted to speak or read out loud in class because of your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

QUESTIONS ABOUT YOU BEING WITH OTHER PEOPLE

How often have you:

24. **Tried not to smile or laugh when with other children because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day
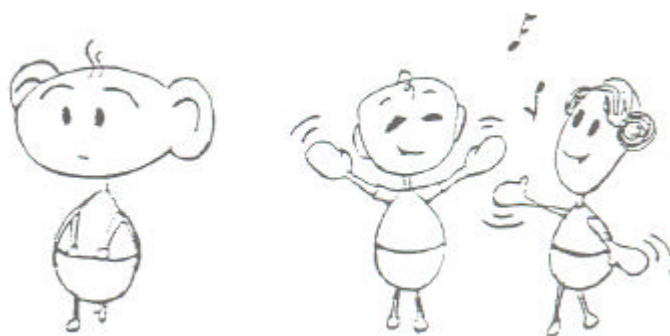
25. **Not wanted to talk to other children because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

26. **Not wanted to be with other children because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

27. **Stayed away from activities like sports and clubs because of your teeth or mouth in the past 4 weeks?**

☐ Never
☐ Once or twice
☐ Sometimes
☐ Often
☐ Everyday or almost every day

How often have:

28. **Other children teased you or called you names because of your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

29. **Other children asked you questions about your teeth or mouth in the past 4 weeks?**

    ☐ Never
    ☐ Once or twice
    ☐ Sometimes
    ☐ Often
    ☐ Everyday or almost every day

THERE, IT'S FINISHED!

One last thing! To see how good these questions are we need a group of children to answer questions again.

Would you like to help?
We would mail you the questions in the next 2 weeks.

YES ☐
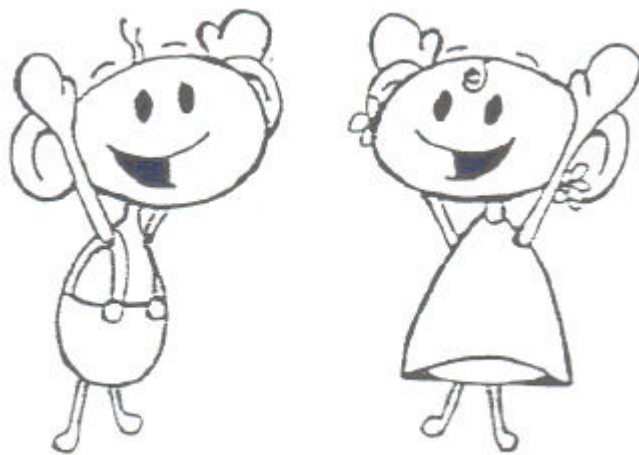
THANK YOU FOR YOUR HELP

COMMUNITY DENTAL HEALTH SERVICES RESEARCH UNIT
FACULTY OF DENTISTRY
UNIVERSITY OF TORONTO
124 Edward Street
Toronto, Ontario
M5G 1G6

CHILD ORAL HEALTH QUESTIONNAIRE
Parental report
6-14 years

INSTRUCTIONS TO PARENTS

1. This questionnaire is about the effects of <u>oral conditions</u> on children's well-being and everyday life, and the effects on their families. We are interested in <u>any condition that involves teeth, lips, mouth or jaws</u>. **Please answer each question**.

2. To answer the question please put an ☒ **in the box by the response**.

3. Please give the response that **best describes your child's experience**. If the question does <u>not</u> apply to your child, please answer with "Never".

> **Example :** How often has your child had a hard time paying attention in school?
>
> If your child has had a hard time paying attention in school <u>because of problems with his/her teeth, lips, mouth or jaws</u>, choose the appropriate response. If it has happened <u>for other reasons</u>, choose "Never".

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

4. Please **do not discuss the questions with your child,** as we are interested only in the parents' perspective in this questionnaire.

SECTION 1:   Child's oral health and wellbeing

1. **How would you rate the health of your child's teeth, lips, jaws and mouth?**

❑	❑	❑	❑	❑
Excellent	Very good	Good	Fair	Poor

2. **How much is your child's overall wellbeing affected by the condition of his/her teeth, lips, jaws or mouth?**

❑	❑	❑	❑	❑
Not at all	Very little	Some	A lot	Very much

SECTION 2:   The following questions ask about <u>symptoms</u> and <u>discomfort</u> that children may experience due to <u>the condition of their teeth, lips, mouth and jaws</u>

During the <u>last 3 months</u>, how often has your child had:

3. **Pain in the teeth, lips, jaws or mouth?**

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

4. Bleeding gums?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

5. Sores in the mouth?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

6. Bad breath?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

7. Food stuck in the roof of the mouth?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

8. Food caught in or between the teeth?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

9. Difficulty biting or chewing foods such as fresh apple, corn on the cob or firm meat?

❏	❏	❏	❏	❏	❏
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

> *During the <u>last 3 months</u>, because of his/her <u>teeth, lips, mouth, or jaws</u>, how often has your child:*

10. Breathed through the mouth?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

11. Had trouble sleeping?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

12. Had difficulty saying any words?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

13. Taken longer than others to eat a meal?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

14. Had difficulty drinking or eating hot or cold foods?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

15. Had difficulty eating foods he/she would like to eat?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

16. **Had diet restricted to certain types of food (e.g. soft food)?**

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

---

SECTION 3: **The following questions ask about the effects that <u>the condition of children's teeth, lips, mouth and jaws</u> may have on their <u>feelings</u> and <u>everyday activities</u>**

During the <u>last 3 months</u>, because of his/her <u>teeth, lips, mouth or jaws,</u> how often has your child been:

---

17. **Upset?**

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

18. **Irritable or frustrated?**

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

19. **Anxious or fearful?**

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

> *During the last 3 months, because of his/her teeth, lips, mouth or jaws, how often has your child:*

20. Missed school (e.g. pain, appointments, surgery)?

❏   ❏   ❏   ❏   ❏   ❏
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

21. Had a hard time paying attention in school?

❏   ❏   ❏   ❏   ❏   ❏
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

22. Not wanted to speak or read out loud in class?

❏   ❏   ❏   ❏   ❏   ❏
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

23. Not wanted to talk to other children?

❏   ❏   ❏   ❏   ❏   ❏
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

24. Avoided smiling or laughing when around other children?

❏   ❏   ❏   ❏   ❏   ❏
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

> *During the <u>last 3 months</u>, because of his/her <u>teeth, lips, mouth or jaws</u>, how often has your child:*

25. Worried that he/she is not as healthy as other people?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

26. Worried that he/she is different than other people?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

27. Worried that he/she is not as good-looking as other people?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

28. Acted shy or embarrassed?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

29. Been teased or called names by other children?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

30. Been left out by other children?

☐   ☐   ☐   ☐   ☐   ☐
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

31. Not wanted or been unable to spend time with other children?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

32. Not wanted or been unable to participate in activities such as sports, clubs, drama, music, school trips?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

33. Worried that he/she has fewer friends?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

---

> *During the <u>last 3 months</u>, how often has your child been:*

---

34. Concerned what other people think about his/her teeth, lips, mouth or jaws?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

35. Asked questions by other children about his/her teeth, lips, mouth or jaws?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

> **SECTION 4:** **The following questions ask about effects that a child's oral condition may have on PARENTS AND OTHER FAMILY MEMBERS**

During the last 3 months, because of your child's teeth, lips, mouth or jaws, how often have you or another family member:

---

36. Been upset?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

37. Had sleep disrupted?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

38. Felt guilty?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

39. Taken time off work (e.g. pain, appointments, surgery)?

❑	❑	❑	❑	❑	❑
Never	Once or twice	Sometimes	Often	Everyday or almost everyday	Don't know

40. Had less time for yourself or the family?

❑   ❑   ❑   ❑   ❑   ❑
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

41. Worried that your child will have fewer life opportunities (e.g. for dating, getting married, having children, getting a job he/she will like)?

❑   ❑   ❑   ❑   ❑   ❑
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

42. Felt uncomfortable in public places (e.g. stores, restaurants) with your child?

❑   ❑   ❑   ❑   ❑   ❑
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

---

During the <u>last 3 months</u>, because of his/her <u>teeth, lips, mouth, or jaws</u>, how often has your child:

---

43. Been jealous of you or others in the family?

❑   ❑   ❑   ❑   ❑   ❑
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

44. Blamed you or another person in the family?

❑   ❑   ❑   ❑   ❑   ❑
Never   Once or twice   Sometimes   Often   Everyday or almost everyday   Don't know

45. Argued with you or others in the family?

❑ Never ❑ Once or twice ❑ Sometimes ❑ Often ❑ Everyday or almost everyday ❑ Don't know

46. Required more attention from you or others in the family?

❑ Never ❑ Once or twice ❑ Sometimes ❑ Often ❑ Everyday or almost everyday ❑ Don't know

---

During the <u>last 3 months</u>, how often has the condition of your child's teeth, lips, mouth or jaws:

---

47. Interfered with family activities at home or elsewhere?

❑ Never ❑ Once or twice ❑ Sometimes ❑ Often ❑ Everyday or almost everyday ❑ Don't know

48. Caused disagreement or conflict in your family?

❑ Never ❑ Once or twice ❑ Sometimes ❑ Often ❑ Everyday or almost everyday ❑ Don't know

49. Caused financial difficulties for your family?

❑ Never ❑ Once or twice ❑ Sometimes ❑ Often ❑ Everyday or almost everyday ❑ Don't know

SECTION 5:   Child's gender and age

a. Your child is:

❑   MALE
❑   FEMALE

b. Your child's age is: _____YEARS

Questionnaire completed by:

❑   MOTHER
❑   FATHER
❑   OTHER   _____

Date completed: _____ / _____ / _____
                                     DAY   MONTH   YEAR

To test how good this questionnaire is at giving us the information we need, we would like a group of parents to complete it again.

Would you be willing to complete another copy of the questionnaire in the next 2 weeks?

☐
Yes

THANK YOU FOR YOUR PARTICIPATION !

3121477566

FDI
Dec. 2006

Iowa Fluoride Study
Family Demographic Information

Family ID: | 0 | 0 | 0 | 2 |

Mailing Date : December 4, 2006

Please help us update our Iowa Fluoride Study family information by indicating current information about your household's socioeconomic status. We collected this information at recruitment and at earlier clinical examinations, and have used the results in our many research articles to describe our study group. Now we want to update this information to enhance our future research publications. The information will be extremely helpful in comparing the results of the Iowa Fluoride Study with other studies in both the U.S. and abroad. As always, when we use the information we will remove any personal identifiers and only report group summary information. For the purpose of this questionnaire, "household" is defined as Haley's primary residence.

1. What is the highest level of education achieved by the **female** head of your household?

   O some high school
   O high school diploma or GED
   O some college
   O 2 year college degree, technical/beauty school

   O 4 year college degree
   O post-graduate or professional degree
   O no female head of household

2. What is her occupation? _____   Office Code

3. What is the highest level of education achieved by the **male** head of your household?

   O some high school
   O high school diploma or GED
   O some college
   O 2 year college degree, technical/beauty school

   O 4 year college degree
   O post-graduate or professional degree
   O no male head of household

4. What is his occupation? _____   Office Code

5. Which of the following best describes your total household income for the last year before taxes (include salaries, wages, interest, etc.)?

   O less than $20,000
   O $20,000 - $39,999
   O $40,000 - $59,999

   O $60,000 - $79,999
   O $80,000 or more

Please return completed questionnaire in the enclosed postage paid envelope.

Thank You!

3398102444
6WOHP v4
April 2011

Iowa Fluoride Study
Oral Health Questionnaire - Parent

Family ID: ☐☐☐☐   **Today's Date:** ☐☐ / ☐☐ / 2 0 ☐☐

Hello and welcome to the Iowa Fluoride Study Oral Health Questionnaire.

Thank you for helping us with our study.

This questionnaire is about the effects of oral conditions on teen's well-being and everyday life, and possible effects on their families. We are interested in any condition that involves your teen's teeth, lips, mouth and jaws. **Please answer each question as accurately as you can.**

PLEASE REMEMBER:

1. **Please use a black pen to complete the questionnaire.**
2. **Please answer each question as accurately as you can.**
3. Do not write your name on the questionnaire.
4. Your teen means the child who participates in the Iowa Fluoride Study and is being invited to take part in this study.
5. Please **do not discuss your responses with your teen**, as we are interested only in the parent's perspective in this questionnaire.
6. Read each question carefully and think about your experiences in the **past three months** when you answer.
7. To answer each question, please **check the one response that best describes your opinion about your teen's experience**.
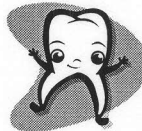
EXAMPLE:

QUESTION: During the past three months, because of his/her teeth, lips, mouth or jaws, how often has your teen been …

	Never	Once or twice	Sometimes	Very Often	Don't know
Upset?	☐	☐	☐	☒	☐

If your teen has **often** been upset because of problems with his/her teeth, lips, mouth or jaws, choose **Often** as the appropriate response as shown above. If the teen was upset for other reasons, please choose **Never**.

If you make a mistake and more than one box ends up being checked, circle the box with the correct answer.

5812102447

6WOHP v4

April 2011

Iowa Fluoride Study
Oral Health Questionnaire - Parent

Family ID: ☐☐☐☐

	Excellent	Very Good	Good	Fair	Poor
1. How would you rate the <u>overall health</u> of your teen's teeth, lips, mouth and jaws?	☐	☐	☐	☐	☐

	Not at all	Very little	Some	A lot	Very much
2. How much is your teen's overall well-being adversely/negatively affected by the condition of his/her teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐

	Very attractive	Somewhat attractive	Just ordinary	Somewhat unattractive	Very unattractive
3. Would you say the <u>color</u> of your teen's teeth is...	☐	☐	☐	☐	☐

	Definitely yes	Probably yes	Neutral	Probably no	Definitely not
4. If it were possible, would you like treatment to change the color of your teen's teeth?	☐	☐	☐	☐	☐

	Very attractive	Somewhat attractive	Just ordinary	Somewhat unattractive	Very unattractive
5. Would you say the <u>shape</u> of your teen's teeth is...	☐	☐	☐	☐	☐

	Definitely yes	Probably yes	Neutral	Probably no	Definitely not
6. If it were possible, would you like treatment to change the shape of your teen's teeth?	☐	☐	☐	☐	☐

	Very crooked	Substantially crooked	A little bit crooked	Not crooked at all	
7. Would you say your teen's <u>front teeth</u> are...	☐	☐	☐	☐	

	Definitely yes	Probably yes	Neutral	Probably no	Definitely not
8. If it were possible, would you like treatment to straighten your teen's teeth?	☐	☐	☐	☐	☐

	Very badly stained	Badly stained	Just slightly stained	Not at all stained	
9. Would you say your teen's <u>front teeth</u> are ...	☐	☐	☐	☐	

	Yes	Almost	No	Definitely not	Did not try
10. Can your teen make his/her teeth look as clean as he/she would like when he/she tries hard to brush them?	☐	☐	☐	☐	☐

	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
11. Are you satisfied with the appearance of your teen's front teeth?	☐	☐	☐	☐	☐

Iowa Fluoride Study
Oral Health Questionnaire - Parent

Family ID: ☐☐☐☐

The following questions ask about <u>symptoms</u> and <u>discomfort</u> that teens may experience due to the <u>condition of their teeth, lips, mouth or jaws.</u> If the questions do not apply to your teen, please answer with "Never"

During the <u>past 3 months</u>, how often has your teen had...

	Never	Once or twice	Sometimes	Often	Very often	Don't know
12. Pain in teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐	☐
13. Bleeding gums?	☐	☐	☐	☐	☐	☐
14. Sores in the mouth?	☐	☐	☐	☐	☐	☐
15. Bad breath?	☐	☐	☐	☐	☐	☐
16. Food caught in or between the teeth?	☐	☐	☐	☐	☐	☐
17. Difficulty biting or chewing foods such as apples, corn on the cob, or steak?	☐	☐	☐	☐	☐	☐

For the rest of the questions...

Has this happened to your teen because of their teeth, lips, mouth or jaws? If it happened only for other reasons, answer 'Never'.

During the <u>past 3 months</u>, because of his/her <u>teeth, lips, mouth or jaws</u>, how often has your teen...

	Never	Once or twice	Sometimes	Often	Very often	Don't know
18. Breathed through the mouth?	☐	☐	☐	☐	☐	☐
19. Had trouble sleeping?	☐	☐	☐	☐	☐	☐
20. Had difficulty saying any words?	☐	☐	☐	☐	☐	☐
21. Taken longer than others to eat a meal?	☐	☐	☐	☐	☐	☐
22. Had difficulty eating hot or cold foods?	☐	☐	☐	☐	☐	☐
23. Had difficulty eating foods he/she would like to eat?	☐	☐	☐	☐	☐	☐
24. Had diet restricted to certain types of food (e.g., soft food)?	☐	☐	☐	☐	☐	☐

Iowa Fluoride Study
Oral Health Questionnaire - Parent

Family ID: [ ][ ][ ][ ]

The following questions ask about the effects that <u>the condition of teen's teeth, lips, mouth or jaws</u> may have on their <u>feelings</u> and <u>everyday activities</u>.

During the <u>past 3 months</u>, because of his/her <u>teeth, lips, mouth or jaws</u>, how often has your teen been…

	Never	Once or twice	Sometimes	Often	Very often	Don't know
25. Upset?	☐	☐	☐	☐	☐	☐
26. Irritable or frustrated?	☐	☐	☐	☐	☐	☐
27. Anxious or fearful?	☐	☐	☐	☐	☐	☐
28. Missed school (e.g., pain, appointments, treatment)?	☐	☐	☐	☐	☐	☐
29. Had difficulty paying attention in school?	☐	☐	☐	☐	☐	☐
30. Not wanted to speak or read out loud in class?	☐	☐	☐	☐	☐	☐
31. Not wanted to talk to other teens?	☐	☐	☐	☐	☐	☐
32. Avoided smiling or laughing when around other teens?	☐	☐	☐	☐	☐	☐
33. Worried that he/she is not as healthy as other people?	☐	☐	☐	☐	☐	☐
34. Worried that he/she is different than other people?	☐	☐	☐	☐	☐	☐
35. Worried that he/she is not as good-looking as other people?	☐	☐	☐	☐	☐	☐
36. Acted shy or embarrassed?	☐	☐	☐	☐	☐	☐
37. Been teased or called names by other people?	☐	☐	☐	☐	☐	☐
38. Been left out by other people?	☐	☐	☐	☐	☐	☐
39. Not wanted or been unable to spend time with other people?	☐	☐	☐	☐	☐	☐
40. Not wanted or been unable to participate in activities such as sport, clubs, drama, music, school trips?	☐	☐	☐	☐	☐	☐
41. Worried that he/she has fewer friends?	☐	☐	☐	☐	☐	☐
42. Been concerned about what others think about his/her teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐	☐
43. Been asked questions by other people about his/her teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐	☐

Iowa Fluoride Study
Oral Health Questionnaire - Parent

Family ID: ☐ ☐ ☐ ☐

The next questions ask about effects a <u>teen's oral condition</u> may have had on <u>PARENTS or OTHER FAMILY MEMBERS</u>.

During the <u>past 3 months</u>, because of your teen's <u>teeth, lips, mouth or jaws</u>, how often have you or another family member ...

	Never	Once or twice	Sometimes	Often	Very often	Don't know
44. Been upset?	☐	☐	☐	☐	☐	☐
45. Had sleep disrupted?	☐	☐	☐	☐	☐	☐
46. Felt guilty?	☐	☐	☐	☐	☐	☐
47. Taken time off work (e.g., pain, appointments, surgery)?	☐	☐	☐	☐	☐	☐
48. Had less time for yourself or the family?	☐	☐	☐	☐	☐	☐
49. Worried that your teen will have fewer life opportunities (e.g., dating, getting married, having children, getting a job they like?)	☐	☐	☐	☐	☐	☐
50. Felt uncomfortable in public places (e.g., stores, restaurants with your teen?)	☐	☐	☐	☐	☐	☐

During the <u>past 3 months</u>, because of his/her <u>teeth, lips, mouth or jaws</u>, how often has your teen...

	Never	Once or twice	Sometimes	Often	Very often	Don't know
51. Been jealous of you or others in the family?	☐	☐	☐	☐	☐	☐
52. Blamed you or another person in the family?	☐	☐	☐	☐	☐	☐
53. Argued with you or others in the family?	☐	☐	☐	☐	☐	☐
54. Required more attention from you or others in the family?	☐	☐	☐	☐	☐	☐

During the <u>past 3 months</u>, how often has the condition of your teen's <u>teeth, lips, mouth or jaws</u> ...

	Never	Once or twice	Sometimes	Often	Very often	Don't know
55. Interfered with family activities at home or elsewhere?	☐	☐	☐	☐	☐	☐
56. Caused disagreement or conflict in your family?	☐	☐	☐	☐	☐	☐
57. Caused financial difficulties for your family?	☐	☐	☐	☐	☐	☐

58. Questionnaire completed by...

☐ Mother ☐ Father ☐ Other (specify) _____

6WQOLP
October 2009

Quality of Life Questionnaire - Parents

Instructions for parents:

On the scale below, please rate the overall impact of "how your teenager's teeth look and feel" on their quality of life in performing usual and social activities that would be expected for his/her age such as eating, speaking, studying, recreation, and participating in school activities, and on his/her overall physical and mental well-being, including the level of comfort, pain, self-esteem, anxiety, or depression.

The scale extends from 0 to 100, where 0 represents the worst health state that you can imagine, and 100 represents "perfect" health.

Please mark the scale with a vertical line to indicate a score (between 0 and 100) that reflects the impact of "how your teenager's teeth look and feel" on his/her quality of life and well-being compared to the two states of worst imaginable health (score of 0) and perfect health (score of 100).

Worst
Imaginable
Health

Perfect
Health

| 0 | 25 | 50 | 75 | 100 |

Office use only

ID: ☐☐☐☐ M ☐

Date: ☐☐ / ☐☐ / 2 0 ☐ P ☐
S ☐

Score: ☐☐☐ O ☐

Iowa Fluoride Study
Oral Health Questionnaire - Teen

6WOHT v4
April 2011

Family ID: ☐☐☐☐   **Today's Date:** ☐☐ / ☐☐ / 2 0 ☐☐

Hello and welcome to the Iowa Fluoride Study Oral Health Questionnaire.

Thank you for helping us with our study.

This questionnaire is about the effects of conditions of your teeth, lips, mouth and jaws on your well-being and everyday life, and their effects on your family. By answering this questionnaire, you will help us to learn more about young people's experiences.

PLEASE REMEMBER:

1. **Please use a black pen to complete the questionnaire.**

2. **Please answer each question as accurately as you can.**

3. Do not write your name on the questionnaire.

4. This is not a test and there are no right or wrong answers.

5. Answer as honestly as you can. Please **do not discuss your responses with your parents**, as we are interested only in your thoughts and feelings in this questionnaire.

6. Read each question carefully and think about your experiences in the **past three months** when you answer.

7. Before you answer, ask yourself: "**Did this happen to me because of problems with my teeth, lips, mouth or jaws in the past three months?**"

8. Please give the response that **best describes your experience** by checking the appropriate answer. Give only one answer for each question.

Here is an example of how to answer the questionnaire:

EXAMPLE:

QUESTION: During the past three months, because of your teeth, lips, mouth, or jaws, how often have you…

	Never	Once or twice	Sometimes	Often	Very often
Had trouble Sleeping?	☐	☐	☐	☒	☐

If you have had trouble sleeping because of problems with your teeth, lips, mouth or jaws, choose the appropriate response. If it has happened for other reasons, please choose **Never.**
For example: If you have **often** had trouble sleeping in the past three months because of your teeth, lips, mouth or jaws, your correct answer is **Often**. Just check Often as shown above.

If you make a mistake and more than one box ends up being checked, circle the box with the correct answer.

2451302984

Iowa Fluoride Study
Oral Health Questionnaire - Teen

6WOHT v4
April 2011

Family ID: ☐ ☐ ☐ ☐

FIRST, A FEW QUESTIONS ABOUT YOU

These questions ask about your opinions about the health of your teeth, lips, mouth and jaws and their effect on your life.

	Excellent	Very Good	Good	Fair	Poor
1. Would you say the <u>overall</u> health of your teeth, lips, mouth and jaws is…	☐	☐	☐	☐	☐

	Not at all	Very little	Some	A lot	Very much
2. How much does the condition of your teeth, lips, mouth or jaws adversely/negatively affect your life overall?	☐	☐	☐	☐	☐

These questions ask about your own opinion about the appearance of your teeth.

	Very attractive	Somewhat attractive	Just ordinary	Somewhat unattractive	Very unattractive
3. Would you say the <u>color</u> of your teeth is…	☐	☐	☐	☐	☐

	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not
4. If it were possible, would you like to change the <u>color</u> of your teeth?	☐	☐	☐	☐	☐

	Very attractive	Somewhat attractive	Just ordinary	Somewhat unattractive	Very unattractive
5. Would you say the <u>shape</u> of your teeth is…	☐	☐	☐	☐	☐

	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not
6. If it were possible, would you like change the <u>shape</u> of your teeth?	☐	☐	☐	☐	☐

	Very crooked	Substantially crooked	A little bit crooked	Not crooked at all	
7. Would you say your <u>front teeth</u> are…	☐	☐	☐	☐	

	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not
8. If it were possible, would you like treatment to straighten your teeth?	☐	☐	☐	☐	☐

	Very badly stained	Badly stained	Just slightly stained	Not at all stained	
9. Would you say your <u>front teeth</u> are …	☐	☐	☐	☐	

	Yes	Almost	Not quite	Definitely not	
10. Can you make your teeth look as clean as you would like when you try hard to brush them?	☐	☐	☐	☐	

	Very satisfied	Satisfied	Somewhat dissatisfied	Dissatisfied	
11. Are you satisfied with the <u>appearance</u> of your front teeth?	☐	☐	☐	☐	

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Iowa Fluoride Study
Oral Health Questionnaire - Teen

6WOHT v4
April 2011

Family ID: ☐☐☐☐

QUESTIONS ABOUT ORAL PROBLEMS

During the <u>past 3 months</u>, how often have you had...

	Never	Once or twice	Sometimes	Often	Very often
12. Pain in teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐
13. Bleeding gums?	☐	☐	☐	☐	☐
14. Sores in the mouth?	☐	☐	☐	☐	☐
15. Bad breath?	☐	☐	☐	☐	☐
16. Food caught in or between the teeth?	☐	☐	☐	☐	☐

For the rest of the questions...

Has this happened to you because of your teeth, lips, mouth or jaws? If you felt this way only for other reasons, answer 'Never'.

In the <u>past 3 months</u>, how often have your teeth, lips, mouth or jaws caused you to...

	Never	Once or twice	Sometimes	Often	Very often
17. Breathe through your mouth?	☐	☐	☐	☐	☐
18. Take longer than others to eat a meal?	☐	☐	☐	☐	☐
19. Have trouble sleeping?	☐	☐	☐	☐	☐

In the <u>past three months</u>, because of your teeth, lips, mouth or jaws, how often has it been...

	Never	Once or twice	Sometimes	Often	Very often
20. Difficult to bite or chew food like apples, corn on the cob, or steak?	☐	☐	☐	☐	☐
21. Difficult to open your mouth wide?	☐	☐	☐	☐	☐
22. Difficult to say any words?	☐	☐	☐	☐	☐
23. Difficult to eat foods you would like to eat?	☐	☐	☐	☐	☐
24. Difficult to drink with a straw?	☐	☐	☐	☐	☐
25. Difficult to eat hot or cold foods?	☐	☐	☐	☐	☐

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Iowa Fluoride Study
Oral Health Questionnaire - Teen

6WOHT v4
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Family ID: ☐☐☐☐

QUESTIONS ABOUT FEELINGS

Have you had these feelings because of your teeth, lips, mouth or jaws?

In the <u>past three months</u>, because of your teeth, lips, mouth or jaws, how often have you...

	Never	Once or twice	Sometimes	Often	Very often
26. Been concerned about the appearance of your teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐
27. Felt irritable or frustrated?	☐	☐	☐	☐	☐
28. Felt unsure of yourself?	☐	☐	☐	☐	☐
29. Felt shy or embarrassed?	☐	☐	☐	☐	☐
30. Been concerned what other people think about your teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐
31. Worried that you are not as good-looking as other people?	☐	☐	☐	☐	☐
32. Been upset?	☐	☐	☐	☐	☐
33. Felt nervous or afraid?	☐	☐	☐	☐	☐
34. Worried that you are not as healthy as other people?	☐	☐	☐	☐	☐
35. Worried that you are different than other people?	☐	☐	☐	☐	☐

QUESTIONS ABOUT SCHOOL

Have you had these feelings because of your teeth, lips, mouth or jaws?

In the <u>past three months</u>, how often have you...

	Never	Once or twice	Sometimes	Often	Very often
36. Missed school because of pain, appointments, or surgery?	☐	☐	☐	☐	☐
37. Had a hard time paying attention in school?	☐	☐	☐	☐	☐
38. Had difficulty doing your homework?	☐	☐	☐	☐	☐
39. Not wanted to speak or read out loud in class?	☐	☐	☐	☐	☐

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Iowa Fluoride Study
Oral Health Questionnaire - Teen

Family ID: ☐☐☐☐

QUESTIONS ABOUT YOUR SPARE-TIME ACTIVITIES

Have you had these experiences because of your teeth, lips, mouth or jaws?

In the past three months, how often have you...

	Never	Once or twice	Sometimes	Often	Very often
40. Avoided taking part in activities like sports, clubs, drama, music, school trips?	☐	☐	☐	☐	☐
41. Not wanted to talk to other people?	☐	☐	☐	☐	☐
42. Avoided smiling or laughing when around other people?	☐	☐	☐	☐	☐
43. Had difficulty playing a musical instrument such as a recorder, flute, clarinet, trumpet?	☐	☐	☐	☐	☐
44. Not wanted to spend time with other people?	☐	☐	☐	☐	☐
45. Argued with other people or your family?	☐	☐	☐	☐	☐

In the past three months, how often have...

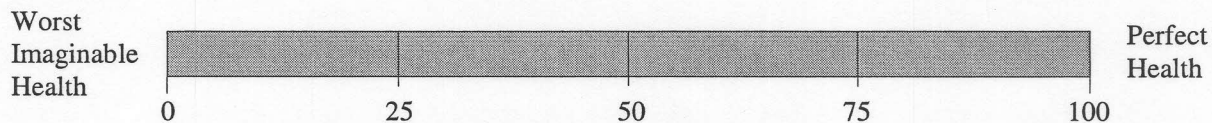|	Never	Once or twice	Sometimes	Often	Very often
46. Other people teased you or called you names?	☐	☐	☐	☐	☐
47. Other people made you feel left out?	☐	☐	☐	☐	☐
48. Other people asked you questions about your teeth, lips, mouth or jaws?	☐	☐	☐	☐	☐

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Quality of Life Questionnaire - Teenagers

Instructions for teenagers:

On the scale below, please rate the impact of "how your teeth look and feel" on your quality of life in performing usual daily activities such as eating, speaking, exercising, studying, working (if applicable), and social interactions, and on your overall physical and mental well-being, including the level of comfort, pain, self-esteem, anxiety, or depression.

The scale extends from 0 to 100, where 0 represents the worst health state that you can imagine, and 100 represents "perfect" health.

Please mark the scale with a vertical line to indicate a score (between 0 and 100) that reflects the impact of "how your teeth look and feel" on your quality of life and well-being compared to the two states of worst imaginable health (score of 0) and perfect health (score of 100).

Worst Imaginable Health					Perfect Health
0	25	50	75	100	

Office use only

ID: ☐☐☐☐

Date: ☐☐ / ☐☐ / 2 0 ☐

Score: ☐☐☐