Oral diseases and problems, and oral impacts on daily performances among adolescents living in Maasai populated areas in Tanzania

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Thesis for the degree of Philosophiae Doctor (PhD)
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List of abbreviations

Child-OIDP - Child-oral impacts on daily performance

CI – Confidence Interval

DMFT – Decayed Missing Filled Teeth

GBI – Gingival Bleeding Index

HIV/AIDS – Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome

ICIDH - International Classification of Functioning, Disability and Health

IKO - Department of Clinical Dentistry

Mg F/L – Milligram Fluoride per Litre

MUHAS – Muhimbili University of Health and Allied Sciences

OHI-S – Simplified Oral Hygiene Index

OHRQoL – Oral Health Related Quality of Life

OIDP – Oral Impact on Daily Performance

OR – Odds Ratio

PCA – Principal Component Analysis

PI – Principal investigator

QoL – Quality of Life

SD – Standard Deviation

SPSS – Statistical Package for Social Sciences

TF-Index – Thylstrup and Fejerskov Index

TMD – Temporomandibular Disorder

TMDp – Temporomandibular Disorder pain

TMJ – Temporomandibular Joint

WHO – World Health Organization

Scientific environment

The work in this thesis was carried out during the period between August 2015 and May 2020 at the Department of Clinical Dentistry (IKO) – Cariology, Faculty of Medicine, University of Bergen, Norway. Data collection was carried out at Monduli and Longido Districts of Arusha region in the Northern part of Tanzania. The work was supervised by Professor Ann-Katrin Johansson as a main supervisor, Department of Clinical Dentistry–Cariology, from the University of Bergen, Norway. Also it was supervised by co-supervisors Professor Anne Nordrehaug Åstrøm from the University of Bergen, Norway and Dr Irene Kida Minja from the Muhimbili University of Health and Allied Sciences, Tanzania.

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Abstract

Background: The study aimed to assess prevalence/frequency and socio-behavioral distribution of oral diseases/problems and their oral quality of life consequences according to Maasai and non-Maasai ethnic groups.

Methods: All adolescents in the selected classes from 23 randomly selected schools were invited to participate in an interview and clinical oral examination.

Results: The observed prevalence in percentage of different oral diseases/problems among adolescents was 65.6, 40.9, 8.8, 48.6, 1.9, 16.5 and 11.8 for poor oral hygiene, gingival bleeding, dental caries (DMFT>0), severe dental fluorosis (TF grade 5-9), dental erosion into dentin, tooth wear into dentin and Temporomandibular disorder (TMD), respectively. The prevalence of Oral Impact on Daily Performance (OIDP>0) was (15.8%). From multiple variable analyses, adolescents from Longido and girls were more likely to present good oral hygiene ($p<0.05$). Males and adolescents from Maasais presented more gingival bleeding than females and adolescents from non-Maasais ($p<0.05$). Age and non-Maasai ethnic group were associated with DMFT>0 ($p<0.05$). Dental erosion was more common among non-Maasais ($p<0.05$). Regular tooth cleaning was associated with less gingival bleeding ($p<0.05$). Severe dental fluorosis was associated with the use of magadi in food ($p<0.05$). Clenching/grinding teeth was the only covariate for TMD ($p<0.05$). Regarding OIDP, adolescents from Longido district and adolescents with good oral hygiene were less likely to report OIDP>0, but non-Maasai, those with DMFT>0 and 2Q/TMD>0 were more likely to report OIDP>0 ($p<0.05$).

Conclusion: Among the study participants, the most common findings were gingival bleeding, dental fluorosis, tooth wear and TMD, less common findings were dental caries and dental erosion. The prevalence of oral impacts was moderate. This study confirmed socioeconomic and oral clinical disparities in OIDP. These results are important for public oral health decision makers in Tanzania.

List of publications

This thesis is based on the following original publications and manuscripts, which will be referred in the text as Papers I-III.

I. **Simangwa LD, Åstrøm AN, Johansson A, Minja IK and Johansson AK.** Oral diseases and socio-demographic factors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study. ***BMC Oral Health.2018;18:200***

II. **Simangwa LD, Åstrøm AN, Johansson A, Minja IK and Johansson AK.** Oral diseases and oral health related behaviors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study. ***BMC Pediatrics. 2019;19:275***

III. **Simangwa LD, Johansson AK, Johansson A, Minja IK and Åstrøm AN.** Oral Impacts on Daily Performances and its socio-demographic and clinical distribution: A cross-sectional study of adolescents living in Maasai population areas, Tanzania. ***Health Qual Life outcomes. 2020;18:181***

1. Introduction

The pastoral societies in Tanzania are due to their specific cultural, political and geographical situation often marginalized from development processes. They are therefore often excluded from many health services, including oral health care services [1]. In order to deliver health care to these remote people in Tanzania, village dispensaries/health centers have been placed in some specific areas. However due to the pastoral way of living among a large proportion of these groups, for example the Maasais who lives and moves with groups of animals, access to these health care facilities often becomes difficult. Therefore mobile general health clinics have sometimes been used in those pastoral societies but this is not the case in all of these societies, for example in the northern part of Tanzania.

Oral diseases are often a costly burden to health care services and in low-income countries may therefore more than 90% of all caries be left untreated [2]. In these poor resource countries oral health services are usually offered at district/regional and/or zonal referral hospitals situated in urban areas. Due to shortage of oral health personnel, the capacity of these services are generally limited to pain relief and/or emergency care [3].

Oral diseases such as dental caries, periodontal diseases, oral-mucosal lesions and oral-pharyngeal cancers, and oral-dental trauma are major public health problems worldwide [4, 5]. It is known that the experience of pain, problems with eating, chewing, smiling and communication due to missing, discolored teeth have a major impact on people's daily lives and well-being [6]. In addition, poor oral health may have a profound effect on general health, and it is also known that several oral diseases are related to other chronic diseases such as diabetes, obesity and coronary heart diseases [2, 6].

Gingival inflammation

The gingiva is the mucosal part of the oral cavity that surrounds the tooth and covers the alveolar bone. The gingiva serves to protect the tissue under the attachment of the tooth to the influence of the oral environment [7]. Gingivitis is an inflammation that affects the soft gingival tissue around the tooth. Clinical features of gingivitis are redness that appears on the gingival margin, enlargement of blood vessels in sub-epithelial connective tissue, edema and bleeding on gentle probing [7, 8].

Epidemiology of gingival disease

Epidemiological studies indicate that gingivitis of varying severity is nearly a universal finding among adolescents [9]. Gingivitis can occur at any age, but most often at the age of puberty due to hormonal factors. The prevalence of gingivitis in girls is less than in boys, probably as a result of a higher level of oral hygiene among girls [9]. The worldwide prevalence of gingivitis among adolescents varies widely from 53% to 100% (Table 1) [10-16]. In comparison with the developed countries, developing countries have higher prevalence of gingival disease among adolescents. The prevalence of gingivitis among adolescents in developing countries figures vary from 35-100% and in developed countries vary from 4-34% [9, 12, 17].

Table 1 Global summaries of studies on gingivitis (gingival inflammation) in adolescents conducted in the period between 2010-2019

Country	Locality	Age (years)	Prevalence (%)	Reference
Brazil	Rural/urban	12	53	Knack et al. 2019 [18]
Puerto Rico	Rural/Urban	12	80	Elias-Boneta et al. 2018 [11]
Saudi Arabia	Urban	14	81	Bahannan et al. 2018 [19]
Greece	Urban	13-16	73	Chrysanthakopoulos et al 2016 [15]
Cameroon	Urban	12-13	27	Azodo et al. 2015 [20]
Thailand	Urban	15	82	Krisdapong et al. 2012 [14]
Thailand	Urban	12	79	Krisdapong et al. 2012 [14]
Kenya	Urban	12	78	Owino et al. 2010 [21]
Yemen	Urban	6-14	100	Al-Haddad et al. 2010 [12]
Sri-Lanka	Urban	15	86	Amarasena et al. 2010 [22]

Etiology of gingivitis

The etiology of gingivitis is multi-factorial and usually the result of more than one factor. Bacterial plaque is the main etiological factor causing gingival disease most often due to a deficiency of oral hygiene [15, 23, 24]. Plaque accumulation on the tooth surface will increase the risk for an inflammatory reaction in the gingiva, with clinical signs of redness, edema, gingival bleeding and sometimes pain [23]. However,

this condition may be aggravated by risk factors such as increased age, the presence of systemic diseases, oral health related behavioral problems, and underprivileged socioeconomic conditions [25, 26]. If prolonged, gingivitis may progress into periodontitis in some individuals [15].

Dental caries

Dental caries is a chronic disease, a process that progresses very slowly in most individuals, affecting enamel, dentine and cementum. The disease is rarely self-limiting and in absence of treatment such as behavioral changes, as a result of for example dietary advice, fluoride recommendations, oral hygiene information, caries may progress until the tooth is totally destroyed [27].

Epidemiology of dental caries

Dental caries is associated with dietary habits and is an important oral health problem in many communities. The distribution of dental caries varies in different parts of the world and also within the same country or region [28]. Studies have shown that caries prevalence and severity is low in many low income African countries compared to high income countries, for example Japan [29, 30]. In developing countries the majority of dental caries remains, as mentioned earlier, untreated due to inappropriate, unaffordable or unavailable oral health care services [31]. Studies on dental caries in sub-Sahara Africa has shown that caries varies in prevalence (9.7 – 43.5%) and severity from one country to another as well as within the same country [32]. For example in Kenya, the prevalence of dental caries among 12 year old adolescents (2012) in urban areas was 37.5% and the corresponding figure in rural areas was 24.0% [33]. A summary showing the prevalence of dental caries among adolescents in sub-Saharan Africa is presented in Table 2.

Regarding high income countries, the prevalence of dental caries among adolescents aged 12 year old range from 22.3 – 84.0% [34]. These are countries that in a global perspective, have affluent societies with well developed health care and educational systems and with the most fundamental prerequisites for health available for most

citizens [35, 36]. However, epidemiological studies among the adolescents of minority ethnic groups in European countries, have reported higher odds of having dental caries compared to majority of native Danish and Dutch adolescents [37, 38].

Etiology of dental caries

The main factors associated with dental caries etiology are bacteria, susceptible tooth surface and fermentable carbohydrates as well as time. Dental caries occurs when a susceptible tooth surface is colonized with cariogenic bacteria and dietary source of sucrose or refined sugar is present for a certain time. Bacterial pathogen produces lactic acid from fermentation of carbohydrates and this acid dissolves the hydroxyapatite crystal structure of the tooth which causes caries [28].

A risk factor is a variable that causes disease and the exposure to which leads to disease occurrence. A longitudinal study is usually required to demonstrate the causal relationship [39]. On the other hand the risk indicator is a variable that correlates with the disease occurrence and usually studied in cross-sectional studies [40]. Reports from cross sectional studies have revealed socio-economic status, maternal education, urban versus rural areas, ethnicity, dietary habits, dental services utilization and tooth cleaning habits as risk indicators for dental caries [41].

Table 2 Summaries of studies on dental caries experience (DMFT>0) in adolescents in sub-Saharan Africa conducted in the period between 2007-2016

Country	Locality	Age (years)	Prevalence (%)	Mean DMFT	Reference
Malawi	Urban/rural	12	19.1	0.7	Msyamboza et al. 2016 [42]
Malawi	Urban/rural	15	21.9	0.7	Msyamboza et al. 2016 [42]
Nigeria	Urban	12-15	21.9	1.8-2.7	Chukwumah et al. 2016 [43]
Kenya	Urban	12	37.5	0.8	Gathecha et al. 2012 [33]
	Rural	12	24.0	0.4	Gathecha et al. 2012 [33]
Tanzania	Urban	15.0	43.5	1.2	Mbawalla et al. 2011 [44]
	Urban	13.0	22.0	0.4	Mbawalla et al. 2011 [44]
Uganda	Urban	11-12	9.7	0.5	Batwalla et al. 2007 [45]

Dental fluorosis

Dental fluorosis is a hypomineralisation in the tooth enamel caused by ingestion of excessive fluoride throughout a long period during the formation of dental hard tissues [46]. The clinical dental manifestations vary from white striations in enamel to confluent staining and later on pits formation [47].

Epidemiology of dental fluorosis

The universal presence of fluoride in water, food, soil, industrial and pharmaceutical products, and the atmosphere exposes the human beings to various levels of fluoride. However, water-borne fluoride, remain the largest single component of this element's daily intake, except where unusual dietary patterns exist [48]. Epidemiological studies on severe dental fluorosis (TF≥ 5) have been reported from various regions of the sub Saharan Africa including Tanzania (10-34%), Kenya (48%) and Ethiopia (24-76%) [49-51]. If also the milder form of fluorosis taken into consideration the prevalence of dental fluorosis is almost 100% in some areas [52].

Etiology of dental fluorosis

Epidemiological studies have revealed the causes of dental fluorosis is not only the high concentration of fluoride in drinking water, but also other well-known sources of fluoride may contribute to overexposure and hence cause dental fluorosis. These includes fluoridated dentifrices and mouth rinse (which young adolescents/children may swallow in excess), inappropriate use of fluoride supplements, ingestion of food rich in fluoride including the use of trona (magadi) in cooking and fluoride in dust from soil [49, 53-55]. Trona is a natural mineral ($Na_2CO_3.NaHCO_3.2H_2O$) which is locally known as magadi and used in Tanzania by some people from Arusha and Moshi regions to speed up the cooking process and as a tenderizer for certain foodstuffs like maize, beans and bananas [56].

Table 3 Prevalence of severe dental fluorosis (TF ≥ 5) in the adolescents in some countries from Sub-Saharan Africa conducted in the period between 2000-2012

Country	Age (years)	Location	Index	Prevalence (%)	Reference
Tanzania	10-14	Urban	TF ≥ 5	10.0	Awadia et al. 2000 [49]
	10-14	Rural	TF ≥ 5	34.0	Awadia et al. 2000 [49]
Ethiopia	12-15	Rural	TF ≥ 5	75.9	Wondwossen et al. 2006 [51]
	12-15	Rural	TF ≥ 5	24.1	Wondwossen et al. 2006 [51]
Kenya	13-15	Urban	TF ≥ 5	48.2	Makhanu et al. 2009 [50]

It has been reported in the literature that the prevalence of dental fluorosis in the permanent teeth is common in both high- and low-fluoridated areas of Tanzania (Arusha and Moshi regions) [57, 58]. Dental fluorosis was found to be related to the use of magadi in the food. Magadi from East Africa is known to have high fluoride content [49, 57].

Tooth wear

Tooth wear is the cumulative surface loss of mineralized tooth substance due to physical or chemo-physical processes (dental erosion, abrasion and attrition) [59, 60]. Dental erosion is a chemical loss of mineralized tooth substance caused by the exposure to acids of non-bacterial origin acting on plaque free tooth surfaces. Abrasion is a physical loss of mineralized tooth substance caused by external sources for example excessive tooth brushing. Attrition is a physical loss of mineralized tooth substance due to tooth-to-tooth contact [59, 60]. It is well known that interactions between different types of tooth wear such as erosion, abrasion and attrition, contribute strongly to clinically observed patterns of wear [61]. However, studies have

revealed that dental erosion is the most important clinical parameter among the tooth wear processes [60, 62]. The definition of erosive tooth wear is therefore tooth wear with dental erosion as the primary etiological factor [60].

For the purpose of clinical diagnosis of tooth wear, a number of indices have been developed [63]. Some of researchers have performed full mouth recordings, grading all available teeth during their investigations [64]. Other researchers preferred the use of partial recordings by using certain marker teeth and surfaces [65, 66], mainly maxillary incisors and first molars and surfaces as these, according to previous reports, were found to be more affected by dental erosion compared to other teeth/surfaces [67]. Compared to the full mouth recording, the partial recording gives advantages of time saving during clinical examination and lower costs and especially when population based studies are conducted [68].

In our ancestors, tooth wear was found largely on occlusal, incisal and proximal surfaces. In the current populations, dental erosion occurs on all tooth surfaces but more commonly on palatal surfaces of maxillary anterior teeth and on occlusal surfaces of mandibular first molars and on incisal surfaces of maxillary central incisors [69]. Cupping, a concavity in the enamel, usually on a cusp tip, occurs in posterior teeth especially in the mandibular first molars [70]. The presence of cupping on first molars is considered one of the signs of dental erosion. Previous studies on dental erosion in Norway, Germany and Sweden have reported that 52%, 94% and 46% of the adolescents (16 year old) had cupping lesions extending into dentine, respectively [71-73].

Epidemiology of tooth wear

Globally, epidemiological studies on the prevalence of tooth wear had been conducted, but the findings are not always easily comparable due to the wide range of indices used [74]. Even so, it is clear that the prevalence of tooth wear in the general population varies widely and increases by age [75]. In Africa, there is a paucity of studies on tooth wear among adolescents. Tooth wear prevalence in adolescents in other parts of the world is summarized in Table 4.

Table 4 Summary of studies conducted in the period between 2013 -2018 on tooth wear in general (extending in to dentin) and dental erosion (extending into dentine) in adolescents worldwide

Country	Type of wear	Age (years)	Prevalence (%)	Reference
Sweden	Dental erosion	15-17	18.3	Skalsky et al. 2018 [76]
Yemen	Dental erosion	13-14	3.0	Al-Ashtal et al. 2017 [77]
Mexico	Dental erosion	14-19	10.8	Gonzalez et al. 2016 [78]
Norway	Dental erosion	16	20.0	Mulic et al. 2016 [71]
China	Tooth wear	12	1.9	Zhang et al. 2015 [79]
	Tooth wear	15	5.6	Zhang et al. 2015 [79]
Jordan	Tooth wear	15-16	51.0	Abu-Ghazaleh et al. 2013 [80]
United States of America	Dental erosion	12	0.0	Habib et al. 2013 [81]

Etiology of tooth wear

The etiology of tooth wear is multifactorial, caused by chemical, biological and behavioral factors. From the chemical factors, chronic exposure of teeth to extrinsic or intrinsic acids may lead to tooth wear. The etiological factors to dental erosion are

traditionally divided in extrinsic and intrinsic factors. Extrinsic factors include any acidic products that we eat or drink, for example acidic beverage, citrus fruits, juice from fruits, sports drinks and some medicines for example vitamin C tablets [76, 82, 83]. Intrinsic causes of dental erosion include several ailments and lifestyles which lead to regurgitation of acids into the oral cavity. For example in patients with eating disorders, gastroesophageal reflux disease (GERD), vomiting and regurgitation, there is in increased risk of erosion [84, 85]. Biological factors for example saliva, acquired pellicle, tooth structure and positioning in relation to soft tissues and tongue plays a great role in tooth wear etiology [86]. Behavioral factors includes eating habits and increased consumption of beverages and foods with high acid contents and otherwise proper oral hygiene measures for example tooth brushing is known to remove the brittle eroded tooth surface after acid attack [87].

Other factors which may cause tooth wear includes, bad oral habits like biting of nails, tacks, clips, threads, as well as holding of different objects between the teeth (pencils, pens, pipes) that can be related to some professions (musicians playing wind instruments, dressmakers, glass blowers). In addition, peculiarities of the environment (mines, dry environment/dust, deserts), where the sand particles and other substances can get into the oral cavity [88, 89].

Temporomandibular disorders

Temporomandibular disorder (TMD) comprises pathologies affecting the temporomandibular joint (TMJ), masticatory muscles and its associated structures. Signs and symptoms include pain in the TMJ, face and/or head, pre-auricular region, muscle fatigue involving the cervical and craniofacial regions and/or the masticatory muscles, limitation to jaw mobility, jaw deviation or deflection and articular noise [90].

Epidemiology of Temporomandibular disorder

The prevalence of TMD in adolescents varies widely in the literature. This is due to differences in the populations studied, diagnostic criteria and examination methods

[91]. A systematic literature review have found that the prevalence of TMD among adolescents (10-19 years) ranges from 7.3 to 30.4% [92]. The disease is more common in females and that the clinical manifestations increases with age [93, 94]. Despite this high prevalence, the extent of its manifest in most population is less known, and the demand for treatment is low [95]. Epidemiological studies have revealed that only 3.0–7.0% of individuals with TMD have sought treatment for TMDs [96]. Usually patients asking for treatment may have severe complaints related to TMDs [97].

Etiology of Temporomandibular disorder

The TMD etiology is complex and multifactorial and numerous factors may contribute to this disorder. Predisposing factors increase the risk of developing TMD, initiating factors cause the onset of the disease and perpetuating factors interfere with the healing process or facilitate the progression of TMD [93]. Etiological factors include occlusal abnormalities, orthodontic treatment, bruxism, trauma, joint hyperlaxity and hypermobility, psychological factors such as stress, mental tension, anxiety or depression. Initiating factors are mainly related to trauma or adverse loading of the masticatory system. Perpetuating factors includes behavioral factors (grinding, clenching and abnormal head posture), social factors (affect perception and influence of learned response to pain) [93, 98].

Oral health related quality of life

The oral health related quality of life (OHRQoL) concept started to evolve in the early 1980s [99]. It was defined as the impact of oral disorders on an individual's life as measured from their own point of view, thus suggesting that people assess their OHRQoL by comparing their expectations and experiences [100]. Since the 1990s, instruments to assess OHRQoL have been developed to supplement, rather than substitute, conventional clinical oral indicators [101]. These instruments are used to assess the effect of intervention, as well as indicators of unmet need for oral care [102].

Oral health is part of general health since oral disorders have as severe emotional and psycho-social consequences as other disorders [103]. Oral diseases and problems may cause pain depending on the severity of the disease. In addition, oral diseases may cause functional problems, worry and anxiety. These problems have a negative effect on personal interactions, social activities and result in lower self-esteem, which in turn can influence the OHRQoL and wellbeing of an individual [36, 104]. The most important aspect of OHRQoL is to bring the patient rather than the mouth into focus in the research field of oral health [105].

From the World Health Organization's International Classification of Impairment, Disabilities and Handicaps (ICIDH), measures of oral health related quality of life based on the conceptual framework were derived and has been amended for dentistry by Locker (Figure 1) [106]. The ICIDH consists of the following key concepts: impairments, functional limitations, pain, discomfort, disability and handicap.

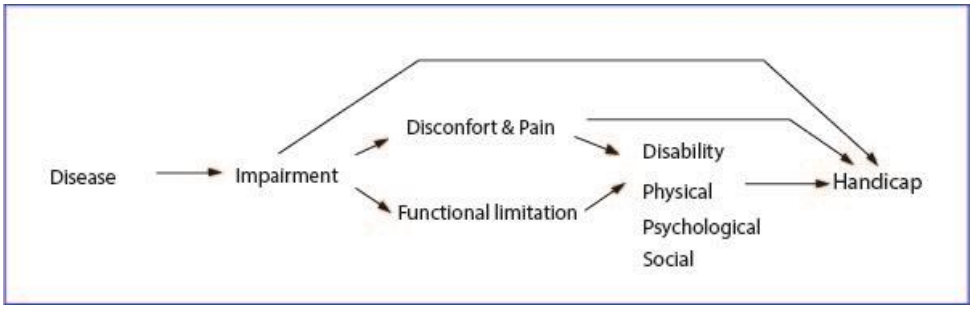

Figure 1. A conceptual model for measuring oral health (Source: Locker, 1988)

Impairments (first level) refer to the immediate biophysical outcomes of disease, commonly assessed by clinical indicators. In additional to dissatisfaction with dental appearance, functional limitations, pain and discomfort (second level) refer to the experiential aspects of oral conditions in terms of symptoms assessed through self-report procedures. Any of the dimensions mentioned at the first and second levels may lead to the third level, which refers to any difficulties in performing activities of daily living and to the broader social disadvantages, called ultimate impacts (third level),

thus corresponding to the WHO's and Locker's concepts of disability and handicap [106, 107]. There is a second version of the ICIDH model, the ICIDH-2 (International Classification of Functioning, Disability and Health). Functioning refers to all body functions, activities and participation as an umbrella term. Disability serves as an umbrella term for impairments, activity limitations or participation restrictions. ICIDH-2 also lists environmental factors that interact with all these constructs, providing a useful profile of individuals functioning, disability and health in various domains [108].

Different inventories have been developed for various age groups to measure oral health related quality of life [102]. Recently, a number of OHRQoL instruments have been developed for use with children and adolescents (Table 5).

Table 5 Instruments used to measure oral health-related quality of life in children and adolescents

Name of the instrument	Age (years)	Number of items	Reference
Early childhood oral health impact scale	3-5	13	Pahel et al. 2007 [109]
Child Perception Questionnaire	11-14	16 and 8	Jokovic et al. 2006 [110]
Parental/caregivers' perceptions of the oral health-related quality of life of children	8-10	47	Jokovic et al. 2004 [111]
Child-oral impacts on daily performance	11-15	8	Gherunpong et al. 2004 [112]
Parental perception Questionnaire	6-14	31	Jokovic et al. 2003 [113]
Family Impact Scale	6-14	13	Locker et al. 2002 [114]
Child Perception Questionnaire	11-14	36	Jokovic et al. 2002 [111]

The majority of these instruments measure the frequency and/or severity of functional, psychological and social impacts that may occur as a consequence of oral disorders. These measures have been referred to as socio-dental indicators, subjective oral health status measures, patient-based outcome measures, participant-based outcome measures, or OHRQoL measures [115]. OHRQoL measures are useful in epidemiological surveys, studies to explore their potential use, and in clinical trials to measure the effectiveness of interventions and as measures of unmet need. Depending on where OHRQoL measures are used and the study design employed, their major technical requirements are reliability, validity and sensitivity to change [115].

Generic and disease specific OHRQoL measures have been developed to understand the psychosocial consequences of oral diseases and to complement the traditional clinical measures [116]. As a result, OHRQoL instruments are recommended to be used as adjuncts and compliments to clinical measures [117]. Most OHRQoL indicators are generic in that they assess the overall impact of oral problems by considering oral diseases and problems in general. In contrast, condition-specific (CS) OHRQoL measures are used when specific oral diseases and problems are considered [118]. Both generic and disease specific measures are commonly used for adults or elderly populations. Some researchers have adapted socio-dental indicators developed for adults to fit younger age groups such as children and adolescents [119].

One commonly used inventory is the Oral Impacts on Daily Performance (OIDP) [120]. The OIDP is recognized internationally and has been shown to be valid and reliable in populations across occidental and non-occidental cultural settings [121]. To capture the needs of younger populations, a Child Oral Impacts on Daily Performances (Child-OIDP) index have been derived from adult OIDP. Child-OIDP was constructed in English, validated in Thailand, and in other countries including Tanzania [122-125]. The Child-OIDP measures the impacts of oral health problems on daily activities commonly performed by adolescents and comprises dimensions not captured by clinical measures, such as functional, psychological and social limitations [125]. The psychometric properties of the Child-OIDP have been assessed in various countries (including Thailand, French, Peru, Sudan and Brazil) with different cultures and languages and found to be successful [112, 123, 125-127]. The availability of multi-lingual versions of instruments is important for epidemiological research [125].

In East Africa region, studies on OHRQoL have received little attention. One study of Ugandan adolescents (mean age 15.8 years) in 2003 found that 62% of the students experienced oral impacts [119]. Using a Swahili version of Child OIDP inventory, previous studies on OIDP in adolescents from Tanzania in 2009 (mean age 13.8 years) found that 31.4% (rural) and in 2010 (mean age 15.2 years) 48.2% (urban) of the adolescents reported oral impacts on daily performances [128, 129]. In all these studies (Uganda and Tanzania), the most frequently reported oral impacts were eating

problems and problems in tooth cleaning [119, 128-130]. Studies among adolescents (11 – 15 year old)from other parts of sub Saharan Africa and other developing countries have reported on the prevalence of OIDP; Sudan (54.6%), Brazil (80.7%), Thailand (85.2%)and Peru (82.0%). In these countries the most reported oral impacts were problems in eating food (35.5 – 64.4%) and tooth cleaning (28.3 – 51.7%) [125, 127, 131, 132]. Studies among adolescents (11 – 14 year old) from high income countries reported the prevalence of OIDP; Spain (36.5%), Italy (66.8%) and France (73.0%), and the most reported impacts being problems with eating (30.4 – 43.5%) and tooth cleaning (24.2 – 31.9%) [126, 133, 134].

Ethnic groups in Arusha region

The Arusha region is located in the north-eastern corner of Tanzania. The region is bordered by Kajiado and Narok County in Kenya to the north, the Kilimanjaro Region to the east, the Manyara and Singida regions to the south, and the Mara and Simiyu regions to the west [135]. There are more than eleven ethnic groups inhabiting the Arusha region. The main ethnic groups are Maasai, Iraqw, Arusha, Meru and Barbaig. Other ethnic groups, small in numbers, are Sonjo, Gorowa, Rangi, Chagga, Pare and Nguu. The Iraqw are found in majority in Mbulu, Babati, Karatu and Hanang districts, while the Maasais are the main tribe in Kiteto, Simanjiro, Monduli, Longido and Ngorongoro districts. The ethnic groups of Meru and Arusha predominate in Arumeru District and Arusha Municipality while the ethnic group of Barbaigis found mainly in Hanang District. The Sonjo along with the Hadzabe (Tindiga) and Ndorobo form a minority of special interest in that until very recently depended on hunting for livelihood.

Maasai ethnic group

The Maasai is a unique and well known tribe due to their long preserved culture. Despite, civilization, western cultural influences and education, the Maasai people have clung to their traditional way of life [136]. The origin of Maasai is from Sudan. From Sudan they migrated via alongside river Nile into Uganda, Kenya and Tanzania, looking for greener pastures for their animals. As a consequence of this lifestyle, they don't have permanent houses [137]. The Maasai usually live in clans which are characterized by several mud houses built closely next to one another and referred to as a 'Boma' (Figure 2).

Figure 2: Aboma for a single family. A boma consists of several small houses built close to one another.Usually a Maasai man is a polygamist and in each house there is one wife (Source:PI, 2016).

The Bomas are built in open areas where they can accommodate also the livestock since they are usually well fenced off with thorny bushes for protection [137]. Researchers have estimated the total population of the Maasai to be about 1,000,000

and that about half of them live in Kenya and the other half in Tanzania [138]. But, it is difficult to estimate the exact number of Maasai living in Tanzania today since the Tanzanian government removed the ethnic variable during the last census in 2012 [139].

Cultures and traditions

Maasais' main food by tradition is meat and milk from their cattle, which means their diet is full of proteins and fats. Consumption of plant foods is uncommon due to the thought that green vegetables were meant for cattle feed [137, 140]. However, recently, the Maasai have increased the dependency on food produced in other areas, for example maize meal, rice, potatoes and cabbage. Today the Maasais who moved near crop farmers are more engaged in cultivation as their alternative mode of subsistence [141]. Thus, change from their traditional diets rich in proteins (milk, meat, blood) may influence not only the pattern of oral diseases but also quality of life.

The Maasai speak the Maa language, which belongs to the family of Nilotic languages, which originate from the Nile valley in Sudan. However, many modern Maasais speak the Swahili language, which is the national language of Tanzania [142]. In the Maasai culture both children and herds are signs of prosperity and richness. Both boys and girls undergo traditional circumcision, carried out with traditional instruments and without anesthetic. The ability to withstand pain is part of the young warriors' transition to manhood. It is during the circumcision period, that an adolescent is taught of his/her role in society. The boys are taught to protect their families and property whilst the girls are taught how to care for their husbands, children and the community in general. There is no marriage before circumcision [137].

Challenges they face

The Maasai traditional lifestyle is today highly challenged and many times overthrown by a lack of customary resources. Time-honored practices have little chance for survival within the context of rapid western influence. No longer are the times where

the Maasai can maintain a cattle centered lifestyle like before. The Tanzanian government, along with some conservationist groups, have come close to eradicating the Maasai way of lifestyles [143]. Traditional means of sustenance, medicine, water, and education have been labeled as inefficient by western influences and newly empowered Kenyan and Tanzanian governments. Due to changes in political structure, the Maasai are facing a number of devastating issues, the most pertinent being the Maasai land allocation, wildlife preservation, lack of healthcare and disease control, as well as lack of clean and safe drinking water. These issues are all tightly intertwined and endlessly complex; altering cultural practices, shifting traditional power dynamics, redefining survival essentials and threatening lives [143].

Healthcare services

Considering health care services, in comparison with other neighboring ethnic groups, the Maasai society is considered to be less privileged for both health service and educational attainment [144]. One reason for this is, as mentioned before, that the Maasai often live in remote areas and that their livestock requires them to be at least semi-nomadic. They therefore tend to migrate during various seasons of the year looking for water and green pastures for their herds. Another problem for the Maasais is physical and language communication. In terms of physical communication, there are bad roads, poor housing, long distances between the Bomas and health centers/schools.

Other ethnic groups in Maasai populated areas in Arusha region

The Maasai people in their areas do live with other ethnic groups. There are a number of other smaller ethnic groups including the Arushas (Wa-arusha), Merus (Wameru) and Rangis in the Arusha region. These groups differ from Maasaisin that the majority of them are not involved in keeping animals. Instead these groups are mainly farmers and business men. They have permanent houses and only few of them are involved in keeping animals and agro-pastoralism or small scale agriculture [144]. Also, the non Maasais main food is from agricultural crops like maize, millets, banana and rice and not animal products (meat and milk) as for the Maasais.

Arushas

The Arushas (Wa-arusha) is an ethnic, indigenous group based in Arusha region in northern Tanzania. The Arusha people should not be confused by Arusha residents who are Tanzanian people of different ethnic backgrounds that are born and reside within the borders of Arusha Region. The Arushas and Maasai ethnic groups are almost similar with regards to traditions. They both speak the same language but in terms of activities, traditionally the Arushas are agriculturalists while the Maasais are pastoralists, moving with their animals from one area to another. The Arushas pride themselves because of being productive farmers. Although for many years they have been growing crops on the same land, their land is still fertile as they protect the soil and conserve nature [145].

Merus

The Meru people, or Wameru, are Bantu-speaking people who settled at the base of Mount Meru over three hundred years ago. They settled in the forested area on the southeastern slopes of the mountain and developed a strong agricultural economy along with livestock keeping. It is believed that the Wameru practiced a traditional style of permaculture, the development of agricultural ecosystem intended to be sustainable and self-sufficient [146]. Generally, the Merus do not differ much in appearance from the majority of the population of modern Tanzania engaging in agricultural activities. The Merus grow coffee, bananas, maize, rice, millet and beans for their food [147].

Sonjos

The Sonjo people is an ethnic group whose people solely depend on herding and agriculture and they are known to have lived in northern part of Tanzania for centuries. They usually, maintain a traditional way of living, with the men tending the livestock and the women farming the land. The most widely practiced art in the Sonjos community is music playing and is being useful in rainmaking ceremonies, for ritual

purposes, marriages, healing ceremonies, and other social events [148]. Their main food includes maize, potatoes, rice, beans, meat, milk and other cereal crops [149].

Education system in Tanzania

The Tanzania education system has been passed over different transitions based on the political and economic changes happening over time. The current structure of the formal education and training system constitutes two years for pre-primary, seven years for primary education, four years for junior secondary education, two years for senior secondary education and at least three years for tertiary education. In addition, there is non formal education for adult people who lost the opportunity to get formal education earlier [150]. According to Tanzania's education act, all adolescents above the age of seven years must attend and complete compulsory primary education [151]. Under the law of the child act, all adolescents have the right and parents have a duty to ensure adolescents can realize this right [152]. However, many adolescents of school-going age are confronted with social and economic barriers that impede their access to education. Many adolescents are also exposed to human rights abuse and harmful practices, for example child labor and marriage, that make schooling difficult [153, 154].

It is clear that adolescents living in Maasai populated areas often face serious problems related to education achievement. For example, many parents are very poor, making their ability to invest in education for their children limited. Insecurity and distance from home to schools; many children have to travel a long distance to go to schools on foot crossing some forests and thus exposing them to dangerous animals. This causes some adolescents to drop out of the schools. In addition, the roads and communication systems are very poor making difficulties in travelling especially during rain season.

Justification for the study

In Tanzania, information about the oral health of the population living in rural areas is scarce. To our knowledge, there is no information on oral health of adolescents living in pastoral societies of Maasai populated areas of Tanzania. Previous studies in Maasai populated areas are not only few but also very old (1931 and 1935) [155, 156] and were conducted in Kenya, not Tanzania. In addition to this, a change of lifestyles, for example a change from their traditional diet to western modern diet, in Maasai populated areas by time may have affected not only general health but also oral health.

Assessing the social, psychological and functional impact of oral diseases/problems among adolescents provides information about their oral health related quality of life and facilitates understanding of the need of oral health care services [157]. Nothing is known about the impact of oral diseases and problems and their sequelae on the Oral Health Related Quality of Life (OHRQoL) of adolescents living in Maasai populated areas in Tanzania. Thus, there is a need to collect information about oral health, assessing oral health status and its impact on OHRQoL among the adolescents in Maasais' populated areas.

The unknown prevalence of oral diseases, oral problems as well as OHRQoL, particularly in the pastoral society underscored the need to estimate the magnitude of oral diseases and OHRQoL in their local setting. Thus, there is a need for epidemiological information about oral diseases and OHRQoL in the adolescents living in Maasai populated areas in the Arusha region, in Tanzania. The information obtained may be utilized for improving oral health care especially in marginalized societies and improving their OHRQoL.

2. Aims of the study

Overall aim

Focusing adolescents living in Maasai populated areas of Tanzania, the overall aim of the study was to assess prevalence/frequency and socio-behavioral distribution of oral diseases/problems and their oral quality of life consequences according to Maasai and non-Maasai ethnic groups.

Specific aims

I. To estimate the prevalence, severity and socio-demographic distribution of oral diseases/problems in adolescents living in Maasai population areas of Tanzania. To explore whether the socio-demographic differences in oral diseases/problems varied according to Maasai and non-Maasai ethnicity.

II. To explore the association between oral health related behaviors and the presence of oral diseases/problems, adjusted for sociodemographic factors, focusing on adolescents living in Maasai population areas in the northern part of Tanzania.

III. To estimate the prevalence of oral impacts and to identify important clinical- and socio-demographic covariates. In addition, this study compares Maasai and non-Maasai adolescents regarding any association of socio-demographic and clinical covariates with oral impacts on daily performances.

3. Materials and methods

3.1 Study area and population

The study was performed in Arusha region (Monduli and Longido districts), Tanzania. Tanzania has a population of approximately 53,950,935 with an annual growth rate of 2.75% (2017 estimates). In the total population, adolescents aged 10-19 years constitutes about 23% [158, 159]. In 2017, the gross domestic product per capita was estimated to be USD 3,300. The total health expenditure as a proportion of gross domestic product in 2014 was 5.6% [158]. The study population was supposed to be adolescents aged 12 - 14 year old attending public rural primary schools in Maasai population area of the two districts, Monduli and Longido in the Arusha region.

According to 2012 population and housing census of Tanzania, Arusha covers an area of 37,576 square kilometer and has a population of 1,694,310 [160]. Arusha has a predominantly poor rural population with an overall literacy rate of 84.5%. Moreover, Arusha is administratively divided into seven districts, two of which, namely Monduli (16422 km^2 and total population 158,929) and Longido (7,782 km^2 and total population 123,153) [160] constituted the study areas (Figure 3 a and b).

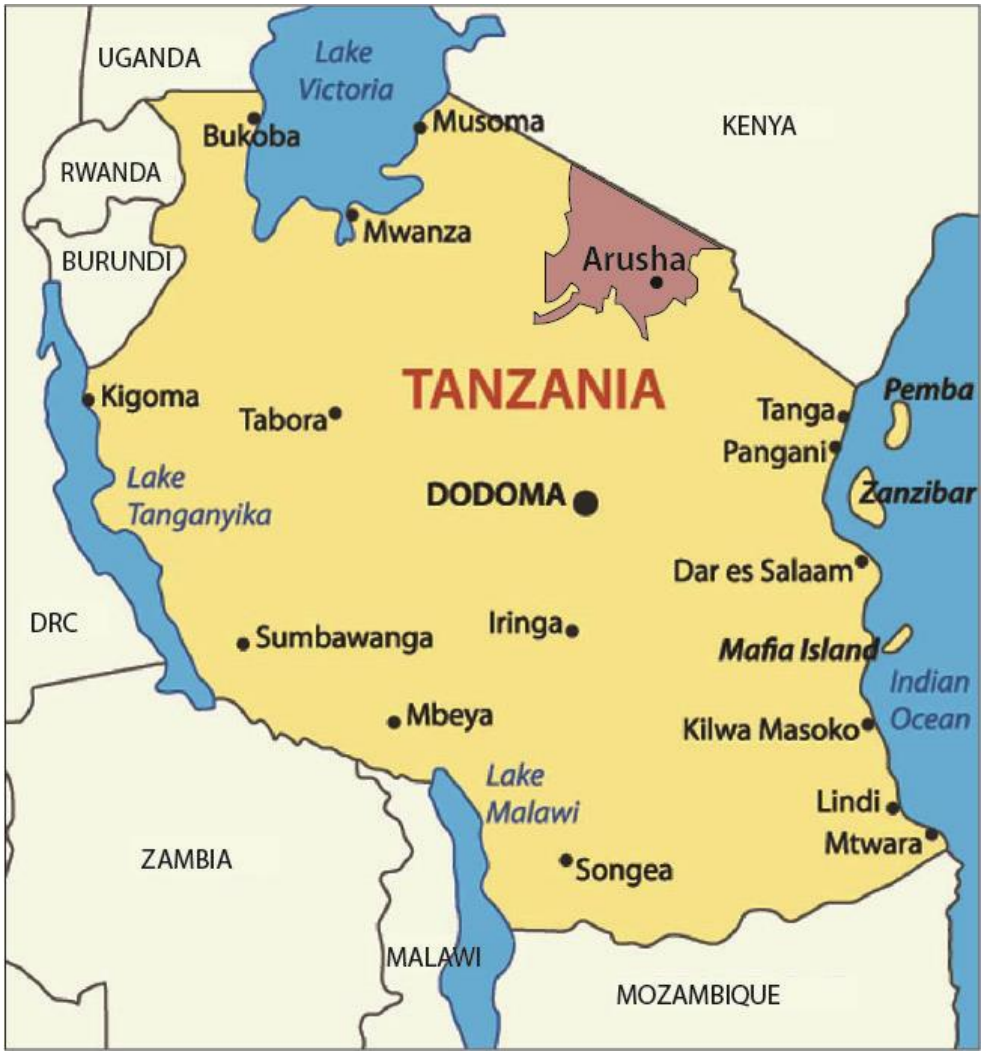

Figure 3a: Map of Tanzania showing bordering countries and some of the regions. (Source:Mapcruzin).

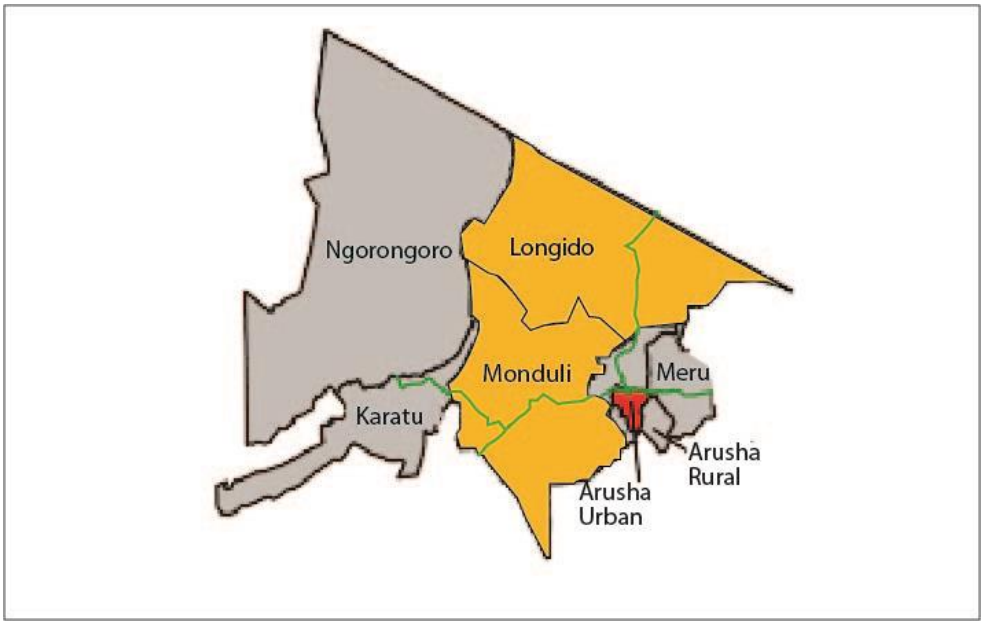

Figure 3b: Map of Arusha region showing its districts. The study was conducted in districts with yellow color (Source:Arusha region council).

3.2 Study design and sampling procedures

A cross-sectional study, which applies to paper I, II and III, was carried out in rural areas of Maasai populated areas of Arusha region in the Monduli and Longido districts, in the northern part of Tanzania during the period from June to November 2016. We used a one-stage cluster sample design to carry out random selection of schools with school as the primary sampling unit. From both districts, a list of all primary public and private schools in urban and rural areas was obtained giving a total of 100 schools. Then all private and urban schools were excluded from the sampling frame. Out of 66 eligible rural public primary schools (38 in Monduli and 28 in Longido), we randomly selected a total of 23 schools, 13 from Monduli and 10 from Longido. Then from each randomly selected school we purposely identified a class expected to contain adolescents aged 12-14 years (6^{th} grade). All adolescents available in the identified class were invited to participate in the study. In calculating the sample size, we assumed that the prevalence of dental erosion in the study area would be 50%.

We further assumed a margin error of 5%, confidence intervals of 95%. Then we multiplied the sample size by 2 to account for the design effect (D), and increased by 10% to account for contingencies for example non-response or recording errors, giving an estimated minimum sample size of 845 study participants.

3.3 Data collection

3.3.1 Interview

The interview schedule was constructed using English language. The University of Dar Es Salaam's translators in Tanzania translated it into Swahili, the Tanzanian national language and back-translated it to English independently. To gather information, closed- and open-ended questions were used.

About fifty primary school adolescents (12-14 year olds) were used for questionnaire pre-testing before the actual fieldwork regarding its correctness and appropriateness of format and modified the questionnaire when deemed necessary. The participants used for questionnaire pre-testing didn't participate in the main study. Two medical nurses were trained to perform face-to-face interviews using Swahili in a school setting. Privacy was observed by interviewing each child individually while others remained inside classes (Figure 4).

Sociodemographic factors were assessed using the variables age, sex, ethnicity, place

Figure 4: The boy is being interviewed under field conditions outside the classroom in natural day light by a research assistant (Source:PI, 2016).

of residence, house ownership, parents' education, number of adolescents, household socio-economic status (perceived affluence of my household) and household wealth index [161]. Ethnicity was assessed by asking "what is your ethnic group?" The response categories were (1) = Maasai, (2) = Meru, (3) = Arusha and (4) = others. For analysis, the items were dichotomized to 1 = Maasai (including option (1)) and 2 = non-Maasai (including option (2), (3) and (4) during analysis.

Parents' education was assessed by asking *what is the highest level of school your mother/father has attended?* Responses were (0) for none, (1) for she/he started but did not complete primary school, (2) for completed primary school (3) for she/he started but did not complete secondary school, (4) for she/he completed secondary school, (5) for she/he started but did not complete college/university, (6) for completed college/university, (7) for I don't know. In the statistical analyses, the items were dichotomized as (0) for low education from original options (0), (1), (2), (3) and (7) and (1) for high education from original options (4), (5) and (6).

Family wealth indicated by presence of durable household assets for example radio, television, refrigerator, mobile telephone, cupboard, bicycle and motorcycle was recorded as (Yes) "available and in working condition" or (No) "not available and/or not in working condition." Two TMD epidemiological questions were used to TMD pain. The questions were: *Do you have pain in your temple, face, jaw or jaw joint once a week or more? Does it hurt once a week or more when you open your mouth or chew?* The response was either *yes* or *no* and positive answer to any of the questions was considered affirmative to TMD diagnosis [162].

Oral hygiene practices, dietary habits, alcohol use & cigarette smoking, use of teeth in their daily activities and utilization of dental service were the variables used to assess oral health related behaviors. The response categories for dietary habits and oral hygiene practices were 0 = never, 1 = once to several times per month, 2 = once weekly, 3 = two or more times per week and 4 = daily. Dichotomized into 0 = low frequency (irregular intake/tooth cleaning)/at most once per week (with options 0, 1 and 2) and 1 = high frequency (regular intake/tooth cleaning)/at least twice per week (with options 3 and 4), during data analysis was done.

A Swahili version of the eight item Child OIDP inventory was used to assess oral health related quality of life [124]. The perceived difficulties in performing daily activities were inquired by asking *'During the past three months; how often have problems with your mouth or teeth caused you any difficulty with'; eating and enjoying food, speaking and pronouncing clearly, cleaning teeth, sleeping and relaxing, smiling and laughing, emotional status, socialization and contact with people.* Each item was scored 0-3 where 0 for never, 1 for once or more a month, 2 for once or more a week and 3 for every day/nearly every day. During analysis the 8 OIDP items were dichotomized into 0 for never affected (including the original category 0) and 1 for affected (including the original categories 1-3). A child OIDP simple count score, ranging 0 to 8 was constructed by summing up the dichotomized frequency items of (0) never affected and (1) affected.

3.3.2 Oral clinical examination

The principal investigator (L.S) performed all clinical oral examinations after an interview. The clinical examiner was not informed about the result of the questionnaire before the clinical examination. Avoiding the direct sunlight under field conditions, either outside or inside the classroom, while sitting on a chair the child was examined using natural day light. By the use of sterile gauze and cotton rolls, the teeth were cleaned/dried and isolated, respectively, when deemed necessary. In examination we used disposable mouth mirrors and probes.

Oral hygiene and gingival health were assessed using the Simplified Oral Hygiene Index (OHI-S) and Gingival Bleeding Index (GBI), respectively. Dental caries and dental fluorosis were assessed using criteria specified by WHO, 2013 and Thylstrup-Fejerskov Index (TF-Index), respectively [163-166]. The method proposed by Johansson et al. 1996 was used to assess dental erosion of maxillary anterior teeth (palatal and facial surfaces) [167]. The grading of first molar cuppings was performed using a scale proposed by Hasselkvist et al. [73]. Using a scale proposed by Carlsson et al 1985, full mouth recording of occlusal/incisal surfaces, tooth wear grading was performed [168].

3.4 Data analysis

The Statistical Package for Social Sciences (SPSS), version 24 - 25 (IBM corporation, Armonk, NY, USA) was used for data analysis. To adjust for the cluster effect of schools, STATA 14.2 (Stata corporation, Lakeway drive college station, Texas, USA) was used. The socio-economic index was categorized into wealth quintiles; 1st quartile (poorest), 2nd quartile (poorer), 3rd quartile (less poor) and 4thquartile (least poor) using principle component analysis (PCA). The socio-economic index based on assets ownership, for example furniture, electricity, type of water source, toilet types and roof material was used to assess their socio-economic status [161]. Statistical tests used in paper I-III are summarized in Table 6. The significance level was set at 0.05.

Table 6 Statistical tests used in paper I-III

Statistical test used	Paper I	Paper II	Paper III
PCA	+		+
Chi Square	+	+	+
Cohen's Kappa	+	+	+
Logistic regression	+	+	+

3.5 Ethical consideration

Before study implementation, the ethical clearance was applied from ethical research committee of both, Norway (REK VEST, reference number **2015/2477**) and Tanzania (the Medical Research Coordinating Committee of Ministry of Health, Community Development, Gender, Elderly and Children in Tanzania, reference number **NIMR/HQ/R.8a/VOL.IX/2214**). The Ministry of Education through the district councils of Monduli and Longido districts via their District education officers, school head teachers and parents gave the permission to work with primary school

adolescents. In this study informed signed consent were obtained from the parents and all participating adolescents gave an assent as they were below 18 year olds. We observed confidentiality and study participants were free to walk out of study without any explanation.

4. Results

Sample characteristics

A total of 930 adolescents accepted to participate in the study after inviting 989 grade 6 primary school adolescents. During analysis, due to too high or low age 24/ 930 (2.6%) of the adolescents were excluded. Thus, a total of 906 adolescents 12-17 years, mean age 13.4 years (SD 1.2) were included in the study. Out of 906 adolescents, 56.1% were females and the response rate was 91.6% (906/989). Among the study participants, 52.9% (479/906) and 57.1% (427/906) were from Monduli and Longido district, respectively. Out of 906 participants, 721 (79.6%) were from the Maasai and 185 (20.4%) were from the non-Maasai ethnic group.

4.1 Paper I

The aim of paper I was to estimate the prevalence, severity and socio-demographic distribution of oral diseases/conditions in adolescents living in Maasai population areas of Tanzania. It also aimed to explore whether the socio-demographic differences in oral diseases/problems varied according to Maasai and non-Maasai ethnicity.

The prevalence of poor oral hygiene was 65.6%, of gingival bleeding 40.9%, of dental caries experience (DMFT>0) 8.8%, of dental fluorosis (TF grade 5-9) 48.6%, of dental erosion into dentin 1.9%, of tooth wear into dentin 16.5% and of TMD 11.8%. The decayed component (D) and the missing component (M) of the DMFT- index was 90% and 10%, respectively. No filled (F) component was recorded in any participant. Multivariable logistic regression analysis showed that, girls (OR=2.0, CI 1.4-2.5) and adolescents from Longido (OR=2.6, CI 1.6-4.4) had higher odds of presenting with good oral hygiene compared to boys and adolescents from Monduli ($p<0.05$). Participants from Monduli district (OR=1.7, CI 1.3-2.5), males (OR=2.1, CI 1.7-2.5), adolescents born in Arusha region (OR=1.9, CI 1.2-3.3) and Maasai ethnic group (OR=1.7, CI 1.1-2.5) had higher odds of presenting with gingival bleeding compared to those respectively, from Longido, females, born outside Arusha region and non

Maasai ethnic group. Dental caries (DMFT>0) was associated with increasing age and non-Maasai ethnic group, (OR=2.0, CI 1.1-3.5) and (OR=2.2, CI 1.1-41), respectively. Dental fluorosis was more likely to occur in adolescents from Monduli district (OR=10.0, CI 3.3-10.0) and to those born in Arusha region (OR=3.2, CI 1.0-10.2). Having mother with high education (OR=2.3, CI 1.3-4.0) and non-Maasais (OR=2.0, CI 1.3-3.2) were associated with having dental erosion.

4.2 Paper II

The aim of paper II was to explore the association between oral health related behaviors and the presence of oral diseases, adjusted for sociodemographic factors, focusing on adolescents living in Maasai population areas in the northern part of Tanzania.

From logistic regression analysis: adolescents with poor oral hygiene were 10.0 times more likely to report low frequency of cleaning teeth (OR = 10.0, 95% CI 4.3-20.0). Regular tooth cleaning was associated with less gingival bleeding (OR = 0.1, 95% CI 0.04-0.14). In addition, using plastic type of tooth brush for cleaning teeth was associated with less gingival bleeding (OR = 0.7, 95% CI 0.53-0.99). Adolescents who reported high consumption of biscuits were 2.5 times more likely to have dental caries (OR = 2.5, 95% CI 1.7-3.8). Those who reported the use of trona/magadi were 24 times more likely to have severe dental fluorosis (OR = 24.2, 95% CI 11.6-50.6). Regular intake of carbonated soft drinks and tooth cleaning, (OR = 1.6, 95% CI 1.1-2.5) and (OR = 1.7, 95% CI 1.2-2.6), respectively, were associated with dental erosion. Covariates of tooth wear were reporting the use of teeth for biting nails (OR = 1.9, 95% CI 1.4-2.4), opening soda (OR = 1.8, 95% CI 1.4-2.4), as well as the use of teeth for holding needles (OR = 1.6, 95% CI 1.3-2.1. Adolescents with a behavior of clenching/grinding their teeth (OR = 2.3, 95% CI 1.5-3.7) were more likely to report TMD symptoms.

4.3 Paper III

The aim of paper III was to estimate the prevalence of oral impacts and to identify important clinical- and socio-demographic covariates. In addition, this study compares Maasai and non-Maasai adolescents regarding any association of socio-demographic and clinical covariates with oral impacts on daily performances.

A total of 143/906 (15.8%) had at-least one oral impact on daily performances (OIDP > 0). The frequency of the reported impacts was eating and enjoying food (7.9%), speaking and pronouncing clearly (4.4%), cleaning teeth (10.5%), sleeping and relaxing (3.9%), smiling and laughing (2.0%), maintaining usual emotional state (2.1%), carrying major school work or social role (2.2%) and enjoying contact with people (2.1%).

Multivariate logistic regression analysis showed that being from Longido compared to Monduli district was associated with lower odds of reporting OIDP (OR = 0.4, CI 0.3-0.7). Adolescents from non-Maasai ethnic group were 1.6-times (OR = 1.6, CI 1.1-2.3) more likely to report any OIDP compared to Maasai adolescents. Adolescents of the least poor parents had higher odds of reporting oral impacts (OR = 2.0, CI 1.2-3.3) compared to adolescents of the poorest parents. In terms of oral diseases/problems, adolescents with good oral hygiene were 0.7-times (OR = 0.7, CI 0.5-0.9) less likely to report oral impacts compared to those with poor oral hygiene. Adolescents with DMFT>0 were 3.1-times (OR = 3.1, CI 2.1-4.5) more likely to report at least one oral impact compared to those with DMFT=0. Similarly adolescents with TMD>0 were 3.9-times (OR = 3.9, CI 2.4-6.2) more likely to report oral impacts as compared to their counterparts in the opposite groups.

5. Discussion

The present study is the first cross-sectional study which assessed the information on oral health and oral health related quality of life in adolescents living in Maasai populated areas of Arusha region in Tanzania. Oral health status in terms of oral hygiene, gingival bleeding, dental caries, dental fluorosis, tooth wear/dental erosion and TMD pain and its impact on oral quality of life and related risk indicators/factors were assessed. Therefore much information was collected from the study participants so as to provide baseline data for future oral health research and guiding oral health care service improvement especially in areas occupied by pastoral societies in the country.

In this section the methodological issues for this thesis and the main findings of the whole study are considered. For a more detailed discussion of the results refer to individual papers I-III included in this thesis.

5.1 Methodological considerations

5.1.1 Study area

This study was conducted in rural primary schools in districts of Monduli and Longido (Arusha region) in Tanzania. The study area was preferred because it was expected that the majority of the residents in these districts should be from the Maasai ethnic group who by tradition is a pastoral society in this area. To maximize the number of adolescents from this ethnic group, we excluded urban primary schools assuming that most Maasais would be living in rural areas where it is possible to keep many animals. In addition, we excluded private primary schools assuming that most people from Maasais would be very poor and therefore won't be able to bring their adolescents in private schools which are very expensive [169]. Our two assumptions worked well as about 80% of the study participants were from the Maasai ethnic group. The remaining 20% were non-Maasais constituting several ethnic groups like the Arushas, Merus, and Sonjos.

5.1.2 Study design and participants

A cross-sectional, one stage cluster sample survey was used to collect data for the present thesis. Data collection was by means of interviews and oral clinical examination. In sample surveys, a group which represents a given population is selected by suitable random sampling methods [170]. Compared to survey the whole population (a census), the sample survey reduces the overall cost for conducting a study and provides an acceptable level of accuracy [170]. On the other hand, it may be prone to various sources of errors, which might bias the results and conclusions [171]. Using cluster sampling with primary schools as the primary sampling unit made the field work cheaper and possible to conduct. But inviting all sixth-graders of randomly selected schools led into having clusters with different sizes. To adjust for the cluster effect and overestimation of the results precision, data were adjusted for clusters using survey design in STATA version 15.0. Adjusting for clusters did not change the point estimate of odds ratios, but there were widening of the 95% confidence intervals. The study population aimed to include all adolescents aged 12-14 year old in Monduli and Longido districts attending rural public primary schools.. This age group was selected due to the fact that, during adolescence, individuals gain independence in making personal and diet related behaviors and these habits are influenced by the social environment related to peers [172]. Adolescents are considered important for oral health intervention because behaviors and attitudes formed during adolescence may last into adult life [173]. However, our results show that the adolescents from the selected classes turned out to be older than we expected, aged 12-17 years, instead of 12-14 years. We also found that the age distribution was such that it was not possible to divide the participants again according to age. In Tanzania set up, especially in rural areas, due to economic situations some adolescents start schools at late age [169], and in this group this was very clear and that's why we ended up with this big range of ages.

The sample size of 845 adolescents was calculated after assuming that the prevalence of dental erosion would be 50%, margin error of 5% and the 95% confidence intervals. In addition, to account for the design effect (D), the sample size obtained was

multiplied by 2. Finally 10% was added to account for contingencies for example non-response or recording errors. This assumption was correct as the final response rate was 91.6% with 9.4% non-response. In calculating the sample size, the prevalence of dental erosion was preferred over the other oral diseases/problems because it gave a maximum number of sample size.

5.1.3 Reliability

Reliability, reproducibility and repeatability are all terms that apply to the ability of the test to produce consistent results. A test is considered reliable if it gives the same result repeatedly. Reliability refers specifically to the overall consistency of a measure [174]. In this dissertation, reliability was measured by the Cohen's Kappa statistics and Cronbach's alpha. In addition, the principal investigator (LS) conducting the oral clinical examination and the interviewers were trained to ensure consistency of the measurements. Test-retest for oral clinical examination was performed onto 93 adolescents in three weeks apart following a previous oral clinical examination. Cohen's Kappa was calculated where according to literature [175], almost perfect intra-examiner agreement (Cohen's Kappa = 98.4) was obtained for dental caries. In addition, Kohen's Kappa of 86.8 for TF index and 69.4 for dental erosion were obtained, ranging from substantial to almost perfect agreement [175]. The internal consistency reliability (Cronbach's alpha based on standardized items) for the child OIDP inventory was 0.82, which is considered good [176] and which is in agreement with previous figures (0.84 to 0.85) from Tanzania [44, 128].

5.1.4 Internal validity

Validity is the ability of a tool to measure what it aimed to measure [177]. Internal validity deals with the question whether or not a true outcome or measure is obtained from the study participants [178]. In this study, internal validity of the findings might have been affected by misclassification during clinical registration, recall bias and social desirability bias in self report questionnaire. For instance, dental caries was assessed using criteria set by WHO [165] in field condition. However for the best diagnosis of dental caries, the use of adequate lighting and the use of visual, tactile

sensation and radiograph is recommended [179]. Lack of optimal examination facilities in the field, might have led to underestimation of the prevalence of DMFT>0 and other oral diseases/problems. For examination of dental caries, it is recommended to use visual-tactile method through use of dental probe or explorer, radiograph and other methods like electrical conductance, computer analysis of digitized radiographic images [180]. In addition, this study used self-reported data for assessing risk indicators of the oral diseases/problems. Self-report data is subject to information bias such as social desirability and recall bias. Therefore it is possible that socially desired behaviors were over-reported and undesired behaviors were under-reported. Furthermore, without proper consideration, recall bias can overestimate or underestimate the true effect or association [181]. To minimize socially desirable answers, the interviews were carried out before the oral clinical examination. Recall bias was minimized by using shorter recall periods for example, weekly, monthly up to three months.

5.1.5 External validity

External validity describes the extent to which the results of the study can be generalized to wider population [170]. The findings of the present thesis might be representative of rural primary adolescents in the Maasai populated areas of Monduli and Longido districts in Tanzania. The random allocation of the primary sampling unit, school, the good response rate and the cluster adjustment during analysis supports this generalizability. The high response rate might be due to personal interviews which were conducted by the research assistants who were native and were able to speak both languages, Swahili and Maasai. Previous study have found that personal interviews have higher response rate compared to self-administered questionnaires [182]. However, the possibility of non response bias cannot be disregarded. The missing information about the non-respondents prohibits conclusions regarding any potential selection bias. In addition, fewer male than female adolescents and absence of school adolescents who did not attend schools were not included in our sample and might have led to selection bias, thus affecting the external validity of our findings. In the current study, the reason behind as to why there was fewer males compared to females,

may be due to, in the Maasai culture, male adolescents have responsibilities of taking care of their animals. Thus some of the boys do not attend schools at all, but some of them may start going to schools at very late as far as age is concerned. Thus, conclusion on the external validity of these findings should be carefully treated.

5.2 Main findings

In this study, some of the oral diseases/problems for example poor oral hygiene, gingival bleeding, dental fluorosis, tooth wear and TMD) were more common, while dental caries and dental erosion were less common among the study participants. In addition, there was a significant difference in some oral diseases/problems, oral health related behaviors and oral health related quality of life between the Maasai and non Maasai groups.

Compared to previous studies from sub-Saharan Africa, in this thesis, poor oral hygiene was more common as about 66% (paper I) of the study participants assessed revealed poor oral hygiene in comparison with only 32–45% which was reported previously in Tanzania and Nigeria [129, 183, 184]. This high poor oral hygiene prevalence may be contributed by irregular frequency of oral hygiene practices and/or poor tooth cleaning techniques. About 25% (paper II) of the adolescents in this study reported to have low frequency (cleaning once or less per week) of cleaning teeth. In this study, sex of the adolescent emerged as an important risk indicator of the adolescent's oral hygiene whereby girls were more likely to have good oral hygiene than boys (paper I), in agreement with reports from previous studies (10-19 year old adolescents) from Africa and India [185-187]. Studies have reported that generally, girls have better attitudes towards oral health, healthier lifestyles and better oral health related behaviors than boys [188]. The present findings revealed that, compared to adolescents who cleaned their teeth more often, adolescents who cleaned their teeth less frequently had poorer oral hygiene (paper II), which was expected and in agreement with previous reports [20, 186, 187]. However, adolescents who reported a regular tooth cleaning were more than 75%, even so 66% of the adolescents had poor oral hygiene status. In this regard, probably there was an over reporting of the tooth

cleaning behavior or ineffective tooth cleaning technique was used [189]. The use of chewing stick (47%) for cleaning teeth was higher than previous reports from rural areas of Tanzania which reported only 4-36% (5-22 year old) but lower than reports from Kenya (59%) in adolescents 5-17 year old [190-193]. The use of a plastic tooth brush (47%) for cleaning teeth was higher than previous findings in Kenya and Burkina Faso (36-41%) [192, 193]. But other findings from Tanzania revealed higher use of plastic tooth brush (64-96%) [190, 191]. In the current thesis, the Maasai adolescents reported to clean their teeth more irregularly than non-Maasais, but also reported to use chewing sticks for cleaning their teeth more regularly than the non-Maasais (Paper I). In this regard, probably the Maasais had more access to chewing sticks and limited access to shops due to economic reasons compared to non- Maasais. This study found that 57% of the Maasais were most poor and only 16% of the non-Maasais were most poor according to wealth index (Paper I). Chewing sticks, has some beneficial effects compared to the commercial toothbrushes since they provide some antibacterial effect, good taste, texture, as well as they are easily available and have less cost [194].

Gingivitis is an inflammatory condition that affects the gingival tissues and is characterized by redness, swelling and occasional bleeding of the gingiva [195]. In this study, about 41% of the investigated adolescents showed a sign of gingivitis (gingival bleeding) (Paper I). This prevalence of gingival bleeding on gentle probing is lower than the previous report from Uganda in 12 year old adolescents (54%) [196]. This proportion of adolescents having gingival bleeding may be due to, probably many adolescents do not perform adequate oral hygiene behaviors. Being a female and non-Maasai adolescent was associated with less gingival bleeding compared to males and Maasais. This may be explained by the fact that in this study, 85% of non-Maasais compared to 73% of Maasais reported to clean their teeth regularly (Paper II). In this study, contrary to a previous study, less gingival bleeding was associated with the use of a plastic tooth brush [197]. Other study revealed no any difference between using chewing stick and using plastic toothbrush for teeth cleaning on gingival health of the adolescents [198].

Similar to other previous studies from East Africa, the mean DMFT was low (0.13) [33, 199]. The low DMFT in this study imply a low exposure to cariogenic diets and/or a high exposure for fluoride. The majority (60.8–64.5%) of the adolescents in this study reported a low intake of sweets and biscuits. Traditionally, the Maasais' diet consists of dairy products from their animals, for example milk, meat and blood. These products have low cariogenic effect [200] compare to more modern diet, for example the choice of soft drinks instead of milk. About 82% of the adolescents in this study (paper II) reported regular intake of fresh milk (compared to only 31% who reported regular intake of soft drinks. Thus the low prevalence of dental caries (9%) (paper I) might have been due to regular intake of fresh milk practices by the adolescents [201]. Also, it is reported that in this region there is a high fluoride content in the drinking water and also in the magadi which is used as food additive. and might have reduced the risk for developing dental caries among the adolescents [202, 203]. The DMFT component consisted mainly of decayed (D) (90%) teeth and 10% consisted of missing teeth due to caries (M). Similar to other findings from Africa, no teeth was recorded as filled (F) with any kind of restorative material [33, 204, 205]. In this study, older age group had significantly higher dental caries compared to younger age group similar to previous reports from East Africa [196, 206, 207]. In addition, prevalence of dental caries was significantly higher among the non-Maasais than the Maasais adolescents which is similar to previous studies as far back in 1931 and 1997 [155, 156]. The DMFT- index in our study constituted decayed component (D) by 90% and the missing component (M) by 10%. No participant in this study was diagnosed having any tooth with any type of filling. The lack of tooth fillings among study participants is a common observation among many countries from sub-Saharan Africa [33, 204]. Poor socioeconomic and poor oral health care services in the community may be contributing to the lack of tooth fillings among the adolescents. The non-Maasai adolescents had more dental caries compared to Maasais, this may be explained by the fact that, a significantly higher number of non-Maasais reported regular intake of high sugar-containing foods/drinks (paper II). The fact that Maasai adolescents were less affected by dental caries may be explained by the finding in this study which revealed

that, compared to non-Maasais (68%), more Maasai adolescents (86%) reported regular intake of fresh milk, as well as the use of magadi in cooking food.

In this study, the prevalence of severe dental fluorosis (TF 5-9) among adolescents was 48.6% in agreement with previous report from Kenya [50], but higher than reports from other studies in Tanzania (10 – 34%) and Ethiopia (24%) [49, 51]. Location/district, region of birth and use of magadi in food emerged as risk indicators of severe dental fluorosis (Paper I). Previous research from Arusha region reported a high fluoride concentration ranging from 0.1-78.09 mg/l in drinking water [202, 208], and might be one of the causes of severe dental fluorosis among the adolescents from the pastoral society [202, 208, 209]. In addition, there was an association between the use of Magadi as food additive and the occurrence of severe dental fluorosis in this study (paper II), similar to other studies [49, 57]. It has been reported that Magadi contains a high concentration of fluoride ranging from 160 - 1750 mg/l [52]. In this regard, compared to non-Maasais, the Maasai adolescents reported the use of Magadi more frequently and this may be one of the reasons for higher prevalence and severe dental fluorosis among the Maasai adolescents (Paper I).

In this study the prevalence of dental erosion extending into dentine was not common among adolescents, as only 1.9% of them were found to have at least one tooth surface affected. This prevalence (1.9%) is lower compared to studies from Saudi Arabia and Sweden which reported that the prevalence of dental erosion extending into dentine ranged from 11.9% to 26.0% [73, 210]. The low prevalence of dental erosion in the current study might be due to rural environment where the adolescents live together with limited economic status and low availability of shops selling erosive conducive products. In this study, one third of all adolescents reported regular intake of carbonated soft drinks and/or fruit juices. Similar to previous findings from Sweden and Denmark, there was a significant association between regular drinking of soft drinks (carbonated) and dental erosion [73, 211]. In addition, the low prevalence of dental erosion in this study might be influenced by high fluoride content in their drinking water [202]. In a study from England, it was reported that the fluoride in water provided protection against dental erosion among 14 year old adolescents [212].

This study revealed also that there was an association between dental erosion and oral hygiene, similar to previous reports [213]. Regarding ethnicity, in comparison with the non-Maasais, the Maasai adolescents reported lesser tooth cleaning and use of toothpaste. In addition, the difference oral health related behavior in terms of dietary habits and oral hygiene practices between the two ethnic groups, may explain why non-Maasais were more affected by dental erosion compared to Maasais (Paper I). In this study, adolescents from mothers with high levels of education had higher chance for developing dental erosion compared to adolescents from mothers with low education (paper I), similar to previous studies from Brazil and China [65, 66], but contrary to studies from Southern China and Saudi Arabia [214, 215]. It is likely that, adolescents from mothers with high level of education were more likely to have lifestyles which favor consumption of erosive conducive products. In the current study, more adolescents from mothers with high education reported regular intake of carbonated soft drinks compared to adolescents from mothers with low education level.

In this study the prevalence of tooth wear extending into dentine was quite common (16.5%) but lower than reports from England which found higher prevalence (30.0-53.0%) [212, 216], and higher than reports from China and Nigeria which found lower prevalence (1.9-8.5%) [79, 217]. In this study, there was no sociodemographic variable which was significantly associated with tooth wear. This may imply that the risk indicators (carbonated soft drinks, acidic food, hard food and using teeth as tool, sand and/or dust) for tooth wear are more uniformly distributed across the school adolescents of this society, and they might be sharing the same risk factors within their environment. Studies have reported that, acidic challenges may influence the severity and pattern of tooth wear. In this regard, carbonated soft drinks, parafunctional habits, using teeth as tools and abrasiveness of the diet, plays a great role as risk factors of tooth wear [218, 219]. It is likely that the community in this study eats food which usually is abrasive in nature and might lead to tooth wear. Meat in this society is eaten when it is raw (half cooked) and it is often mixed with ashes and sand in the process of cooking making it more abrasive, hard and difficult to chew. The abrasive effect and

more severe tooth wear might had been contributed by the regular intake of acidic drinks among the adolescents [73]. In this study, about 45% and 52% of the adolescents reported that they used teeth in biting nails and opening soda bottles, respectively. The relatively high prevalence of tooth wear among the adolescents might be due to these practices which usually need extra biting forces. However, the tooth wear might have been caused by other factors which were not investigated in this study [218]. It must, however, be pointed out that the presence of high fluoride content in their drinking water might have a preventive effect on tooth wear occurrence. Previous reports have found that tooth wear is less common in people who have been exposed to fluoride because exposing teeth to water with fluoride results into higher fluoride concentration on the enamel surface and greater hardness of teeth [212].

In this study, the prevalence of adolescents with TMD pain was about 12%, higher than that reported from Western countries (5- 7%) [220, 221], but lower than reports from China and Saudi Arabia (15 -27%) [221, 222]. Compared to adolescents from Longido and mothers with low education, adolescents from Monduli district and from mothers with high education reported more TMD problems. A study from America reported same findings that TMD was associated with the geographical study [223]. However, findings from China, found that higher rates of TMD pain was associated with lower parental educational levels or household income [221]. Other previous studies have also reported the association between low educational level and other types of pain [224, 225]. This prevalence in the nomadic community was unexpectedly high, probably environmental and cultural factors may have contributed to the development of TMD. The environment they live, for example walking a long distance to/from school, staying with hunger for long duration in schools might be causing some stress for them. Reports reveals that psychological factors for example stress related behaviors are among the causes of development of TMD [226]. Previous findings have revealed that self-reported bruxism is correlated with TMD, in agreement with this thesis (paper II) [222, 227]. But, findings from previous polysomnography research on sleep bruxism have not shown this association [228, 229]. In the current study, similar to results from other study, other parafunctional habits were not found associated with development of TMD [230].

The dental services utilization in the current study was low as only 95% of the adolescents had never been to a dentist for any reason for example, toothache or checkup. Probably the society in the study population is less aware of the oral health services provided and there is a need of oral health education that could make them aware and have access to these services. According to previous reports, oral health education is an important tool for promoting oral health in societies especially among adolescents [231] and in this regard, schools provides a good setting for health-education programs [232]. The relationship between dental services utilization and oral diseases/problems was not analyzed in this study due to few cases.

According to the findings of the present thesis, the prevalence of oral impact or reduced OHRQoL in terms of OIDP was lower (16%) (paper III) than what has been reported previously (29-62%) in East Africa among comparable groups [119, 124, 128, 129]. Difficulties with eating food and cleaning teeth were the most common reported problems affecting adolescents, similar to other reports from Africa [124, 128, 129, 233]. Adolescents from Longido district had less odds of reporting any OIDP compared to adolescents from Monduli district. Adolescents with good oral hygiene had less odds of reporting any OIDP compared to adolescents with poor oral hygiene, respectively. Adolescents from Longido district had good oral hygiene, less gingival bleeding, less dental fluorosis and reported less TMDp compared to those from Monduli (paper I) and this may explain why adolescents from Longido district were less likely to report any OIDP. Non-Maasais had higher odds of reporting any OIDP than Maasais (paper III). Previous reports from sub Saharan Africa are lacking, but reports from other countries have found an association between ethnicity and OHRQoL. For example, in Brazil it was found that non Whites individuals or minority ethnic groups had higher oral health impact scores than the whites [234, 235]. The link between ethnicity and oral health might be attributed to differences in socioeconomic, behavioral and psychosocial factors that vary across the ethnic groups [236]. In paper I, the non-Maasai adolescents were more affected by oral diseases like dental caries and dental erosion than Maasais. The higher prevalence of oral diseases like dental caries and dental erosion among the non-Maasais compared to Maasais might be one

reason as to why non-Maasais reported more OIDP than the Maasai adolescents. In this study, adolescents from least poor families reported higher odds of OIDP than those from most poor families. This is contrary to previous findings that most poor families were likely to report higher OIDP than least poor families [129, 237, 238]. The link between least poor families and higher odds of OIDP in the current thesis may be due to the fact that adolescents from least poor families had ability to access foods/drinks that are detrimental to oral health and therefore exposing them to develop more oral diseases compared to adolescents from most poor families. This is also supported by one study of Tanzanian students which found that students from least wealthier families, as classified by family wealth index, had more oral problems compared to students from poor families [128]. Previous reports have revealed that high levels of dental disease distracts their daily quality of life [104]. In addition, adolescents with good oral hygiene had lower odds for reporting any oral impact than adolescents with poor oral hygiene. Other studies from Tanzania found no significant differences between those with good oral hygiene and those with poor oral hygiene [124, 129]. Poor oral hygiene may be caused by irregular tooth cleaning and may lead to periodontitis [239], which has a negative impact on OHRQoL [240, 241]. In the present study, DMFT>0 was significantly correlated with more oral impacts similar to previous reports from Tanzania and other developing countries [44, 124, 132]. In this regard some studies shows that there was a non significant association between DMFT and impacts on quality of life [242, 243] while other studies shows that untreated dental caries can affect adolescent's quality of life through causing dental pain leading to limitations in oral functioning, emotional state, as well as performing social roles [13].

The association observed between the presence of TMD pain and OHRQoL in this study, suggests that the TMD pain have a negative influence on the quality of life in terms of OIDP. In this regard, previous studies have found that there is positive association observed between TMD pain and OIDP [244-246], and these findings indicate that TMD pain affects the quality of life across various populations worldwide, which is in agreement with this study.

It is expected that in the Maasai society, there will be some changes from their traditional lifestyles of herding animals to modern lifestyles. This might happen especially if the society undergoes socioeconomic development and/or interacts with other ethnic groups and thus adopting to lifestyles similar to the rest of the world. It is likely that in near future the society will have more access to IT technology, sweets, soft drinks, advanced education and physical activities, amongst many others. In this process of civilization, oral diseases such as dental caries and erosion might increase tremendously affecting the oral health related quality of life. The OHRQoL goes beyond oral functioning and oral diseases, reports have shown that social indicators might be as important predictors of oral quality of life as clinical measures of oral diseases [247].

This study used random sampling of the primary sampling units (schools). By this method, the results obtained might be generalized to a larger community of school going adolescents living in Maasai populated areas. The research assistants we used for interview were medical nurses and fluent in both Swahili and Maasai language and this made the adolescents to understand the question during interview. In addition, all oral clinical examinations were performed by one examiner, thus inter-examiner variability was reduced. But, using one examiner only, this sometimes leads to causation of observer effect bias and confirmation bias. In observer effect bias the study participants are influenced by the observer. In confirmation bias the results are incorrectly interpreted by the experimenter due to the fact that the experimenter usually look for information associated or related with their hypothesis, and ignores the information that is contrary to hypothesis. In this study, there is a possibility that the child didn't understand the question, has forgotten or findings were influenced by social desirability. By using the cross-sectional design, establishing a causal relationship was difficult. In addition, a selection bias might have been introduced and thus affecting the results and generalization due to fewer males compared to females and adolescents not attending schools. In this study, we had less number of males than females probably due to the fact that, in Maasai society male adolescents are responsibility for caring of their animals and therefore some male adolescents don't even go to schools, some register to schools in late age and some they register to

schools earlier but they don't complete the school program. For example, the researcher witnessed some of the primary school students who were above 20 years old. In terms of infrastructures, it might be very difficult in implementing oral health programs and preventive studies in Maasai populated areas due to poor infrastructures in terms of communication. The researcher witnessed poor roads which caused some delays in finishing data collection on time. Fortunately, the study was conducted during dry season, hence the roads were passable, otherwise if it was rainy season, it would have been impossible to visit the schools.

6. Conclusions

The findings in this thesis contributed important information on oral diseases/problems and OHRQoL among adolescents of the pastoral societies living in Maasai populated areas of Monduli and Longido districts that was previously lacking. The following secondary conclusions can be drawn from this thesis:

- This study revealed uncommon occurrence of dental caries and dental erosion. However, the study revealed common occurrence of gingival bleeding, dental fluorosis, tooth wear, TMD and OIDP types of oral diseases/problems among the study participants. The oral diseases/problems varied according to various sociodemographic and clinical conditions.
- Oral diseases/problems among adolescents attending rural primary schools in Maasai populated areas in Tanzania were significantly impacted by sociodemographic and oral health related behaviors.
- There was a remarkable ethnic difference between the Maasais and non-Maasais in terms of oral diseases/problems in association with sociodemographic, oral health related behaviors and OIDP.
- Dental services utilization among the adolescents in this society was very low.
- Oral health care workers need to encourage behaviors that promote good oral health behaviors and dental care service utilization among the adolescents in this pastoral society.

7. Future perspectives and recommendations

Based on the results obtained from this thesis, there is a need to plan for provision of an appropriate oral health education in adolescents in this area for prevention of oral diseases and problems. Oral health education can be done using primary school teachers, because in Tanzania oral health personnel are scarce. Teachers once trained, they can provide oral health education to their pupils/students. Studies have reported positive attitudes and knowledge on oral health among teachers, and that they showed willingness to participate in oral health promotion [248, 249]. Using primary school teachers in provision of oral health education to adolescents will help a lot in reducing the costs of research interventions in poor resource setting [250].

With increased influence of civilization and changes in oral health related behaviors, this society will have a higher access of cariogenic/erosive food products thus increasing the risks for developing oral diseases and problems. In recent decades the influence of nation states, monetization of the traditional economy, formal education, land tenure changes and demographic factors have all played a part in shaping the socio-economic situation of Maasai in Tanzania [251]. Thus there is a need of planning for appropriate primary and secondary preventive programs and to conduct research that could verify the effectiveness of such programs in preventing the oral diseases in Maasai populated areas. On the other hand probably there will be more access to oral health care services and good oral hygiene instructions leading to less gingival diseases. In addition, due to civilization process, it is likely that the Maasais and non Maasais will have similar oral health related behaviors and same pattern of oral diseases and problems within this society. Therefore planning for intervention programs in this society is important for the prevention and promotion of oral health. In addition, the use of parents in providing better oral hygiene practices among the adolescents is important as most of the time and before school age, the adolescents stays with their parents. In terms of language, the main language among the Maasai is Maasai language (Maa) and they have a relatively poor command of Swahili, the national language of Tanzania. All of this reduces the opportunities for both health

service provision and educational attainment for the Maasais. Thus in future, planning for promotion of the use of the national language (Swahili) is necessary in this society. For the better outcomes in this society, the information should be in both Maa and Swahili.

In addition, there is a need to conduct further population –based oral health research in Maasai populated areas of Tanzania to investigate oral health status and their associated factors/indicators in primary school adolescents. Oral health service providers need to recognize the multiple influences of broader determinants associated with clinical oral health outcomes, for example oral health related behaviors and practices and health care systems, including psychosocial environments affecting this community. There is therefore a need for more clinical investigations to explore and compare the occurrence of oral diseases in different socially disadvantaged communities in Tanzania. Future studies in this society should involve their parents and communities at large so as to make oral health interventions more effective and successful. In this study, the involvement of other communities like health care workers, pregnant mothers and mothers with children below five years, was not sought and this is an area which needs more exploration in future studies. According to this study, consumption of magadi is the main determinant of the severe dental fluorosis observed among adolescents. It is advised that careful attention should be paid to local customs in the preparation of food, in order to identify possible additional fluoride sources. Dental fluorosis is common among several communities in Tanzania due to high levels of fluoride in their drinking water. However, other communities experience severe dental fluorosis due to the use of magadi. This problem requires further investigation, preferably, a population based study, so as to find out appropriate measures for reducing the prevalence and severity of dental fluorosis.

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9. Appendices I-VI

Appendix I – Questionnaire for paper I-III

ORAL HEALTH AND ORAL QUALITY OF LIFE OF ADOLESCENTS IN PASTORAL SOCIETY OF MAASAI POPULATION AREA IN TANZANIA

ID. No _____

Date of Interview _____

Name of School _____

District _____

Sex □ M □ F

Weight _____ (Kg) Height _____ (cm) (Note: Weight and Height was measured at the field)

A. Socio-demographic characteristics
(I will start by asking some personal questions)

1. How old are you?
   Years……..

2. What is your ethnic group?
   □ *Maasai*
   □ *Meru*
   □ *Arusha*
   □ *Others……..*

3. Have you lived in the same area of residency since birth?
   □ *Yes*
   □ *No*

   If moved after birth, from other region, where and when?……..

4. What is the highest level of school your mother (or care giver) has attended?
   □ *None*

   □ *She started but did not complete primary school*
   □ *Completed primary school*

   □ *She started but did not complete secondary school*
   □ *Completed secondary school*

   □ *She started but did not complete College/University*
   □ *Completed college/university*
   □ *I don't know*

5. What is the highest level of school your father (or guardian) has attended?
   □ *None*
   □ *He started but did not complete primary school*
   □ *Completed primary school*
   □ *He started but did not complete secondary school*
   □ *Completed secondary school*

   □ *He started but did not complete College/University*
   □ *Completed College/University*
   □ *I don't know*

6. Who owns the house your family is living in at the moment?
   □ *Owned by your family*
   □ *Rented house*
   □ *I don't know*

7. How many adolescents are there in your family?_____

8. How many herds do you have at home
   - □ *Cows*……..
   - □ *Goats*……..
   - □ *Sheep*……
   - □ *Not applicable*

9. What is your birth order?_____

10. Does your household have the following equipment?

Radio	□ *Yes*	□ *No*
Television	□ *Yes*	□ *No*
Refrigerator	□ *Yes*	□ *No*
Mobile phone	□ *Yes*	□ *No*
Cupboard	□ *Yes*	□ *No*
Bicycle	□ *Yes*	□ *No*
Motor cycle	□ *Yes*	□ *No*
Plough	□ *Yes*	□ *No*

11. What type of fuel does your household mainly use for lighting?
    - □ *Electricity*
    - □ *Kerosene/paraffin*
    - □ *Candle light*
    - □ *Others* ……..

12. What type of energy for cooking does your family use at home most of the time? (select one option only)
    - □ *Electricity*
    - □ *Solar*
    - □ *Gas*
    - □ *Paraffin*
    - □ *Charcoal*
    - □ *Firewood*
    - □ *Others*……

13. What is the main material for the wall of your family's house?
    - □ *Thatch*
    - □ *Mad and poles*
    - □ *Mad only*
    - □ *Others*……..

14. What is the main material for the roof of your family's house?
    - □ *Thatch*
    - □ *Iron sheets*
    - □ *Tiles*
    - □ *Others* ……

15. What are the main materials for the floor of your family's house?
    - □ *Earth/dung*
    - □ *Cement*
    - □ *Others*……

16. Where does your family get food?
    - □ *We produce our own food by farming*
    - □ *We produce our own food from our own animals/herds*
    - □ *We hunt our own meat*
    - □ *We buy food from neighbors or shops*
    - □ *We interchange food with our herds*
    - □*Others*……

17. Do you eat the following when you are at home?

Breakfast	□ *Yes*	□ *No*
Lunch	□ *Yes*	□ *No*
Dinner	□ *Yes*	□ *No*

18. Do you eat the following during school-days?

Breakfast	□ *Yes*	□ *No*
Lunch	□ *Yes*	□ *No*
Dinner	□ *Yes*	□ *No*

B. Dietaryhabits

Tick the best option with (√)	**Never**	**Once to several times/month**	**Once weekly**	**Two or more times weekly**	**Daily**
How often do you eat					
19. *Sweets*					
20. *Biscuits*					
21. *Sugar*					
22. *Honey*					
23. *Ugali = maize stiff porridge*					
24. *Rice*					
25. *Cassava*					
26. *Sweet potatoes*					
27. *Irish potatoes*					
28. *Cooked vegetables*					
29. *Raw vegetables*					
30. *Meat*					
31. *Boiled blood*					
32. *Beans*					
33. *Fish*					
34. *Groundnuts*					
How often do you drink the following:					
35. *Carbonated Soft Drink*					
36. *Fruit drink*					

37. *Water plain*					
38. *Water with sugar*					
39. *Tea plain*					
40. *Tea with sugar*					
41. *Blood from animals*					
42. *Milk fresh from cow*					
43. *Milk fresh from Goat*					
44. *Milk from powder*					
45. *Soured milk*					
Others					
46. *How often do you clean your teeth?*					
47. *Do you use tooth paste during tooth cleaning?*					
48. *How often do you smoke or chew tobacco?*					
49. *How often do you drink alcohol*					

Tick the best option with (√)	**Plastic**	**Wooden**	**Charcoal**	**Others**
50. *What type of toothbrush do you most often use?*				

51. From where do you get sweets/ biscuits/soft drinks? _____, _____, _____

52. Which type of fruits do you most often eat? _____, _____, _____, _____.

53. Which type of vegetables do you usually eat? _____, _____, _____, _____

C. Child's general and dental health

(The following questions are about the oral health status, dental attendance and dental habits)

General health

54. How satisfied are you with your health?
    - □ *Very satisfied*
    - □ *Satisfied*
    - □ *Dissatisfied*
    - □ *Very dissatisfied*

55. Do you suffer from any medical disease?
    - □ *Yes (specify) ……..*
    - □ *No*

56. Do you eat or drink any medicine?
    - □ *Yes*
    - □ *No*

57. Where does your family seek treatment if you are sick
    - □ *Hospital*
    - □ *Traditional healer*
    - □ *Both*
    - □ *Others* _____

58. When you fall sick what do you use to cure the disease
    - □ *Hospital medicines*
    - □ *Traditional medicines*
    - □ *Both*
    - □ *Others ……*

Dental health

59. How satisfied are you with your teeth?
    - □ *Very satisfied*
    - □ *Satisfied*
    - □ *Dissatisfied*
    - □ *Very dissatisfied*

60. Before today, have you ever visited a dentist/dental therapist due to toothache?
    - □ *Yes*
    - □ *No*

    If yes, what treatment was offered?

……..

61. Before today, have you ever visited a dentist/dental therapist for a *checkup*?
    - □ *Yes*
    - □ *No*

62. Where do you go to seek treatment when you have tooth pain?
    - □ *Dispensary/Health care center/ hospital*
    - □ *Traditional healer*
    - □ *I chew herbs/roots at home*
    - □ *I stay at home*
    - □ *I never had a tooth pain*

63. Have you ever had swollen and bleeding gums? (see blood when spitting after tooth brushing).
    - □ *Yes*
    - □ *No*
    - □ *I don't know*

D. Dental fluorosis

64. Where does your family get the drinking water?
    - □ *Tap*
    - □ *Well*
    - □ *Borehole*
    - □ *Spring*
    - □ *Lake*
    - □ *River*
    - □ *Rain water*
    - □ *Stream*
    - □*Others ……*

65. Does your family use the same water source throughout the year?
    - □*Yes*
    - □*No*

66. If your family does not use the same source of water, what are the alternatives?

……

67. Does your family boil your drinking water?
    - □ *Yes*
    - □ *No*

68. Have you ever heard of the following food additives?

Trona (magadi)	□ *Yes*	□ *No*
Masala	□ *Yes*	□ *No*
Ginger	□ *Yes*	□ *No*

69. Does your family use any of the food additives mentioned above?
    - □ *Yes*
    - □ *No*
    - □ *Not applicable*

    If yes, which type ……

70. Do you have any remarks regarding your teeth?
    - □ *Yes*
    - □ *No*

71. If Yes, why?
    - □ *Discolored*
    - □ *Pitting*
    - □ *Fractured (due to trauma)*
    - □ *Worn*
    - □ *Others* _____

72. Have you ever heard about tooth wear?
    - □ *Yes*
    - □ *No*

73. Have you ever head heard about dental caries?
    - □ *Yes*
    - □ *No*

74. Have you ever heard about dental fluorosis?
    - □ *Yes*
    - □ *No*

E. General Dental Knowledge

Do you know that	Yes	No	I don't know
75. Not doing tooth cleaning properly might cause tooth decay			
76. Frequent intake of sugary foods can cause tooth decay			
77. Frequent intake of sugary drinks can cause tooth decay			
78. Brushing teeth can prevent your gums from bleeding			
79. High fluoride concentration in drinking water may cause dental fluorosis			
80. Soft drinks and juices can cause tooth wear			

F. Dental awareness

81. Have you ever received information on how to care for your teeth?	Yes	No
• From parents		
• From health worker		
• From dentist		
• From radio		
• From television		
• From newspapers		
• From relatives/friends		
• Others		
82. Would you like to get more information on oral health?		

G. The following are questions about your mouth and teeth (Oral quality of life using the Condition specific Child OIDP frequency scale) (Mtaya et al, Hvaring et al)

Please answer the following questions irrespective of the answers to the above problems (respond only one category)

83. During the past 3 months, how often have problems with your mouth or teeth (for example such as mentioned above or other) caused you any difficulty with eating and enjoying food?
    - *0* □ *Never*
    - *1* □ *Once or twice a month*
    - *2* □ *Once or twice a week*
    - *3* □*Everyday/nearly everyday*

84. During the past 3 months, how often have problems with your mouth or teeth (for example such as mentioned above or other) caused you any difficulty with speaking and pronouncing clearly?
    - *0* □ *Never*
    - *1* □ *Once or twice a month*
    - *2* □ *Once or twice a week*
    - *3* □*Everyday/nearly everyday*

85. During the past three months, how often have problems with your mouth or teeth caused you any difficulty with cleaning teeth?
    - 0 □ *Never*
    - *1* □ *Once or twice a month*
    - *2* □ *Once or twice a week*
    - *3* □*Everyday/nearly everyday*

86. During the past 3 months, how often have problems with your mouth or teeth caused you any difficulty with sleeping and relaxing?
    - 0 □ *Never*
    - *1* □ *Once or twice a month*
    - *2* □ *Once or twice a week*
    - *3* □*Everyday/nearly everyday*

87. During the past 3 months, how often with your mouth or teeth caused you any difficulty with smiling, laughing and showing teeth without embarrassment?
    - 0 □ *Never*

1 □ *Once or twice a month*
2 □ *Once or twice a week*
3 □ *Everyday/nearly everyday*

88. During the past three months, how often have problems with your mouth or teeth caused you any difficulty with maintaining usual emotional state without being irritable?
    0 □ *Never*
    1 □ *Once or twice a month*
    2 □ *Once or twice a week*
    3 □*Everyday/nearly everyday*
89. During the past three months, how often have problems with your mouth or teeth caused you any difficulty with carrying out major school work or social role?
    0 □ *Never*
    1 □ *Once or twice a month*
    2 □ *Once or twice a week*
    3 □*Everyday/nearly everyday*
90. During the past three months, how often have problems with your mouth or teeth caused you any difficulty with enjoying contact with people?
    0 □ *Never*
    1 □ *Once or twice a month*
    2 □ *Once or twice a week*
    3 □*Everyday/nearly everyday*

Reported oral health status/perceived treatment needs. Tick only one answer.

Question	Very good	Good	Bad	Very bad
91. *What do you think about the state of your teeth?*				
	Very satisfied	Satisfied	Dissatisfied	Very dissatisfied
92. *Are you satisfied or dissatisfied with your mouth/teeth?*				
93. *How satisfied or dissatisfied with the appearance of your teeth?*				
94. *How satisfied or dissatisfied are you with the color of your teeth?*				

H. Tooth wear *(tick the best option)*

Do you	Never	Once or more /month	Once or more per week	Once per day	Every day several times	Always
95. *Have mouth dryness during the day?*						
96. *Have mouth dryness at night?*						
97. *Have sensitivity in your teeth?*						
98. *Have pain in your teeth?*						
99. *Have stomach pain?*						
100. *Have acid reflux or heart burn?*						

101. *Vomit?*						

102. **Do you use your teeth in any habit like:**	**Yes**	**No**	
• *Nail cutting*			
• *Pen/pencil biting*			
• *Opening soda*			
• *Holding needle*			
• *Chewing sticks*			
• *Chewing roots*			
• *Chewing leaves/vegetables*			
• *Chewing sunflower seeds*			
			I don't know
103. *Do you clench or grind your teeth?*			

I. Temporomandibular joint disorders

104. Do you have pain in your temple, face, jaw or jaw joint once a week or more?
□ *Yes*
□ *No*

105. Does it hurt once a week or more when you open your mouth or chew?
□ *Yes*
□ *No*

106. Does your jaw lock or become stuck once a week or more?
□ *Yes*
□ *No*

107. If you have answered 'Yes' to any of the three questions above (Q, 104-106), do you think you need treatment for the problems?
□ *Yes*
□ *No*

Appendix II – Clinical examination form and respective indices

Id no…….. Date of birth…….

Gender: Female ☐ Male ☐

SIMPLIFIED ORAL HYGIENE INDEX (Greene and Vermillion, 1964)

Plaque					**Calculus**			
16B	11B	11P	26B		16B	11B	11P	26B
46L	31B	31L	36L		46L	31B	31L	36L

Gingival bleeding Index (GBI, Ainamo and Bay, 1975)

	17	16	15	14	13	12	11		21	22	23	24	25	26	27
Buccal															
Mesio-buccal															
Lingual															
0=no, 1=yes	47	46	45	44	43	42	41		31	32	33	34	35	36	37
Buccal															
Mesio-buccal															
Lingual															

Dental Fluorosis(TF Index, 1978)

Tooth	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Score														
Score														
Tooth	27	46	45	44	43	42	41	31	32	33	34	35	36	37

DMFT/DMFS Index (WHO, 2013)

	17	16	15	14	13	12	11	21	22	23	24	25	26	27
B														
P														
M														
D														
O/I														
O/I														

D														
M														
L														
B														
	47	46	45	44	43	42	41	31	32	33	34	35	36	37

Tongue impression:yes / no

Linea alba: yes / no

Dental Erosion(Johansson AK et al, 1996)

Tooth	13	12	11	21	22	23
B						
P						
Approximal						
Shoulder						

Note: **Approximal erosion and presence of "shoulder" should be recorded.**

Dental Erosion, Cupping scale on first molars (Hasselkvist A et al. 2010)

Tooth	16	26	36	46
Occlusal				

Tooth wear on occlusal/incisal surfaces (Carlsson GE et al. 1985)

	17	16	15	14	13	12	11	21	22	23	24	25	26	27
O/I														
O/I														
	47	46	45	44	43	42	41	31	32	33	34	35	36	37

Tooth wear on cervical region, buccal cervical defects
(1= present or 0 = absent)

	17	16	15	14	13	12	11	21	22	23	24	25	26	27
	47	46	45	44	43	42	41	31	32	33	34	35	36	37

Tooth wear (WHO, 2013)

Severity		
Tooth (surface)		
Total teeth affected	Upper jaw	
	Lower jaw	

Appendix III – Ethical Clearance Certificate

THE UNITED REPUBLIC OF TANZANIA

National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 9653
11101 Dar es Salaam
Tel: 255 22 2121400
Fax: 255 22 2121360
E-mail: headquarters@nimr.or.tz

Ministry of Health, Community
Development Gender, Elderly & Children
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

NIMR/HQ/R.8a/Vol. IX/2214

03rd June 2016

Lutango Daniel Simangwa
Department of Restorative Dentistry, MUHAS
P O Box 65001
DAR ES SALAM

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Oral Health and Oral Quality of Life of Adolescents in a Pastoral Society in a Maasai Population area in Tanzania (Simangwa L D *et al*), has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Monduli and Longido Districts in Arusha

Approval is for one year: 03rd June May 2016 to 02nd June 2017.

Name: Dr Mwelecele N Malecela
Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi
Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY &CHILDREN

CC: **RMO**
DED
DMO

Appendix IV –Parent information

Oral diseases and problems, and oral impacts on daily performances among adolescents living in Maasai populated areas in Tanzania

Introduction

This is to request your child to participate in a research projects aimed at assessing the teeth and try to find possible factors that might affect the child's susceptibility for tooth diseases. In order to achieve this information we need to examine your child's mouth and ask her/him some questions about the tooth health. This study is conducted by the University of Bergen in collaboration with Monduli and Longido district councils in Arusha region.

Research description

We will ask questions about the tooth health, feeding habits and other habits relevant for children's tooth health. Then, we will examine teeth and gums using a dental mirror and probe only which will minimize the risk and any unpleasant experience for your child. The answers they give will help us finding ways to assist the child and parents in taking care of children's teeth so that diseases can be prevented as well and the quality of life improved. The amount of time that we will need is about 25 minutes for the interview and 20 minutes for the oral clinical examination.

Research benefits and risks

Children and parents participating in this study will benefit by having specific information about how to best take care of teeth and if we find tooth diseases during the oral examination – we will refer the child to the health center for management under the school authority. Once the study is finished it could provide information about oral health, which is useful to healthcare professionals and planners. On the other hand, it could be that the child may not be comfortable talking about his/her oral health and dietary habits and the things done to stay healthy. Also the child may feel uncomfortable during oral examination, but we will use only dental mirror and

probe only to minimize any risk that might arise. Generally the procedure is not harmful by anyhow.

Compensation

No any compensation will be given to the child or parent. However both the parent and child will be thanked for giving their time to participate in the research.

Confidentiality

The information that we achieve from this study will be kept in secret, treated without name and birth number of your child. The information will be destroyed when the research project is completed. Information that is provided through this project will be published. From this published material it will not be possible to identify your child as a participant.

Voluntary participation

The participation in this research project is absolutely voluntary. Whether your child participates or not and whether he/she answers "may be" will not affect school life. Even if your child agrees to participate he/she might stop participating at any time and without any negative consequences.

Contacts

Lutango Daniel Simangwa (Restorative Dentistry Specialist, Project leader, Principal Investigator and PhD candidate)

Muhimbili National Hospital

Po Box 65000

Dar Es Salaam, Tanzania

Cel: +255784390195

Email:lutangillo@yahoo.com, Lutango.Simangwa@uib.no

Appendix V: Parent consent form

Name of the parent:

…….

Date: ……...

Name of school: …….

District: ……..

Please tick in the boxes below if you/your child agree to participate or not:

1. I consent my child WILL take part in the above study.☐
2. I confirm that I have read or been read the information form for the above study and have had the opportunity to ask questions which have been answered to my satisfaction. ☐
3. I understand that my child's participation is voluntary and he/she is free to withdraw at any time without giving any reason or consequence.☐

Name of the parent	Date	Signature
_____	_____	_____
Name of interviewer	Date	Signature
_____	_____	_____

Thank you for answering and please give the Consent form to your child who will bring it back to the principal investigator/school by tomorrow!

Best Regards

Dr. Lutango Daniel Simangwa

Restorative Dentistry Specialist, Project leader, Principal Investigator and PhD Candidate.

Appendix VI: Children research information and assent

Oral diseases and problems, and oral impacts on daily performances among adolescents living in Maasai populated areas in Tanzania

Introduction

This is to request you to participate in a research projects aimed at assessing the teeth and try to find possible factors that might affect the child's susceptibility for tooth diseases. In order to achieve this information we need to examine your mouth and ask you some questions about the tooth health. This study is conducted by the University of Bergen in collaboration with Monduli and Longido district councils in Arusha region. I, who is speaking is Dr Lutango Simangwa, a dentist and PhD candidate at the University of Bergen, Norway.

Research description

We will ask you some questions about the tooth health, feeding habits and other habits relevant for children's tooth health. Then, we will examine your teeth and gums using a dental mirror and probe only which will minimize the risk and any unpleasant experience. The answers you give will help us finding ways to assist the children and parents in taking care of children's teeth so that diseases can be prevented as well and the quality of life improved. The amount of time that we will need is about 25 minutes for the interview and 20 minutes for the oral clinical examination.

Research benefits and risks

Children participating in this study will benefit by having specific information about how to best take care of teeth and if we find tooth diseases during the oral examination – we will refer you to the nearest health center for management under the school authority. Once the study is finished it could provide information about dental health, which is useful to healthcare professionals and planners. On the other hand, it could be that you may not be comfortable talking about your oral health and

dietary habits and the things that you do to stay healthy. Also you may not feel comfortable during oral examination, but we will use only dental mirror and probe only to minimize any risk that might arise. Generally the procedure is not harmful by anyhow.

Compensation

You will not be given any compensation for participation in the research, however your participation in the research will be highly appreciated.

Confidentiality

The information that we achieve from this study will be kept in secret, treated without name and birth number of your child. The information will be destroyed when the research project is completed. Information that is provided through this project will be published. From this published material it will not be possible to identify your child as a participant. The researchers will not let anyone other than themselves see your answers or any other information about you. Your teachers and parents will never see the answers you gave or the information we wrote about you.

Voluntary participation

The participation in this research project is absolutely voluntary. Whether you participate or not and whether you answers "may be" will not affect your school life. Even if you agree to participate you might stop participating at any time and without any negative consequences.

Do you have any questions?

You can ask questions at any time. You can ask now or you can ask later. You can talk to me or you can talk to someone else at any time during the study. Below are our contacts to reach us.

Do you agree to participate in this survey?

_____ Yes

_____ No

Contacts

Lutango Daniel Simangwa (Restorative Dentistry Specialist, Project leader, Principal Investigator and PhD candidate)

Muhimbili National Hospital

Po Box 65000 Dar Es Salaam, Tanzania

Cel: +255784390195

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10. Original papers I-III

Paper I

Oral diseases and socio-demographic factors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study

Simangwa LD, Åstrøm AN, Johansson A, Minja IK and Johansson AK. *BMC Oral Health. 2018;18:200.*

Simangwa et al. BMC Oral Health (2018) 18:200
https://doi.org/10.1186/s12903-018-0664-6

BMC Oral Health

RESEARCH ARTICLE Open Access

Oral diseases and socio-demographic factors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study

Lutango D. Simangwa[1*], Anne N. Åstrøm[2], Anders Johansson[3], Irene K. Minja[4] and Ann-Katrin Johansson[1]

Abstract

Background: Oral diseases may cause serious health problems, especially in socially disadvantaged populations and in low-income countries. In populations living in the rural areas of Tanzania there is paucity of reports on oral health. The study aim was to estimate the prevalence, severity and socio-demographic distribution of oral diseases/conditions in adolescents living in Maasai population areas of Tanzania and to compare oral diseases/conditions between Maasai and non-Maasai ethnic groups.

Methods: A total of 23 schools were randomly selected from 66 rural public primary schools in Monduli and Longido districts, Tanzania. All pupils in the selected classes, 6th grade, were invited to participate in the study. A total of 989 were invited and 906 (91.6%) accepted the invitation and completed an interview and a clinical oral examination.

Results: Out of 906 study participants (age range 12–17 years), 721(79.6%) were from Maasai and 185 (20.4%) from non-Maasai ethnic groups. Prevalence of poor oral hygiene, gingival bleeding, dental caries experience (DMFT> 0), dental fluorosis TF grade 5–9, dental erosion (into dentin), tooth wear (into dentin) and TMD was 65.6, 40.9, 8.8, 48.6, 1.9, 16.5 and 11.8%, respectively. Multiple variable logistic regression analysis revealed that, girls (OR = 2.0) and participants from Longido (OR = 2.6) were more likely to present with good oral hygiene ($p < 0.05$). Adolescents from Monduli (OR = 1.7), males (OR = 2.1), being born within Arusha region (OR = 1.9) and Maasai (OR = 1.7) were more likely to present with gingival bleeding ($p < 0.05$). DMFT> 0 increased by age (OR = 2.0) and was associated with non-Maasai ethnic group (OR = 2.2), ($p < 0.05$). Adolescents from Monduli district (OR = 10.0) and those born in Arusha region (OR = 3.2) were more likely to present with dental fluorosis ($p < 0.05$). Dental erosion was more common among non-Maasais (OR = 2.0) as well as having mother with high education (OR = 2.3), ($p < 0.05$).

Conclusions: Oral diseases like dental caries and dental erosion were less common, but gingival bleeding, dental fluorosis, tooth wear and TMD were common findings in adolescents attending primary schools in the Maasai population areas of Tanzania. Notable differences between Maasai and non-Maasai ethnic groups and certain correlations to sociodemographic factors were detected. Our findings can be utilized by policy makers in the planning of oral health programs in public primary schools of Maasai population areas of Tanzania.

Keywords: Adolescents, Dental caries, Dental erosion, Dental fluorosis, Maasai population areas, Oral hygiene, Temporomandibular disorders, Tooth wear

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Introduction

Oral diseases are among the most common diseases and yet it is not unusual that these type of problems receive little attention especially so in countries with weak health care systems [1]. Most countries in sub-Saharan Africa, for example Tanzania, focus on high mortality diseases like HIV/AIDS, cancer, tuberculosis, diabetes and malaria and pay less attention to oral health issues [2]. In many regions it is therefore common that oral diseases, such as dental caries, are left untreated or at the best treated with tooth extraction as the only choice for emergency treatment [3]. The remote population in Tanzania is more or less excluded from oral health services. To improve the access to general health care for pastoralists in the northern part of Tanzania, to a large extent including the Maasai tribe, village dispensaries/health centers have been placed in specific areas [4]. However, due to the pastoral lifestyle of these groups of people, which implies living and moving together with their animals, this special service has been of limited use [4].

A relation between oral diseases/conditions and socio-demographic factors such as sex, age, education, ethnicity and wealth/family income have been reported worldwide [5–10]. Studies have shown that children from lower-income households are more likely to experience dental caries than their economically more advantaged counterparts [11–13]. It is also clear that children of parents with high education experience less dental caries than children of parents with low education [12, 14]. Considering sex and age, findings from sub-Saharan Africa have shown a consistent pattern in which dental caries experience is not only significantly greater in females, but also increases with age [15–18]. Studies from sub-Saharan Africa have also shown that the prevalence of dental caries often is low and the mean DMFT of 14 year olds living in rural areas of Tanzania (2010), 12 year olds in Kenya (2012), and 10–14 year olds in Uganda (2003) has been found to be 0.3, 0.4 and 0.7, respectively [19–21]. Besides this, one older study as far back as 1931 and another more recent study from 1997 are addressing mainly the medical health of the pastoral societies in Sub-Saharan Africa but also including a few oral health parameters reported that the occurrence of dental caries among the Maasais at that time was lower than in the other groups [22, 23].

Poor oral hygiene have commonly been reported among both children and adolescents and may lead to a number of oral health problems such as dental caries, gingivitis, periodontitis and tooth loss [24, 25]. For example in Zambia, the prevalence of poor oral hygiene in 10–14 year old adolescents (2011) was 10% and in Nigeria the corresponding figures among 11–14 years olds was found to be 32% (2011) [26, 27]. Among adolescents in Tanzania, the prevalence of poor oral hygiene was found to be as high as 65–99% (1988, 1996) and the occurrence of gingivitis as high as 80–90% [28, 29].

Reports from the Eastern part of sub-Saharan Africa show that dental fluorosis is very common and in certain regions its prevalence has been found to be nearly 100% [30, 31]. The prevalence of more severe dental fluorosis according to Thylstrup Fejerskov index (TF-index) grade ≥ 5 in Kenyan adolescents 13–15 year olds was found to be 48% in 2009 [32]. In the Northern part of Tanzania, the concomitant corresponding prevalence in 10–14 year olds (2000) varied between 10 and 34% [33].

The presence of more severe dental erosion in adolescents in many parts of the world has been reported with varying prevalence (3–26%) [34–38]. To our knowledge no studies on dental erosion have been performed in sub-Saharan African adolescents. The literature on tooth wear in general in the Sub-Saharan populations is scarce and focused mainly on adults. A study in the Sudanese population aged 16–75 years and older (2012) found that 26% of the population had tooth wear [39] and a corresponding figure from Nigeria (2010) among of 20–64 year olds was 53% [40].

Temporomandibular disorders (TMD) are a significant public health problem worldwide affecting 3 to 11% depending on diagnosis [41]. Studies on TMD in sub-Saharan Africa are rare, however studies from Nigeria and Tanzania found that 26% of the Nigerian young adults and 67% of the Tanzanian adults had some evidence of signs and symptoms of TMD [42, 43]. Reports from other parts of the world using the research diagnostic criteria (RDC/TMD) are reporting diverging figures. For example among 10–18 year olds, studies in Sweden (1999 and 2009) found that 5–9% of the participants had TMD [44, 45] and in a Saudi Arabian study (2016) it was found that one third of the participants had at least one TMD diagnosis [46]. Among adolescents and young adults in a Mexican study conducted in 2006 it was reported that the prevalence of some grade of TMD was as high as 46% [47].

To the best of our knowledge, there is no information on the oral diseases of contemporary adolescents living in Maasai population areas in Arusha region, northern Tanzania. Thus, the aim of this study was to estimate the prevalence, severity and socio-demographic distribution of oral diseases/conditions in adolescents living in Maasai population areas of Tanzania. It also aimed to explore whether the socio-demographic differences in oral diseases/problems varied according to Maasai and non-Maasai ethnicity.

Methods

Sample size

The sample size was estimated based on the assumption that the prevalence of dental erosion among adolescents was 50%. The estimated minimum sample size for this study, 845 adolescents, was obtained by assuming a margin error of 5% and, confidence intervals of 95%. Furthermore,

the sample size was multiplied by 2 to account for the design effect (D), and increased by 10% to account for contingencies such as non-response or recording errors.

Sampling technique

A cross-sectional study was carried out in Maasai population areas of Monduli and Longido districts, in the Arusha region, in the northern part of Tanzania from June to November 2016. The study aimed to focus on 12–14-year-old adolescents, attending rural public primary schools. A list of all primary schools comprising public (urban and rural) and private schools (total of 100 schools) was obtained from both districts. After having excluded urban and private schools, 23 (13 from Monduli and 10 from Longido) out of a total of 66 (38 from Monduli and 28 from Longido) eligible rural public primary schools were randomly selected using a one-stage cluster sample design with school as the primary sampling unit and random number generator software. In each randomly selected school, a class expected to contain adolescents aged 12–14 years was purposively identified (6th grade). All children available in the identified class were invited to participate in the study. Thus, the inclusion criteria were adolescents expected to be in age 12 to 14 year old attending rural public primary schools of Monduli and Longido districts. The exclusion criteria were adolescents attending urban and private primary schools, those absent during the interview/oral examination day and those with learning difficulties.

Interviews

The questionnaire was constructed in English, translated into Swahili and back-translated to English independently by qualified translators from the University of Dar Es Salaam, Tanzania. Closed- and open-ended questions were used to gather information.

Pre-testing of the questionnaire took place in fifty primary school children (12–14 year olds) before the actual fieldwork regarding wording, meaning, and content of each item, and appropriateness of format and modified as needed. Two especially trained medical nurses performed face-to-face interviews in Swahili/Maa (Maasai language) with each adolescent. Face-to-face interview was done in a school setting, either under the tree or inside the classroom depending on availability and each child was interviewed privately while others were inside their classes. In this study, the pilot participants were not part of the main study.

Socio-demographic factors were assessed in terms of age, ethnicity, sex, place of residence (place of residence was defined as the district where an adolescent was living in e.g., Monduli or Longido districts), father's and mother's education, house ownership, number of children, household socio-economic status (perceived affluence of my household) and household wealth index [48]. For the purpose of assessing their wealth index, their livestock were not included because we used Principal Component Analysis (PCA) in calculating the wealth index and PCA works best when the household asset variables are correlated, but also works best when the distribution of variables varies across the households. It is those assets that are more unequally distributed between households that are given more weight in PCA [49]. Variables with low standard deviations carry a low weight from PCA. For example an asset which is owned by almost all households would exhibit no variation between households and would be zero weighted and thus of no use in differentiating the wealth of a particular family. In our study livestock were owned by the majority (93%) of their families, and so livestock was of little or no use in differentiating their wealth. Ethnicity was assessed by asking "what is your ethnic group?" The response categories were (1) = Maasai, (2) = Meru, (3) = Arusha and (4) = others. For analysis, the items were dichotomized to 1 = Maasai (including option (1)) and 2 = non Maasai (including option (2), (3) and (4) during analysis.

Parents' education was assessed by asking *what is the highest level of school your mother/father has attended?* Responses were (0) for none, (1) for she/he started but did not complete primary school, (2) for completed primary school (3) for she/he started but did not complete secondary school, (4) for she/he completed secondary school, (5) for she/he started but did not complete college/university, (6) for completed college/university, (7) for I don't know. In the statistical analyses, the items were dichotomized as (0) for low education (from options (0), (1), (2), (3) and (7) and (1) for high education (from options (4), (5) and (6).

Durable household assets indicative of family wealth (i.e. radio, television, refrigerator, mobile telephone, cupboard, bicycle and motorcycle) was recorded as (Yes) "available and in working condition" or (No) "not available and/or not in working condition." The TMD epidemiological questions were *Do you have pain in your temple, face, jaw or jaw joint once a week or more? Does it hurt once a week or more when you open your mouth or chew?* The response was either *yes or no* and positive answer to any of the two questions is considered affirmative to TMD diagnosis [50].

Clinical examination

After an interview, clinical oral examinations were performed by the principal investigator (L.S). The child was examined under field conditions outside or inside the classroom sitting on a chair in natural day light, avoiding the direct sun light. When necessary, the teeth were cleaned and dried by sterile gauze and isolated by cotton rolls. Disposable mouth mirrors and sickle probes (No. 23 explorer or Shepherd's hook) were used.

Oral hygiene was assessed using the Simplified Oral Hygiene Index (OHI-S) [51]. The scores were (0) for no plaque/calculus present, (1) for plaque or supra-gingival calculus covering not more than one third of the tooth surface, (2) for plaque or supra-gingival calculus covering more than one third but less than two thirds of the tooth surface, and (3) for plaque or supra-gingival calculus covering more than two thirds of the tooth surface. For each individual, the plaque and calculus scores were summed up and divided by total number of teeth examined to obtain the Simplified Debris Index (DI-S) and simplified calculus index (CI-S). The OHI-S was constructed by summing up the DI-S and CI-S. During analysis the OHI-S scores were dichotomized into 1 = good oral hygiene (OHI-S < 1) and 2 = poor oral hygiene (OHI-S ≥ 1).

Gingival health was assessed by Gingival Bleeding Index (GBI) [52]. Dental caries was assessed according to criteria specified by WHO, 2013 [53] and dental fluorosis was assessed by Thylstrup- Fejerskov - index (TF-index) [54]. Dental erosion on palatal and facial surfaces of maxillary anterior teeth was recorded according to Johansson et al. 1996 [55] and grading of first molar cuppings by Hasselkvist et al. [37]. Tooth wear was graded as a full mouth recording of occlusal/incisal surfaces according to Carlsson et al. [56].

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) for PC, version 24 (IBM corporation, Armonk, NY, USA). STATA 14.2 (Stata corporation, Lakeway drive college station, Texas, USA) was used to adjust for the cluster effect of school. Principle component analysis was used to construct a socio-economic index categorized into wealth quintiles (1st quartile, 2nd quartile, 3rd quartile and 4th quartile implying the poorest, poorer, less poor and least poor respectively) and based on ownership of assets such as furniture and household characteristics including electricity, type of water source roof material and toilet types [48]. Descriptive statistics was carried out followed by bivariate analysis using cross tabulations and Pearson's chi-square statistical test. Multiple variable logistic regression analysis (Odds Ratio and 95% CI) was carried out with all socio-demographic variables that were statistically significantly associated with oral hygiene status, gingival bleeding, dental caries, dental fluorosis, dental erosion/tooth wear, and TMD in Pearson's chi-square test (unadjusted analysis) were included in the model simultaneously. For each outcome variables, there were two levels/categories used in the multiple variable logistic regression analysis. For instance, oral hygiene status was dichotomized into 0 = poor oral hygiene and 1 = good oral hygiene; gingival bleeding was dichotomized into 0 = without bleeding and 1 = with bleeding; dental caries was dichotomized into DMFT = 0 and DMFT > 0 and dental fluorosis was dichotomized into 0 = TF score 0–4 and 1 = TF score 5–9. In addition, Dental erosion was dichotomized into 0 = grade 0 and 1 = grade 1–4; tooth wear was dichotomized into 0 = grade 0 and 1 = grade 1–4; and TMD was dichotomized into 0 = without TMD symptoms and 1 = with TMD symptoms.

Results

Sample characteristics

A total of 989 grade 6 primary school adolescents were invited to participate in the study. Of those, 930 adolescents accepted to participate. Twenty-four (2.6%) children who attended the study were excluded during analysis due to too high or low age. Thus, the study included 906 children 12–17 years, mean age 13.4 years (SD 1.2) of which 56.1% were females. The final response rate was 91.6%. Among the participants, 52.9% were from Monduli district and the remaining from Longido district. Of the participants 79.6% were from the Maasai ethnic group and the remaining 20.4% from the non-Maasai group.

Reliability

Duplicate clinical examinations (intra-examiner concordance, LS), 3 weeks apart, were carried out with 93 randomly selected participants. Analysis performed on duplicate examination records revealed Kappa value of 0.98, 0.87, and 0.69 for DMFT, TF-index, and dental erosion respectively. Higher Kappa values for DMFT and TF-index might have been contributed by the examiners common knowledge about the disease/condition in the population being rated [57].

Socio-demographic characteristics by ethnicity

As depicted in Table 1, mothers who reported secondary school education level or above were 3.2% for the Maasais and 11.9% for the non-Maasais ($p < 0.001$). All socio-demographic characteristics except sex and age group differed statistically significantly between the two ethnic groups.

Prevalence, severity of oral diseases/conditions and correlated sociodemographic factors

The overall prevalence of poor oral hygiene (OHI-S ≥ 1) was 65.6% (good oral hygiene was 34.4%) and gingival bleeding was 40.9%. As depicted in Table 2 oral hygiene status and gingival bleeding varied statistically significantly according to district, sex, age group, birth region and ethnicity ($p < 0.05$). Good oral hygiene was more common among the non-Maasai adolescents (45.9%) than the Maasai adolescents (31.5%). A total of 27.4% of the males and 40.0% of the females had good oral hygiene ($p < 0.05$). Similarly, gingival bleeding was more common in Maasai adolescents (44.4%) than non-Maasai (27.6%) ($p < 0.05$).

Table 1 Socio-demographic characteristics by ethnic groups

Variable	Categories	Maasai % (n)	Non-Maasai % (n)	*p*-value
District	Monduli	58.0 (418)	33.0 (61)	
	Longido	42.0 (303)	67.0 (124)	< 0.001*
Sex	Male	43.1 (311)	47.0 (87)	
	Female	56.9 (410)	53.0 (98)	0.341
Age group	12–14 years	86.5 (610)	90.3 (167)	
	15–17 years	13.5 (95)	9.7 (18)	0.173
Wealth index	1st quartile (poorest)	29.4 (209)	7.0 (13)	
	2nd quartile (very poor)	27.9 (199)	9.2 (17)	
	3rd quartile (less poor)	28.5 (203)	12.4 (23)	
	4th quartile (least poor	14.2 (101)	71.4 (132)	< 0.001*
Region of Birth	Arusha	99.0 (714)	78.4 (145)	
	Others	1.0 (7)	21.6 (40)	< 0.001*
Mother's education	Low (≤ primary school)	96.8 (698)	88.1 (163)	
	High (≥ secondary school)	3.2 (23)	11.9 (22)	< 0.001*
Father's education	Low (≤ primary school)	95.0 (685)	80.5 (149)	
	High (≥ secondary school)	5.0 (36)	19.5 (36)	< 0.001*
House ownership	Yes	98.6 (711)	80.0 (148)	
	No	1.4 (10)	20.0 (37)	< 0.001*
Number of children	1–5 children	45.1 (325)	63.8 (118)	
	6–14 children	54.9 (396)	36.2 (67)	< 0.001*

*Significant Pearson's Chi-square test ($p < 0.05$)
Maasai $n = 721$, non-Maasai $n = 185$

Dental caries prevalence (DMFT> 0) was 8.8%. The overall mean DMFT was 0.13 (SD 0.5). The DMFT was composed of the decayed (D = 90.0%), missing teeth due to caries (M = 5.0%) and filled teeth (F = 0). Adolescents with both, decayed and missing teeth due to caries were 5.0%. The overall mean DMFS was 0.22 (SD 0.9). The mandibular first permanent molar was the most commonly registered tooth with dental caries (60.0%) and the occlusal surface was the most common registered site with caries (71.6%). As shown in Table 3, 7.4% of the Maasai adolescents had a DMFT> 0 and the corresponding figures for the non-Maasai was 14.6% ($p < 0.05$). Among the 12–14 year old adolescents, a total of 8.2 and 13.3% of the 15–17 year old adolescents had DMT > 0 ($p < 0.05$).

Dental fluorosis, TF grade 1–9, was recorded in 89.7% of the participants and more severe fluorosis TF-grade 5–9 in 48.6%. More severe dental fluorosis (TF grade 5–9) was more common among the Maasai than non-Masaai (52.1 and 34.6% respectively, $p < 0.05$). About 51% of the adolescents born in Arusha region was registered with severe dental fluorosis TF score 5–9, while only 12.8% of the adolescents born outside Arusha region ($p < 0.05$) had so.

Figure 1 shows the percentage distributions of adolescents according to maximum TF score per subject by ethnic groups. Dental fluorosis, TF grade 1–9, was more common and more severe among the Maasai adolescents (97.6%) than the non-Maasai (58.9%).

Dental erosion extending into dentine (grade 3–4) was registered in 1.9% (grade 1–4 was 30.0%) of the participants and tooth wear extending into dentine (grade 2–4) in 16.5% (grade 1–4 was 44.3%). As shown in Table 4 dental erosion was less common among the Maasai- than the non-Maasai- adolescents since 26.8 and 43.8%, respectively showed any grade of erosion (grade 1–4) ($p < 0.05$). Furthermore, dental erosion was registered among 24.0% of the adolescents from Monduli districts and 36.8% of the adolescents from Longido districts ($p < 0.05$). However, none of them was registered with the most severe grade of dental erosion (grade 4). In general, the pattern of tooth wear was more similar across the ethnic groups and 44.9% of the Maasais and 50.3% of the non-Maasais was registered with some type of tooth wear ($p > 0.05$).

TMD pain (TMD-p) was found in 11.8% of the participants. The prevalence of TMD among Maasais and non-Maasais was 11.2 and 14.1% respectively ($p > 0.05$).

Socio-demographic variables found statistically significantly associated with oral diseases and problems in unadjusted analysis (Tables 2, 3 and 4) were entered simultaneously, into seven separate multiple variable logistic regression models in order to investigate the likelihood of having good oral hygiene, gingival bleeding, dental caries

Table 2 Frequency distribution of oral hygiene status and bleeding gums by socio-demographic factors

Variable	Oral hygiene status % Good (n with OHI-S < 1)	Gingival Bleeding % (n)
Prevalence (whole sample)	34.4 (312)	40.9 (371)
District		
Monduli	24.6 (118)	47.4 (227)
Longido	45.4 (194)*	33.7 (144)*
Sex		
Male	27.4 (109)	50.3 (200)
Female	40.0 (203)*	33.7 (171)*
Age group		
12–14	35.9 (279)	38.6 (300)
15–17	23.9 (27)*	56.6 (64)*
Region of Birth		
Arusha	33.6 (288)	42.3 (363)
Others	48.9 (23)*	17.0 (8)*
Ethnicity		
Maasai	31.5 (213)	44.4 (320)
Non-maasai	45.9 (85)*	27.6 (51)*
Wealth index		
1st quartile (poorest)	29.3 (65)	44.6 (99)
2nd quartile (very poor)	28.2 (61)	48.1 (104)
3rd quartile (less poor)	30.5 (69)	42.0(95)
4th quartile (least poor)	47.2 (110)*	30.9 (72)
Mother's education		
Low (≤ primary school)	33.9 (292)	41.7 (359)
High (≥ secondary school)	44.4 (20)	26.7 (12)*
Father's education		
Low (≤ primary school)	34.1 (285)	41.2 (344)
High (≥ secondary school)	38.9 (28)	37.5 (27)*

*Significant Pearson Chi-square test ($p < 0.05$)

Table 3 Frequency distribution of dental caries experience (DMFT > 0) and severe dental fluorosis (TF grade 5–9) by socio-demographic factors

Variable	DMFT > 0 % (n)	Dental fluorosis % (n)
Prevalence (whole sample)	8.8 (80)	48.6 (440)
District		
Monduli	10.0 (48)	77.8 (339)
Longido	7.5 (32)	23.7 (101)*
Sex		
Male	9.5 (38)	47.2 (188)
Female	8.3 (42)	49.6 (252)
Age group		
12–14	8.2 (64)	46.3 (360)
15–17	13.3 (15)*	63.7 (72)*
Region of Birth		
Arusha	8.4 (72)	50.5 (434)
Others	17.0 (8)	12.8 (6)*
Ethnicity		
Maasai	7.4 (53)	52.1 (376)
Non-maasai	14.6 (27)*	34.6 (64)*
Wealth index		
1st quartile (poorest)	7.7 (17)	49.1 (109)
2nd quartile (very poor)	6.9 (15)	59.3 (128)
3rd quartile (less poor)	10.2 (23)	56.2 (127)
4th quartile (least poor)	10.7 (25)	30.9 (72)*
Mother's education		
Low (≤ primary school)	8.8 (76)	49.2 (424)
High (≥ secondary school)	8.9 (4)	35.6 (16)
Father's education		
Low (≤ primary school)	8.9 (74)	49.0 (409)
High (≥ secondary school)	8.3 (6)	43.1 (31)

*Significant Pearson Chi-square test ($p < 0.05$)

experience (DMFT> 0), dental fluorosis TF grade 5–9, dental erosion (grade 1–4), tooth wear (grade 1–4), and TMD (2Q/TMD > 0). As shown in Table 5, adolescents from Longido district were 2.6 times (OR = 2.6, CI 1.6–4.4) more likely to have good oral hygiene compared to adolescents from Monduli district. Females were 2.0 (OR = 2.0, CI 1.4–2.5) times more likely to have good oral hygiene compared to males. Adolescents from Longido district, females and non Maasai were respectively 0.6-times (OR = 0.6, CI 0.4–0.8), 0.5-times (OR = 0.5, CI 0.4–0.6) and 0.6 (0.4–0.9) times less likely to have gingival bleeding compared to their counterparts in Monduli district, males and Maasais. Adolescents born within the Arusha region and older age groups were 2.0-times (OR = 2.0, CI 1.2–3.3) and 1.6 (1.0–2.5) more likely to have gingival bleeding compared to those born outside Arusha and younger age group. Statistically significant two-way interactions occurred between ethnicity and wealth index on oral hygiene status whereby adolescents from non Maasais and least poor families were 2.8 (OR = 2.8, CI 1.1–7.2) times more likely to have good oral hygiene compared to those from Maasais and most poor families. Female adolescents from non Maasai were 2.5 (OR = 2.5, CI 1.2–5.4) times more likely to have gingival bleeding compared to males from Maasais group. As shown in Table 6, older aged (OR = 2.0, CI 1.1–3.5) and non-Maasai adolescents (OR = 2.2, CI 1.1–4.1) were more likely to have DMFT> 0 compared to the younger aged and Maasai adolescents, respectively. Adolescents from Longido district (OR = 0.1, CI 0.1–0.3) were less likely to have dental fluorosis TF grade 5–9 than children from Monduli district. Moreover, adolescents born within the Arusha region (OR = 3.2, CI 1.0–10.2) were 3.2-times more likely to have dental fluorosis TF grade 5–9 than those born

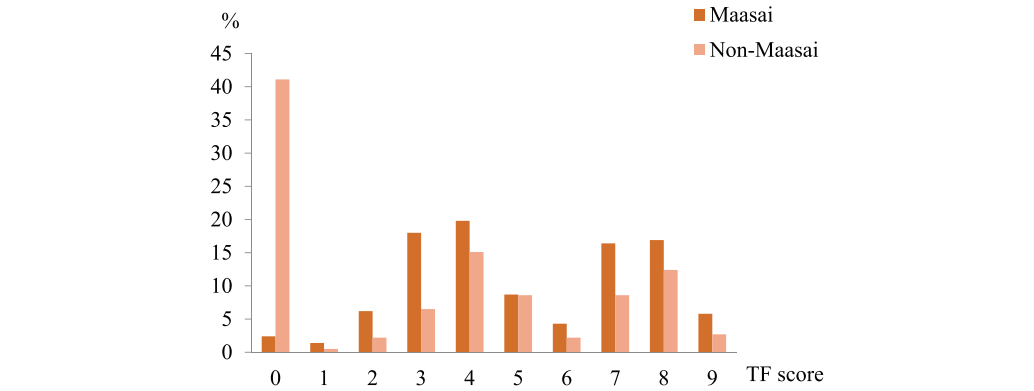

Fig. 1 Percentage distributions of children with dental fluorosis according to maximum TF score per subject by ethnic groups. Maasai $n = 721$; non-Maasai $n = 185$

Table 4 Frequency distribution of dental erosion (grade 1–4), tooth wear (grade 1–4) and TMD by socio-demographic factors

Variable	Dental erosion % (n)	Tooth wear % (n)	TMD > 0 % (n)
Prevalence (whole sample)	30.0 (372)	44.3 (401)	11.8 (107)
District			
Monduli	24.0 (115)	42.8 (205)	18.0 (86)
Longido	36.8 (157)*	45.9 (196)	4.9 (21)*
Sex			
Male	28.1 (112)	46.0 (183)	12.3 (49)
Female	31.5 (160)	42.9 (218)	11.4 (58)
Age group			
12–14	30.4 (236)	43.8 (340)	11.2 (87)
15–17	28.3 (32)	48.7 (55)	17.7 (20)*
Region of Birth			
Arusha	29.2 (251)	44.7 (384)	11.9 (102)
Others	47.7 (21)*	36.2 (17)	10.6 (5)
Ethnicity			
Maasai	26.8 (193)	44.9 (324)	11.2 (81)
Non-maasai	43.8 (81)*	50.3 (92)	14.1 (26)
Wealth index			
1st quartile (poorest)	29.7 (66)	28.6 (113)	12.2 (27)
2nd quartile (very poor)	25.5 (55)	23.0 (91)	8.8 (19)
3rd quartile (less poor)	20.8 (47)	21.5 (85)	13.3 (30)
4th quartile (least poor)	42.9 (100)*	26.8 (106)*	12.9 (30)
Mother's education			
Low (≤ primary school)	28.8 (248)	44.5 (383)	10.8 (93)
High (≥ secondary school)	53.3 (24)*	40.0 (18)	31.1 (14)*
Father's education			
Low (≤ primary school)	29.4 (245)	44.2 (369)	11.6 (97)
High (≥ secondary school)	37.5 (27)	44.4 (32)	13.9 (10)

*Significant Pearson Chi-square test ($p < 0.05$)

Table 5 Oral hygiene status and gingival bleeding regressed on socio-demographic characteristics and statistically significant interactions

Variable	Oral hygiene status (Good oral hygiene)		Gingival bleeding	
	OR (95% CI)	*P*	OR (95% CI)	*P*
District				
Monduli	1		1	
Longido	2.6 (1.6–4.4)	< 0.001	0.6 (0.4–0.8)	0.002
Sex				
Male	1		1	
Female	2.0 (1.4–2.5)	< 0.001	0.5 (0.4–0.6)	< 0.001
Age group				
12–14 years	1		1	
15–17 years	0.8 (0.4–1.5)	0.519	1.6 (1.0–2.5)	0.053
Region of birth				
Others	1		1	
Arusha	1.0 (0.7–1.5)	0.794	2.0 (1.2–3.3)	0.005
Ethnic groups				
Maasai	1		1	
Non-Maasai	1.4 (0.9–2.4)	0.140	0.6 (0.4–0.9)	0.008
Wealth index				
Most poor	1			
Least poor	1.3 (0.8–2.0)	0.323		
Ethnicity by wealth Index				
Maasai x most poor	1			
Non Maasai x least poor	2.8 (1.1–7.2)	0.038		
Ethnicity by sex				
Maasai x Males			1	
Non Maasai x Female			2.5 (1.2–5.4)	0.019

Adjusted odds ratios (OR) and 95% confidence intervals (CI)

outside the Arusha region . Statistically significant two way interaction occurred between ethnicity and district on DMFT, and between ethnicity and wealth index on dental fluorosis. Adolescents from non Maasai and Longido district were 3.9 (OR = 3.9, CI 1.3–12.2) times more likely to have DMFT> 0 in comparison with those from Maasai and Monduli district. Also non Maasai adolescents and being from least poor families were 0.1 (OR = 0.1, CI 0.04–0.3) times less likely to have dental fluorosis compared to Maasais and from most poor families. As shown in Table 7, non-Maasai adolescents and adolescents of mothers with high education level were 2.0 (OR = 2.0, CI 1.3–3.2) and 2.3 (OR = 2.3, CI 1.3–4.0) times more likely to have dental erosion than Maasai adolescents and adolescents from mothers with low education level, respectively. No cuppings were observed on occlusal surfaces of first molars. Considering TMD, adolescents from Longido district (OR = 0.2, CI 0.1–0.4) were 0.2-times less likely to have TMD compared to those from Monduli district. Also adolescents from mothers with high education (OR = 5.1, CI 2.5–10.2) were more likely to have TMD compared to those from mothers with low education. Regarding TMD, statistically significant two way interaction occurred between ethnicity and district where non Maasai adolescents and being from Longido district were 3.4 (OR = 3.4, CI 1.1–10.4) times more likely to have TMD compared to those from Maasai and being from Monduli district.

Discussion

To our knowledge, this is the first study reporting on the prevalence, severity and socio-demographic distribution of oral diseases and conditions affecting Tanzanian school adolescents living in Maasai population areas of Monduli and Longido districts. According to the present findings, poor oral hygiene and gingival bleeding on gentle probing was common in the study group as a whole, whereas both severity and prevalence of dental caries prevalence seemed to be quite marginal. Moreover, about half the study group presented with sever dental fluorosis whereas the presence of erosion, tooth wear and TMD symptoms were rare.

Table 6 Dental caries and dental fluorosis regressed on socio-demographic characteristics and statistically significant interactions

Variable	Dental caries (DMFT > 0)		Dental fluorosis (TF grade 5–9)	
	OR (95% CI)	*P*	OR (95% CI)	*P*
District				
Monduli			1	
Longido			0.1 (0.1–0.3)	< 0.001
Sex				
Male				
Female				
Age group				
12–14 years	1		1	
15–17 years	2.0 (1.1–3.5)	0.017	1.4 (0.9–2.3)	0.171
Region of birth				
Others			1	
Arusha			3.2 (1.0–10.2)	0.044
Ethnic groups				
Maasai	1		1	
Non-Maasai	2.2 (1.1–4.1)	0.018	0.9 (0.5–1.8)	0.767
Wealth index				
Most poor			1	
Least poor			1.0 (0.7–1.4)	0.880
Ethnicity by district				
Maasai x Monduli	1			
Non-Maasai x Longido	3.9 (1.3–12.2)	0.018		
Ethnicity by wealth index				
Maasai x most poor			1	
Non-Maasai x Least poor			0.1 (0.04–0.3)	< 0.001

Adjusted odds ratios (OR) and 95% confidence intervals (CI)

In this study, poor oral hygiene was found to be more common than in other comparable studies from sub-Saharan Africa since about 66% of the school adolescents investigated showed bad oral hygiene compared to only 32–45% reported earlier for instance in Tanzania and Nigeria [58–60]. Consistent with the sex distribution of oral hygiene observed in this study, where girls were twice as likely as boys to have good oral hygiene status, this finding is in agreement with several other studies from Nigeria (10–19 year olds) [61], Kenya (12 year olds) [62] and India (7–12 year olds) [63]. Contrary to these findings, one urban study in Tanzania (15 year olds) found that poor oral hygiene status was equally distributed between girls and boys [60]. A large proportion of the adolescents (41%) investigated showed gingival bleeding on gentle probing, a sign of gingivitis. This prevalence is lower than the one reported in 12 year old children in Uganda where about 54% of the participants presented with gingival bleeding [17].

The mean DMFT (0.13) in our study was low and in agreement with other studies from East Africa [19–21]. As expected, the prevalence of dental caries in this study was significantly higher in older than in younger age groups [15–17, 64, 65]. The decayed component (D) of the DMFT- index in our study constituted 90%, and the missing component (M) was 10%. It is noteworthy that none of the participants in this study was diagnosed with any type of dental restoration. The lack of dental restorations has earlier been reported on from other studies in sub-Saharan Africa [2, 20, 66] and may be an indicator of limited professional oral health services and poor socioeconomic situation prevailing in this area. The finding that Maasai adolescents had less dental caries compared to non-Maasai adolescents, is also in agreement with previous findings dateing as far back as 1931 but also 1997 [22, 23].

As expected, due to the high fluoride content in the drinking water [67–69], severe dental fluorosis (TF grade 5–9) was common and presented in nearly half of the participants (48.6%). This is also in accordance with earlier findings from Kenya [32] but contrary to other studies from Tanzania and Ethiopia [33, 70] where a lower prevalence of

Table 7 Dental erosion, tooth wear and TMD regressed on socio-demographic characteristics and statistically significant interactions

Variable	Dental erosion (Grade 1–3)		Tooth wear (Grade 1–4)		TMD (2Q/TMD > 0)	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
District						
Monduli	1				1	
Longido	1.6 (0.9–3.2)	0.140			0.2 (0.1–0.4)	< 0.001
Sex						
Female					1	
Male					1.2 (0.7–2.2)	0.483
Age group						
12–14 years					1	
15–17 years					1.3 (0.8–2.2)	0.251
Region of birth						
Others	1		1			
Arusha	1.1 (0.5–2.3)	0.897	1.3 (0.9–1.9)	0.129		
Ethnic groups						
Maasai	1				1	
Non maasai	2.0 (1.3–3.2)	0.003			1.6 (0.9–2.9)	0.096
Wealth index						
Most poor	1		1			
Least poor	0.9 (0.6–1.2)	0.455	0.8 (0.7–1.1)	0.157		
Mother's education						
Low (≤ primary school)	1				1	
High (≥ secondary school)	2.3 (1.3–4.0)	0.002			5.1 (2.5–10.2)	< 0.001
Ethnicity by district						
Maasai x Monduli					1	
Non Maasai x Longido					3.4 (1.1–10.4)	0.034

Adjusted odds ratios (OR) and 95% confidence intervals (CI)

severe dental fluorosis (10–34%) has been reported. Identified sociodemographic covariates of dental fluorosis were location and region of birth. In this regard, previous studies from the Arusha region reported a fluoride concentration between 0.1–78.09 mg/l in drinking water [67, 68].

In the present study, dental erosion extending in to dentine was found only in 1.9% of the adolescents. This is lower than that found in other comparable studies from Saudi Arabia and Sweden which reported prevalence of 11.9 to 26.0% [36, 37]. The rural environment in which the adolescents in this study from both districts live in combination with a restricted economic situation and a reduced availability to shops might be limiting the access to erosive conducive products/challenges. Non-Maasai adolescents were more prone to have dental erosion than Maasai adolescents. This might be attributed to differences in exposure to risk factors for erosion between the two ethnic groups. Adolescents whose mothers had higher levels of education had an elevated risk to develop dental erosion than children whose mothers had low education. This finding is in agreement with some studies [71, 72] but in contradiction to other studies [73, 74]. The relationship between the mother's high level of education and the presence of dental erosion in the children in this study may be due to the wealth and lifestyle of such a family and thereby greater chances for the children to consume erosive conducive products.

This study revealed that 16.5% of the adolescents had tooth wear extending into dentine. This is contrary to findings from England where a higher prevalence (30.0–53.0%) has been reported [75, 76] and also contrary to findings from China, Nigeria, which found lower prevalence rates (1.9–8.5%) [77, 78]. Regression analysis revealed no socio-demographic variable that was significantly correlated with tooth wear. Thus, non of the socio-demographic factors of importance for the development of tooth wear was included in the present analysis.

Comparing studies using a similar diagnostic system (TMD-p, RDC/TMD), the prevalence of adolescents with TMD pain in this study was 11.8% which is slightly higher than in other previous studies in Sweden and United States of America [45, 79–81], but also lower than other previous studies in Saudi Arabia and China [46, 79].

Psychosocial factors, for example stress related behaviors, are considered to be a common cause for development of TMD [82]. It was expected that in a nomadic society, this impact would be low and thus lessen the occurrence of reported TMD, but instead the prevalence of TMD was higher than in comparable studies performed in Western societies. This variation in TMD magnitude could be because of the differences related to heterogeneous age groups, the sample size and the setting of sample selection [83]. This study identified adolescents from Monduli district and adolescents of mothers with high education to be more likely to have TMD pain. This may imply that environmental and cultural factors may have a great role in the development of TMD among adolescents. One American study reported similar findings, that the geographical study site was independently associated with TMD [84]. However, our finding is contrary to the findings from China, which found that children and adolescents with lower parental educational levels or household income, had higher rates of TMD pain [79]. Similar findings on correlation between low educational level and other types of pain has also been reported on [85, 86]. The correlation between high education level of the mother and TMD in our study may be due to subgroup differences in emotional responsivity to chronic pain as well as pain intensity within a group of individuals [86]. However, further investigations are needed to clarify the association between mother's education level and TMD in this particular society.

Study limitations

The cross-sectional method utilized in data collection, has some drawbacks as it is difficult to establish a causal relationship. The information on oral health was collected by interviews/clinical examination conducted by trained medical/dental personnel. Information bias, recall bias and social desirability bias might have been introduced due to the self-report method employed. In addition, fewer male than female adolescents and school non-attenders in our total study sample, might have contributed to a selection bias that could have affected the study findings and generalization. Relatively fewer males than females in our study sample might be due to the fact that, in their setting male adolescents are responsible for taking care of their livestock, as a result some do not attend schools at all and some start attending schools very late age-wise. Although the methods used in this study have been utilized in other studies in East Africa [60, 87], precautious interpretation should be employed in extrapolating these findings into other societies in Tanzania, but it can be useful in other Maasai population areas in the country, especially for adolescents attending primary schools. There is a need for conducting longitudinal studies in order to further assess the sociodemographic risk indicators in this society and to explore the direction of the relationships identified.

Conclusion

The study showed that oral diseases/conditions like dental caries and dental erosion were less common, but gingival bleeding, dental fluorosis, tooth wear and TMD were common findings in adolescents attending primary schools in the Maasai population areas in Tanzania. Notable differences between Maasai and non-Maasai ethnic groups and certain correlations to sociodemographic factors were detected. Our findings can be utilized by policy makers in the planning of oral health programs in all public primary schools of Maasai population areas of Tanzania in order to address oral diseases/conditions in this area.

Abbreviations

2Q/TMD: 2 epidemiological Questions on Temporomandibular Disorder; CI: Confidence Interval; CI-S: Simplified Calculus Index; DI-S: Simplified Debris Index; DMFS: Decayed Missing Filled Surfaces; DMFT: Decayed Missing Filled Tooth; DMT: Decayed Missing Tooth; GBI: Gingival Bleeding Index; OHI-S: Simplified Oral Hygiene Index; OR: Odds Ratio; RDC: Research Diagnostic Criteria; SD: Standard Deviation; SPSS: Statistical Package for Social Sciences; TF-index: Thylstrup-Fejerskov-index; TMD: Temporomandibular Disorder; TMDp: Temporomandibular Disorder pain; WHO: World Health Organisation

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on request.

Authors' contributions

LS principal investigator, designed the study, collected the data, performed the statistical analyses, and wrote the manuscript. ANA co-supervisor, designed the study, guided the statistical analyses and writing the manuscript. AJ participated in the design of the study, guided the statistical analyses and writing the manuscript. IK co-supervisor, participated in the design of the study and provided valuable guidance in the data collection and writing the manuscript. AGJ main supervisor, designed the study, guided the statistical analyses and writing the manuscript. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

Ethical clearance was obtained prior to study from the ethical research committee in Norway (REK VEST, reference number 2015/2477) and the

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Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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Paper II

Oral diseases and oral health related behaviors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study

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RESEARCH ARTICLE Open Access

Oral diseases and oral health related behaviors in adolescents living in Maasai population areas of Tanzania: a cross-sectional study

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Abstract

Background: Oral diseases, such as dental caries, tooth wear, dental erosion and periodontal diseases are major health problems in many societies. The study aim was to explore the association between oral health related behaviors and the presence of oral diseases in adolescents living in Maasai population areas in the northern part of Tanzania.

Methods: A cross sectional study was conducted in 2016 using one stage cluster sample design. A total of 989 adolescents were invited and 906 (91.6%; (Maasais $n = 721$, non Maasais $n = 185$) accepted the invitation and completed an interview and clinical oral examination in a school setting (mean age 13.4 years, SD 1.2, range 12–17 years). Chi-square test, bivariate analysis and logistic regression were performed to analyze data.

Results: Logistic regression revealed that: adolescents with low frequency of tooth cleaning (OR = 10.0, CI 4.3–20.0) was associated with poor oral hygiene and that more regular tooth cleaning (OR = 0.1, CI 0.04–0.14) and the use of plastic type of tooth brush (OR = 0.7, CI 0.53–0.99) were associated with less gingival bleeding. High consumption of biscuits (OR = 2.5, CI 1.7–3.8) was associated with presence of dental caries and the use of magadi (OR = 24.2, CI 11.6–50.6) as a food additive was the covariate for more severe dental fluorosis (TF grade 5–9). Regular intake of carbonated soft drinks (OR = 1.6, CI 1.1–2.5) and regular tooth cleaning (OR = 1.7, CI 1.1–2.6) were independently associated with dental erosion. Using teeth as a tool for: biting nails (OR = 1.9, CI 1.4–2.4), opening soda (OR = 1.8, CI 1.4–2.4) and holding needles (OR = 1.6, CI 1.3–2.1) were covariates for tooth wear. Adolescents who reported to clench/grind their teeth (OR = 2.3, CI 1.5–3.7) was the only covariate for TMD. In several of the investigated factors, there were significant differences between the Maasai and non Maasai ethnic groups.

Conclusion: Oral health related behaviors have a significant impact on oral diseases/conditions among adolescents attending primary schools in Maasai population areas with obvious differences in behavior between the Maasai and non Maasai ethnic groups. There is a need for addressing oral health and to encourage behaviors that promote good oral health and dental care service utilization in this society.

Keywords: Adolescents, Maasai populated areas, Oral diseases, Oral health related behaviors

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Background

Oral diseases are among the major public health problems in many societies [1, 2]. Research evidence suggest that oral health related behaviors, for example dietary habits and oral hygiene practices, are strongly related to the occurrence of oral diseases [3, 4]. Thus, oral diseases can often be avoided by modification of certain behaviors, for instance, the consumption of sugary or acidic foods and drinks, the exposure to fluoride and the level of oral hygiene practices [3–5]. Regarding the extent and severity of oral diseases, studies among adolescents aged 10–14 years from Tanzania (2010), Kenya (2012) and Uganda (2003) have revealed low prevalence of dental caries and the mean DMFT ranging from 0.3 to 0.7 [6–8]. Dental fluorosis is quite common in some regions of East African countries with a prevalence of 100% [9]. The prevalence of more severe dental fluorosis (grade ≥ V) according to Thylstrup Fejerskov Index in adolescents 10–15 year olds in Kenya (2009) and Tanzania (2000) was found to be 48% and 10–34%, respectively [10, 11]. Severe dental erosion in adolescents have been reported worldwide with prevalence varying from 3 to 20% [12, 13]. There is no information on dental erosion from sub-Saharan Africa in adolescents. Temporomandibular disorders (TMD) are a significant public health problems reported to affect 3–11% of the population [14]. In sub-Saharan Africa, studies on TMD are rare, studies from Tanzania and Nigeria reported that 67% of the Tanzanian adults and 26% of the Nigerian young adults had some signs and symptoms of TMD [15, 16].

In addition to individual oral health related behaviors, access to professional oral health care and lack of knowledge in combination with shortage of economic resources are influencing the possibility for the individuals to maintain an adequate oral health [17, 18]. It has to be considered that treatment of oral diseases is expensive, and in many developing countries reflected by the fact that the costs of treating children's dental caries alone would exceed the total health care budget for those children [19]. The majority of the population in sub-Saharan Africa do not have access to appropriate oral health care services, especially those living in the rural areas [20, 21]. As a consequence, untreated oral diseases might lead to pain, problems with eating/chewing, smiling as well as speaking and limiting individual's daily activities and quality of life [2]. In addition, other difficulties are related to life experiences and psychosocial factors including age, gender, education, ethnicity, language, anxiety, feeling of vulnerability, treatment need and cost, disability, beliefs and attitude towards oral health [20, 22–24].

In Tanzania there are more than 125 different ethnic groups. The Maasais is one of them living around the Arusha region in the Northern part of Tanzania. Historically the Maasai are believed to have originated from Sudan and to have migrated through the river Nile into Kenya and then further on in- to Tanzania. Their migration is due to their traditionally nomadic lifestyle whereby they move from one region to another searching for greener pastures for their livestock. Due to this kind of lifestyle they do not have permanent houses [25]. Historically, the Maasais original survival depends much on pastoralism, but today their way of living is increasingly moving towards agro-pastoralism [26]. This follows that their traditional diet, consisting of mainly meat and milk products, nowadays more often will include farm products, such as maize, rice and potatoes. Changes in dietary patterns, may expose the Maasai society to a different pattern of both oral and general diseases [2]. Previous report from Tanzania have shown that oral diseases associate with oral health related behaviors [27]. One previous study have shown that oral diseases among young adolescents in the Maasai population areas in Tanzania are common [28]. However, associations between oral diseases/ and oral health related behaviors have not recently been investigated in this particular socio-cultural context.

This study aims to explore associations between oral health related behaviors and the presence of oral diseases, adjusted for socio-demographic factors, focusing on adolescents living in Maasai population areas in the northern part of Tanzania.

Methods

Sample size

The sample size 845 was estimated based on the assumption that the prevalence of dental erosion, among the adolescents would be 50%, a margin error of 5% and confidence intervals of 95%.

Sampling technique

A cross-sectional study was carried out, from June to November 2016, among adolescents living in Maasai population areas of Monduli and Longido districts, Arusha region in the Northern part of Tanzania. A list of all primary schools comprising public (urban and rural) and private schools (total of 100 schools) from both districts was obtained from the district education department. From this list all urban and private primary schools were excluded, leaving 66 eligible rural public primary schools (38 schools from Monduli and 28 from Longido district) for the sample frame. Urban and private schools were excluded because our main aim was to capture a maximum number of adolescents from pastoral societies living in remote rural areas and the majority of them cannot afford to attend private schools as they are very expensive. Out of these 66 schools, 23 schools were randomly selected (13 from Monduli and 10 from Longido) using a one-stage cluster sample

design with schools as the primary sampling unit and random number generator software. From each randomly selected school a class expected to contain adolescents aged 12–14 years was identified (grade 6). All pupils in the selected classes meeting the inclusion criteria for age were invited to participate in the study. Further details of the sampling procedure has been described elsewhere [28].

Interview

In this paper, some of the methods used have been described in our previous work [28]. Trained medical nurses, native of the study area, who spoke both Swahili and Maasai language fluently, performed a face- to- face interview with each participant at school outside or inside the classroom, depending on availability. The participants were interviewed using a questionnaire with closed- and open-ended questions. The questions were constructed in English, translated into Swahili and back-translated to English independently by qualified translators from the University of Dar Es Salaam, Tanzania. A pilot study ($n = 50$, age 12–14), testing the interview schedule, took place before the actual fieldwork regarding wording, meaning, and content on each item, and appropriateness of format. Participants of this pre-testing were not included in the main study [28].

Socio-demographic factors were assessed in terms of district of residence, age, sex, ethnicity, wealth index and mother's education. Details of the assessment of sociodemographic factors have been described elsewhere [28]. Wealth index was assessed by asking the presence/absence of durable household assets indicative of family wealth (i.e. radio, television, refrigerator, mobile telephone, cupboard, bicycle and motorcycle) was recorded as (Yes) "available and in working condition" or (No) "not available and/or not in working condition." Oral health related behaviors were assessed in terms of dietary habits, oral hygiene practices, alcohol, tobacco use, dental service utilization, sources of fluoride ingestion and use of teeth in their daily activities. Dietary habits were assessed by asking *"How often do you eat" a particular type of food* e.g. *sweets, biscuits, sugar, honey, maize stiff porridge, rice, cassava, sweet potatoes, Irish potatoes, meat, boiled blood, beans, fish, groundnuts* and *"How often do you drink" a particular type of drink* e.g. *carbonated soft drink, fruit drink, water plain, water with sugar, tea plain, tea with sugar, blood from animals, fresh milk from animals and soured milk?* Oral hygiene practice was assessed by asking two questions: *"How often do you clean your teeth"* and *"Do you use toothpaste during tooth cleaning"?* For both the dietary habits and oral hygiene practices the response categories were 0 = never, 1 = once to several times per month, 2 = once weekly, 3 = two or more times per week and 4 = daily. During analysis, the categories were dichotomized into 0 = low frequency/at most once per week (with options 0, 1 and 2) and 1 = high frequency/at least twice per week (with options 3 and 4). The type of cleaning instrument used was assessed by asking *"What type of cleaning instrument do you most often use to clean your teeth"?* The responses were *plastic type, chewing stick, charcoal or don't have*. In logistic regression the options of charcoal and don't have were omitted due to fewer cases. The tobacco and alcohol habits were assessed by asking *"How often do you smoke/chew tobacco"* and *"How often do you drink alcohol"?* The response categories were 0 = never, 1 = once to several times per month, 2 = once weekly, 3 = two or more times per week and 4 = daily. During analysis, the categories were dichotomized into 0 = never (with option 0) and 1 = irregularly (with options 1, 2, 3 and 4). Dental services utilization was assessed by asking *"Before today, have you ever visited a dentist/dental therapist for toothache"* and *"Before today, have you ever visited a dentist/dental therapist for checkup"?* The responses were *"yes"* or *"no"*. If "*yes*", then the type of treatment that they received was requested. Source of fluoride ingestion from drinking water was assessed by asking *"Where does your family get the drinking water?"* The options were 1 = tap, 2 = well, 3 = borehole, 4 = spring, 5 = lake, 6 = river, 7 = rain water, 8 = stream. During analysis, the categories were dichotomized into 0 = tap water (with option 1) and 1 = non tap water (with options 2, 3, 4, 5, 6 and 7). In addition, we asked if their family uses magadi/masala/ginger as food additives when cooking. The options were "yes" or "no" for each item. During analysis the items were dichotomized into 0 = family do not use magadi and 1 = family uses magadi. Use of teeth in daily activities was assessed by asking *"Do you use your teeth in any habit like: nail biting, pen/pencil biting, opening soda, holding needles, chewing sticks/roots/sunflower seeds etc."?* The responses were *"yes"* or *"no"*. As described elsewhere [28], prevalence of temporomandibular disorder (TMD) was assessed by asking two validated epidemiological questions: "*Do you have pain in your temple, face, jaw or jaw joint once a week or more?"* and *"Does it hurt once a week or more when you open your mouth or chew?"* The response was either *"yes"* or *"no"* and by having a positive response to one or all of the two questions was considered affirmative to TMD diagnosis [29].

In the multiple variable logistic regression analyses, each outcome variable had two levels/categories. Oral hygiene status was dichotomized into 0 = poor oral hygiene and 1 = good oral hygiene; gingival bleeding was dichotomized into 0 = without bleeding and 1 = with bleeding; dental caries was dichotomized into DMFT = 0 and DMFT > 0 and dental fluorosis was dichotomized into 0 = TF score 0–4 and 1 = TF score 5–9. In addition,

dental erosion was dichotomized into 0 = grade 0 and 1 = grade 1–4; tooth wear was dichotomized into 0 = grade 0 and 1 = grade 1–4; and TMD was dichotomized into 0 = without TMD symptoms and 1 = with TMD symptoms.

Oral clinical examination

The principal investigator (LS) performed all clinical examinations. The participant was examined in natural day light under field conditions, sitting on a chair, outside or inside the classroom. The dentition was cleaned and dried by sterile gauze and isolated by cotton rolls, if necessary. Disposable mouth mirrors and Sickle probe (No. 23 explorer or Shepherd's hook) were used. Full report over the clinical findings has been reported elsewhere [28].

The Simplified Oral Hygiene Index (OHI-S) was used to assess the oral hygiene status [30]. This method also has been described elsewhere [28]. The scores were (0) for no plaque/calculus present, (1) for plaque or supra-gingival calculus covering not more than one third of the tooth surface, (2) for plaque or supra-gingival calculus covering more than one third but less than two thirds of the tooth surface, and (3) for plaque or supra-gingival calculus covering more than two thirds of the tooth surface.

Gingival Bleeding Index (GBI) was used to assess the gingival health [31]. Dental caries was assessed according to criteria specified by WHO, 2013 [32] and dental fluorosis by Thylstrup- Fejerskov - index (TF-index) on all buccal surfaces, except wisdoms teeth [33]. Dental erosion was partially recorded according to Johansson et al. 1996 [34] for palatal and facial surfaces of maxillary anterior teeth, and by the scale of Hasselkvist et al. [35] for grading cuppings of first molars. Tooth wear was graded as a full mouth recording of occlusal/incisal surfaces of all teeth according to Carlsson et al. 1985 [36].

Statistical analysis

The Statistical Package for Social Sciences (SPSS) for PC version 25 (IBM corporation, Armonk, NY, USA) and STATA 15.0 (Stata corporation, Lakeway drive college station, Texas, USA) were used for data analysis. Descriptive statistics were carried out, followed by bivariate analysis using cross tabulations and Pearson's chi-square statistical test. Intra-examiner concordances were examined using percentage agreement and Cohen's Kappa. Multiple variable logistic regression analyses were performed to assess associations between oral health behaviors and oral diseases/conditions whilst adjusting for potential confounding factors in terms of socio-demographics (sex, age group, district, ethnicity, wealth index and maternal education) and using odds ratio (OR) and 95% confidence intervals (CI). Oral health related behaviors, significantly associated with oral diseases/conditions in unadjusted bivariate analyses were included in the multiple logistic regression analyses. The analyses were adjusted for the cluster of school, the primary sampling unit in this study. Level for statistical significance was set to $p < 0.05$.

Results

Sample characteristics

A total of 906 adolescents attending primary school grade 6 participated in this study (response rate 91.6%). Initially, a total of 989 adolescents were invited to participate, out of which 59 (6.0%) were absent during interviewing and 24 (2.6%) were excluded during analysis because of too high or low age. The age range finally accepted for participation in the study was 12–17 years (mean age 13.4 years, SD 1.2) and 56.1% of those were females. A total of 52.9 and 47.1% of the adolescents were from Monduli and Longido districts, respectively. Among the participants, 79.6% were from the Maasai ethnic group and 20.4% from the non Maasai ethnic group. For details of sociodemographic features and oral diseases/conditions frequency distribution in the total sample see Table 1.

Reliability testing

During training for scoring of dental erosion, the inter-examiner (between LS and AKJ) Cohen's Kappa for all examined teeth during examination was 0.82. Oral clinical examination was carried out by the principal investigator (LS). Duplicate clinical examinations were carried out with 93 randomly selected participants 3 weeks apart. Intra-examiner reliability as per Cohen's Kappa value was 0.98 for DMFT, 0.87 for TF index and 0.69 for dental erosion.

Oral health related behaviors by ethnic group

As shown in Tables 2 and 3, a majority of the oral health related behaviors investigated varied significantly ($p < 0.001$) with ethnic group belongingness with the exception of eating sweets, drinking sour milk, meat consumption, use of teeth for nail biting, pencil biting, opening soda and holding needle, eating vegetables and fruits, and having a behavior of clenching and/or grinding teeth. Totals of 32.6% of the Maasai and 47.0% of the non Maasai adolescents reported high frequency of intake of biscuits. The ethnic distribution for use of plastic toothbrush and chewing sticks were respectively, 39.8% versus 74.6% ($p < 0.001$) and 53.7% versus 21.1% ($p < 0.001$) for Masaai and non-Masaai, respectively.

Oral diseases by oral health related behaviors

Socio-demographic and oral health related behaviors significantly associated with oral health outcomes in unadjusted analyses, were included as covariates in the

Table 1 Frequency distribution of sociodemographic features and oral diseases/conditions in a total sample, $N = 906$

Sociodemographic feature	Category	Frequency % (*n*)
District of residence	Monduli	52.9 (479)
	Longido	47.1 (427)
Sex	Male	43.9 (398)
	Female	56.1 (508)
Age	12–14 years	87.3 (777)
	15–17 years	12.7 (113)
Ethnicity	Maasai	79.6 (721)
	Non Maasai	20.4 (185)
Wealth Index	Most poor	48.8 (438)
	Least poor	51.2 (459)
Mother's education	Low (≤ primary school)	95.0 (861)
	High (≥ secondary school)	5.0 (45)
Oral hygiene status	Poor (OHI-S ≥ 1)	65.6 (594)
	Good (OHI-S < 1)	34.4 (312)
Gingival bleeding	Negative	59.1 (535)
	Positive	40.9 (371)
Dental caries	DMFT = 0	91.2 (826)
	DMFT > 0	8.8 (80)
Dental fluorosis	TF score 0	10.3 (93)
	TF score 1–9	89.7 (813)
Dental fluorosis	TF score 0–4	51.4 (466)
	TF score 5–9	48.6 (440)
Dental erosion	Grade 0–2	98.1 (889)
	Grade 3–4 (extending into dentine)	1.9 (17)
Dental erosion	Grade 0	70.0 (634)
	Grade 1–4	30.0 (272)
Tooth wear	Grade 0–1	83.5 (757)
	Grade 2–4 (extending into dentine)	16.5 (149)
TMD pain	No	88.2 (799)
	Yes	11.8 (107)

multiple variable logistic regression. Tables 4, 5, 6 and 7 depicts unadjusted frequency distributions and the ORs and 95% CI for oral hygiene, gingival bleeding, caries experience, dental fluorosis, dental erosion, tooth wear and TMD by oral health related behaviors whilst adjusted for sociodemographic characteristics.

As shown in Table 4, frequency of tooth cleaning was statistically significantly associated with oral hygiene status, whereas frequency of tooth cleaning and type of toothbrush were significantly associated with gingival bleeding both in bivariate and multiple variable logistic regression analyses. As compared to adolescents reporting high frequency of tooth cleaning, those who reported low frequency were significantly more likely to present with poor oral hygiene status. The corresponding OR was 10.0 (95% CI 4.3–20.0). Adjusted ORs for presenting with gingival bleeding were 0.1 (95% CI 0.04–0.14) if reporting high versus low frequency of tooth cleaning and 0.7 (95% CI 0.53–0.99) if reporting use of plastic toothbrush versus chewing stick.

Frequency of eating biscuits was the only behavior that was significantly associated with caries experience in both unadjusted and adjusted analyses. As compared to adolescents reporting low frequency of intake, their counterparts who reported high intake frequency were 2.5 times (OR 2.5, 95% CI 1.7–3.8) more likely to present with DMFT > 0 after having adjusted for socio-demographic characteristics. Those who reported use of magadi, compared to those who did not, were more likely to present with dental fluorosis (TF 5–9, OR 24.2 (95% CI 11.6–50.6). For more details see Table 5.

Table 2 Frequency distribution of oral health related behaviors (dietary and oral hygiene) overall and by ethnic groups

Variable	Overall ($N = 906$) % (n)	Maasai ($n = 721$) % (n)	non Maasai ($n = 185$) % (n)	p-value*
Frequency of: Eating sweets				
Low (≤1per week)	60.8 (551)	62.4 (450)	54.6 (101)	
High (≥2 per week or daily)	39.2 (355)	37.6 (271)	45.4 (84)	0.052
Eating biscuits				
Low (≤1per week)	64.5 (584)	67.4 (486)	53.0 (98)	
High (≥2 per week or daily)	35.5 (322)	32.6 (235)	47.0 (87)	< 0.001
Drinking carbonated soft drinks				
Low (≤1per week)	66.3 (601)	70.2 (506)	51.4 (95)	
High (≥2 per week or daily)	33.7 (305)	29.8 (215)	48.6 (90)	< 0.001
Drinking fruit drink				
Low (≤1per week)	68.7 (622)	71.8 (518)	56.2 (104)	
High (≥2 per week or daily)	31.3 (284)	28.2 (203)	43.8 (81)	< 0.001
Drinking tea with sugar				
Low (≤1per week)	21.7 (197)	24.7 (178)	10.3 (19)	
High (≥2 per week or daily)	78.3 (709)	75.3 (543)	89.7 (166)	< 0.001
Drinking tea without sugar				
Low (≤1per week)	88.7 (804)	87.5 (631)	93.5 (173)	
High (≥2 per week or daily)	11.3 (102)	12.5 (90)	6.5 (12)	0.021
Drinking milk from cows				
Low (≤1per week)	17.9 (162)	14.1 (102)	32.4 (60)	
High (≥2 per week or daily)	82.1 (744)	85.9 (619)	67.6 (125)	< 0.001
Drinking soured milk				
Low (≤1per week)	41.7 (378)	41.5 (299)	42.7 (79)	
High (≥2 per week or daily)	58.3 (528)	58.5 (422)	57.3 (106)	0.762
Eating meat				
Low (≤1per week)	55.4 (502)	56.7 (409)	50.3 (93)	
High (≥2 per week or daily)	44.6 (404)	43.3 (312)	49.7 (92)	0.115
Cleaning teeth				
Low (≤1per week)	24.6 (223)	27.2 (196)	14.6 (27)	
High (≥2 per week or daily)	75.4 (683)	72.8 (525)	85.4 (158)	< 0.001
Using toothpaste				
Low (≤1per week)	62.4 (565)	69.6 (502)	34.1 (63)	
High (≥2 per week or daily)	37.6 (341)	30.4 (219)	65.9 (122)	< 0.001
Type of tooth brush				
Plastic	46.9 (425)	39.8 (287)	74.6 (138)	
Chewing stick	47.0 (426)	53.7 (387)	21.1 (39)	
Charcoal	0.7 (6)	0.8 (6)	0.0 (0)	
Don't have	5.4 (49)	5.7 (41)	4.3 (8)	< 0.001

*Pearson's Chi-square teik

In the adjusted regression analyses (Table 6), those who reported high frequency of intake of carbonated soft drinks (OR = 1.6, 95% CI 1.1–2.5) and cleaning teeth (OR = 1.7, 95% CI 1.2–2.6), were more likely to present with dental erosion. Biting nails (OR = 1.9, 95% CI 1.4–2.4), using teeth for opening soda and holding needles (OR = 1.8, 95% CI 1.4–2.4 and OR = 1.6, 95% CI 1.3–2.1, respectively), and using chewing stick type (OR = 1.7, 95% CI 1.3–2.5) were significantly associated to increased severity of tooth wear.

Adolescents who reported clenching and/or grinding teeth (OR = 2.3, 95% CI 1.5–3.7) were more likely to

Table 3 Frequency distribution of oral health related behaviors (dental fluorosis, daily use of teeth as tool and TMD) overall and by ethnic groups

Variable	Overall ($N = 906$) % (n)	Maasai ($n = 721$) %(n)	Non Maasai ($n = 185$) %(n)	p-value*
Source of drinking water				
Tap water	56.7 (514)	49.8 (359)	83.8 (155)	
Non tap water	43.3 (392)	50.2 (362)	16.2 (30)	0.001
Family uses magadi				
No	59.9 (483)	57.7 (374)	69.0 (109)	
Yes	40.1 (323)	42.3 (274)	31.0 (49)	0.010
Do you use teeth for nail biting?				
No	54.9 (497)	55.9 (403)	50.8 (94)	
Yes	45.1 (409)	44.1 (318)	49.2 (91)	0.215
Do you use teeth for pen/pencil biting?				
No	58.1 (526)	58.9 (425)	54.6 (101)	
Yes	41.9 (380)	41.1 (296)	45.4 (81)	0.285
Do you use teeth for opening soda?				
No	48.2 (437)	48.1 (347)	48.6 (90)	
Yes	51.8 (469)	51.9 (374)	51.4 (95)	0.899
Do you use teeth for holding needle?				
No	57.9 (525)	57.6 (415)	59.5 (110)	
Yes	42.1 (381)	42.4 (306)	40.5 (75)	0.640
Do you use teeth for chewing sticks?				
No	57.1 (517)	55.2 (398)	64.3 (119)	
Yes	42.9 (389)	44.8 (323)	35.7 (66)	0.025
Do you use teeth for chewing roots?				
No	61.0 (553)	56.7 (409)	77.8 (144)	
Yes	39.0 (353)	43.3 (312)	22.2 (41)	< 0.001
Do you use teeth for chewing sunflower?				
No	57.3 (519)	58.9 (425)	50.8 (94)	
Yes	42.7 (387)	41.1 (296)	49.2 (91)	0.046
Do you eat vegetables?				
No	11.5 (104)	11.8 (85)	10.3 (19)	
Yes	88.5 (802)	88.2 (636)	89.7 (166)	0.563
Do you eat fruits				
No	4.6 (42)	5.0 (36)	3.2 (6)	
Yes	95.4 (864)	95.0 (685)	96.8 (179)	0.313
Do you clench or grind your teeth?				
No	64.8 (587)	64.8 (467)	64.9 (120)	
Yes	19.1 (173)	19.0 (137)	19.5 (36)	
I don't know	16.1 (146)	16.2 (117)	15.7 (29)	0.978

*Pearson's Chi-square test

present with TMD pain compared to those who did not (Table 7).

Discussion

This study aimed to explore the association between oral health related behavior and oral diseases in adolescents living in Maasai population areas of Tanzania. As earlier reported, poor oral hygiene, gingival bleeding and dental fluorosis were common findings among this group of adolescents while dental caries, dental erosion, tooth wear and TMD symptoms were less common. Ethnic disparities predominated with respect to gingival bleeding,

Table 4 Oral hygiene status and gingival bleeding according to oral health related behaviors. Unadjusted a Chi square and adjusted multiple variable logistic regression analyses

Dependent variable	Independent variables	Unadjusted analysis % (*n*)	Adjusted OR (95% CI)[a]
Oral hygiene status (poor hygiene)	Frequency of cleaning teeth		
	High (≥2 per week or daily)	56.4 (385)	1
	Low (≤1per week)	93.7 (209)*	10.0 (4.3–20.0)
	Type of cleaning instrument		
	Chewing stick	67.6 (288)	1
	Plastic	60.2 (256)*	0.9 (0.7–1.3)
Gingival bleeding (Yes)	Frequency of cleaning teeth		
	Low (≤1per week)	84.3 (188)	1
	High (≥2 per week or daily)	26.8 (183)*	0.1 (0.04–0.14)
	Type of cleaning instrument		
	Chewing stick	45.5 (194)	1
	Plastic	31.8 (135)*	0.7 (0.53–0.99)

*Significant Pearson Chi-square test ($p < 0.05$)
[a]Multiple variable logistic regression analyses were adjusted for sex, age and ethnicity

dental caries and dental erosion [28]. In this study, there was a significant difference in some oral health related behavior between the Maasai and non Maasai groups. Low frequency of oral hygiene practices was associated with poor oral hygiene. High frequency of cleaning teeth and the use of plastic type of tooth brush were associated with less gingival bleeding. High consumption of biscuits was associated with presence of dental caries and the use of magadi as a food additive was associated with severe dental fluorosis (TF grade 5–9). Regular intake of carbonated soft drinks and regular tooth cleaning were covariates for dental erosion. Using teeth as a tool as for: biting nails, opening soda and holding needles were independently associated with tooth wear.

Table 5 Dental caries experience and dental fluorosis according to oral health related behaviors. Unadjusted Chi square and adjusted multiple variable logistic regression analyses

Dependent variable	Independent variables	Unadjusted analysis % (*n*)	Adjusted OR (95% CI)[a]
Dental caries experience (DMFT> 0)	Frequency of eating biscuits		
	Low (≤1per week)	5.8 (34)	1
	High (≥2 per week or daily)	14.3 (46)*	2.5 (1.7–3.8)
	Frequency of drinking tea with sugar		
	Low (≤1per week)	9.6 (19)	
	High (≥2 per week or daily)	8.6 (61)	
	Frequency of drinking milk from cows		
	Low (≤1per week)	5.6 (9)	
	High (≥2 per week or daily)	9.5 (71)	
	Frequency of tooth cleaning		
	Low (≤1per week)	9.0 (20)	
	High (≥2 per week or daily)	8.8 (60)	
Dental fluorosis (TF grade 5–9)	Source of drinking water		
	Tap water	41.2 (212)	1
	Non tap water	58.2 (228)*	1.3 (0.6–2.8)
	Family uses magadi		
	No	24.4 (118)	1
	Yes	90.4 (292)*	24.2 (11.6–50.6)

*Significant Pearson Chi-square test ($p < 0.05$)
[a]logistic regression analyses adjusted for district of residence, age and ethnicity

Table 6 Dental erosion and tooth wear according to oral health related behaviors. Unadjusted a Chi square and adjusted multiple variable logistic regression analyses

Dependent variable	Independent variables	Unadjusted analysis % (*n*)	Adjusted OR (95% CI)[a]
Dental erosion (grade 1–4)	Frequency of drinking carbonated soft drinks		
	Low(≤ once per week)	23.1 (139)	1
	High (≥ twice per week)	44.3 (135)*	1.6 (1.1–2.5)
	Frequency of drinking fruit drink		
	Low(≤ once per week)	24.0 (149)	1
	High (≥ twice per week)	44.0 (125)*	1.5 (1.0–2.2)
	Frequency of drinking milk from cows		
	Low (≤1per week)	35.8 (58)	1
	High (≥2 per week or daily)	29.0 (216)*	0.7 (0.5–1.0)
	Eating meat		
	Low (≤1per week)	25.3 (127)	1
	High (≥2 per week or daily)	36.4 (147)*	1.3 (0.9–2.0)
	Frequency of cleaning teeth		
	Low (≤1per week)	19.7 (44)	1
	High (≥2 per week or daily)	33.7 (230)*	1.7 (1.1–2.6)
	Frequency of using tooth paste		
	Low(≤ once per week)	25.5 (144)	1
	High (≥ 2x per week)	38.1 (130)*	1.1 (0.7–1.8)
Tooth wear (Grade 1–4)	Frequency of drinking carbonated soft drinks		
	Low(≤ once per week)	46.3 (278)	
	High (≥ twice per week)	45.6 (139)	
	Frequency of drinking fruit drink		
	Low(≤ once per week)	46.9 (292)	
	High (≥ twice per week)	44.0 (125)	
	Frequency of drinking milk from cows		
	Low (≤1per week)	50.0 (81)	
	High (≥2 per week or daily)	45.2 (336)	
	Frequency of cleaning teeth		
	Low (≤1per week)	51.1 (114)	1
	High (≥2 per week or daily)	44.4 (303)*	0.8 (0.6–1.1)
	Type of cleaning instrument		
	Chewing stick	50.9 (217)	1
	Plastic	40.7 (173)*	0.6 (0.4–0.8)
	Frequency of using tooth paste		
	Low(≤ once per week)	46.5 (263)	
	High (≥ 2x per week)	45.2 (154)	
	Uses teeth for nail biting		
	No	35.8 (178)	1
	Yes	58.4 (239)*	1.9 (1.4–2.4)
	Uses teeth for pen/pencil biting		
	No	41.4 (218)	1
	Yes	52.4 (199)*	0.9 (0.6–1.3)
	Uses teeth for opening soda		

Table 6 Dental erosion and tooth wear according to oral health related behaviors. Unadjusted a Chi square and adjusted multiple variable logistic regression analyses *(Continued)*

Dependent variable	Independent variables	Unadjusted analysis % (*n*)	Adjusted OR (95% CI)[a]
	No	35.9 (157)*	1
	Yes	55.4 (260)	1.8 (1.4–2.4)
	Uses teeth for holding needles		
	No	38.1 (200)	1
	Yes	57.0 (217)*	1.6 (1.3–2.1)
	Uses teeth for chewing sunflower seeds		
	No	42.6 (221)*	1
	Yes	50.6 (196)	1.0 (0.8–1.3)

*Significant Pearson Chi-square test ($p < 0.05$)
[a] Multiple variable logistic regression analyses were adjusted for ethnicity, maternal education and wealth index

Adolescents who reported to clench/grind their teeth was the only covariate for TMD.

Consistent with previous studies, low frequency of oral hygiene practices associated with poor oral hygiene and a high frequency of oral hygiene practices associated with less gingival bleeding [37, 38]. In addition a high frequency of intake of biscuits and carbonated soft drinks was associated with dental caries (DMFT> 0) and dental erosion, respectively [35, 39]. Not surprisingly, those who reported to clean their teeth less often, had poorer oral hygiene status and more gingival bleeding compared to those who cleaned more often [40]. But, although > 75% of the adolescents reported a high frequency of tooth cleaning, the majority of them (66%) had poor oral hygiene status. This imply that cleaning teeth twice to daily a week is not enough and/or that an ineffective cleaning technique was utilized or maybe there was over reporting of the frequency of oral hygiene habits.

In this study, the use of a wooden chewing stick (47%) was less common than previous reports from rural areas of Kenya (59%, 5–17 year olds) and Burkina Faso (64%, 12 year olds), but more common than reports from the rural areas of Tanzania (4–36%,5–22 year olds) [41–44]. On the other side, the use of a plastic tooth brush in this study (47%) was more common than reports from Kenya (41%) and Burkina Faso (36%) [43, 44], but less common than earlier reports from Tanzania (64–96%) [41, 42]. In this study, the use of a plastic tooth brush was correlated with less gingival bleeding. This finding is contrary to an earlier report from India where it was shown that there were no significant difference between the use of a chewing stick or a plastic toothbrush on gingival health [45]. Regarding ethnicity there was a significant difference between the ethnic groups in this study in terms of oral hygiene behavior. Compared to non Maasai group, the Maasai group reported to clean their teeth more irregularly and reported to use chewing sticks for cleaning teeth more regularly. The more common use of chewing sticks than plastic toothbrushes among the Masaai in this study might be a result of availability and economic considerations. In this regard, our previous report

Table 7 TMD pain according to oral health related behaviors. Unadjusted a Chi square and adjusted multiple variable logistic regression analyses

Dependent variable	Independent variables	Unadjusted analysis % (n)	Adjusted OR (95% CI)[a]
TMD (2Q/TMD > 0)[b]	Eating vegetables		
	No	13.5 (14)	
	Yes	11.6 (93)	
	Eating fruits		
	No	9.5 (4)	
	Yes	11.9 (103)	
	Do you clench or grind your teeth?		
	No	9.0 (53)	1
	Yes	23.1 (40)*	2.3 (1.5–3.7)

*Significant Pearson Chi-square test ($p < 0.05$)
[a] Multiple variable logistic regression analyses were adjusted for district of residence, ethnicity and mother's education
[b] Two epidemiological questions regarding TMD

showed that the Maasai adolescents in this study were from more poor families compared to the non Maasais in terms of wealth index [28].

The low prevalence of dental caries found in this study (8.8%) [28] imply a low exposure to cariogenic diet, which is supported by the findings in this study where the majority (60.8–64.5%) of adolescents reported low intake of sweets and biscuits. The traditional diet for the Maasais is consisting of dairy products such as milk but also meat and blood from cattles, products with low cariogenic potential [46]. In this study, 82.1% of the adolescents reported high frequency of drinking fresh milk and this might have contributed to the low prevalence of dental caries among the adolescents [47]. In addition, a high fluoride content in their drinking water and using Magadi as food additive [48] may also have reduced their risk for dental caries [49]. Considering ethnicity, more adolescents from Maasai group (85.9%) reported regular intake of fresh milk from cows and regular intake of magadi as food additives compared to non Maasais. Probably due to this, it is therefore not surprising to find that more Maasais were less affected by dental caries compared to non Maasais [28].

In this study a correlation between severe dental fluorosis and the use of Magadi as food additive was found, similar to other studies [11, 50]. It is known that Magadi from Tanzania contain a high concentration of fluoride (160 to 1750 mg/l) [51]. The Maasai group reported the use of Magadi more often than the non Maasais which may be one explanation for their higher prevalence and severity of dental fluorosis [28].

Probably the rural environment and poor economic situation in which study participants live might limit their access to erosive conducive challenges. But even so, about one third of all study participants reported to drink carbonated soft drinks and/or fruit juices regularly. Our previous study [28] revealed low prevalence (1.9%) of dental erosion extending into dentine and there was a significant association between high frequency intake of carbonated soft drinks and dental erosion in this study, similar to others [35, 52]. This study revealed also, in agreement with previous reports, an association between dental erosion and oral hygiene [53, 54]. In this regard, the Maasai adolescents reported significantly lesser teeth cleaning and use of toothpaste than non Maasais. Subsequently, the difference in dietary habits between the two ethnic groups in addition to more irregular oral hygiene practices may also explain why Maasais were less affected by dental erosion compared to non Maasais [28].

The severity and pattern of tooth wear could be influenced not only by acidic challenges such as soft drinks but also factors like abrasiveness of the diet, parafunctional habits and/or the use of teeth as tools [55, 56]. Foods consumed in this society might often be hard and abrasive in nature, especially meat, since it is often mixed with ashes in the process of cooking and eaten when half cooked making it more abrasive to chew. The relative frequent intake of acidic drinks among the participants may also contribute to a worsening of the abrasive effect, resulting in more severe tooth wear [35]. About 45% of the study participants reported to use teeth for biting nails and 52% reported to use teeth for opening soda bottles. The excessive biting force required for exercising these habits and the abrasiveness of the material involved in the practice could also have contributed to relatively high prevalence of tooth wear. However, the tooth wear process has a multifactorial etiology and other not investigated factors may have played a role as well [55].

This study found that self-reported bruxism was associated with TMD similar with previous reports [57, 58]. Although previous reports have revealed that self-reported bruxism is associated with TMD, reports based on polysomnography (PSG) studies on sleep bruxism have not [59, 60]. In this study, other parafunctional habits apart from bruxism, were not associated with development of TMD similar to previous reports [61].

A clear majority (about 95%) of the adolescents in this study had never visited a dentist/dental therapist for toothache or checkup. The low dental service utilization indicates a need of actions that could facilitate access to these services. Oral health education is an essential and basic part of dental health care services as it provides information empowering people to raise awareness leading to the adoption of healthier lifestyles, positive attitudes and good oral health behaviors. It has been reported that oral health education is a powerful and successful tool in promoting oral health in adolescents [62] and that school provides a good setting for health-education programs [63]. In sub Saharan Africa, the health technology assessment (HTA) reports is scarce due to lack of capacity to undertake HTA and lack of high-quality data and lack of research evidence [64]. However, HTA reports from WHO suggests that structured research methodology and transparent and health procedures, including preventive intervention, helps to obtain information for evaluation of safety, cost-effectiveness, quality, and efficiency dimensions of such techniques when used in the health systems [65].

The strengths with the present study are the random sampling of the primary sampling units (schools), which may permit the generalization of the results to the communities living in Maasai populated areas. Using the research assistants fluent in both Swahili and Maasai language to interview the adolescents ensured that the interviewee had understood the question. In addition, one examiner performed the clinical examinations of all children thus reducing any inter-examiner variability. On the other side, using one examiner only may lead to

introduction of observer effect bias where the observer may influence the participants of the study. Also it can lead to confirmation bias whereby the experinmenter interprets the results incorrectly because of the tendency to look for information that conforms to their hypothesis, and overlook information that argues against it [66]. However, since most of the background factors, such as dietary habits were based on self-report, it is always a possibility that the child might have misunderstood the question, forgotten or that the response might be influenced by social desirability. The cross-sectional method was utilized in data collection, making difficulties in establishing a causal relationship.

Conclusion

Oral health related behaviors have a significant impact on oral diseases/conditions among adolescents attending primary schools in Maasai population areas with obvious differences in behavior between the Maasai and non Maasai ethnic groups. There is a need for addressing oral health and to encourage behaviors that promote good oral health and dental care service utilization in this society.

Abbreviations

CI: Confidence Interval; DMFT: Decayed Missing Filled Tooth; GBI: Gingival Bleeding Index; HTA: Health Technology Assessment; OHI-S: Simplified Oral Hygiene Index; OR: Odds Ratio; SD: Standard Deviation; SPSS: Statistical Package for Social Sciences; TF-index: Thylstrup-Fejerskov-index; TMD: Temporomandibular Disorder; WHO: World Health Organisation

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Authors' contributions

LS: principal investigator, designed the study, collected the data, performed the statistical analyses, and wrote the manuscript. ANA: co-supervisor, designed the study, guided the statistical analyses and writing the manuscript. AJ: participated in the design of the study, guided the statistical analyses and writing the manuscript. IK: co-supervisor, participated in the design of the study and provided valuable guidance in the data collection and writing the manuscript. AKJ: main supervisor, designed the study, guided the statistical analyses and writing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

Ethics approval and consent to participate

Prior to study implementation, ethical clearance from, the ethical research committee in Norway (REK VEST, reference number **2015/2477**) and the Medical Research Coordinating Committee of Ministry of Health and Social Welfare in Tanzania (reference number **NIMR/HQ/R.8a/VOL.IX/2214**) were obtained. Permission to work with primary school adolescents was obtained from Ministry of Education and Vocational Training through Monduli and Longido district councils, their respective educational authorities, school teachers and parents. Informed written signed consent was obtained from the parents. Besides this the participating adolescents gave an assent. Confidentiality was ensured and participants were allowed to walk out of the study for whatever reason.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Publisher's Note

Paper III

Oral Impacts on Daily Performances and its socio-demographic and clinical distribution: A cross-sectional study in adolescents living in Maasai population areas, Tanzania

Simangwa LD, Johansson AK, Johansson A, Minja IK and Åstrøm AN.

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Health and Quality of Life Outcomes

RESEARCH Open Access

Oral impacts on daily performances and its socio-demographic and clinical distribution: a cross-sectional study of adolescents living in Maasai population areas, Tanzania

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Abstract

Background: In a global perspective, oral health among adolescents has improved during recent decades. However, oral problems still persist especially in many underprivileged societies. This study aimed to estimate the prevalence of oral impacts in adolescents and to identify important clinical- and socio-demographic covariates. In addition, this study compares Maasai and non-Maasai adolescents regarding any association of socio-demographic and clinical covariates with oral impacts on daily performances.

Methods: A total of 989 adolescents were invited from 23 randomly selected public primary schools in Monduli and Longido districts, Tanzania. All adolescents attending 6th grade classes were invited to participate. A total of 930 accepted and of those 24 were excluded, leaving 906 (91.6%) participants for the study.

Results: A total of 143/906 (15.8%) had at-least one oral impact on daily performances (OIDP > 0), 14.6% among the Maasai and 20.5% among the non-Maasai ethnic group. Cluster adjusted logistic regression revealed that: adolescents from Longido district (OR = 0.4) and adolescents with good oral hygiene (OR = 0.7) were less likely to report OIDP> 0 and; non Maasai (OR = 1.6), those with least poor parents (OR = 2.0), DMFT> 0 (OR = 3.1) and those with positive answers to questions regarding TMD pain, 2Q/TMD > 0 (OR = 3.9) were more likely to report OIDP> 0. Stratified logistic regression by ethnicity revealed that, among the non-Maasais, older adolescents (OR = 3.7, 95% CI 1.1–12.8), those with DMFT> 0 (OR = 3.3 (1.2–9.0) and 2Q/TMD > 0 (OR = 9.0, 95% CI 3.3–25.0) were more likely to report at least one OIDP. The corresponding figures among the Maasais were (OR = 0.9, 95% CI 0.5–1.7), (OR = 2.8, 95% CI 1.4–5.5) and (OR = 3.0, 95% CI 1.7–5.2), respectively.

(Continued on next page)

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(Continued from previous page)
Conclusions: The prevalence of oral impacts was moderate but higher among the non-Maasai- than Maasai-adolescents attending rural primary schools in the Maasai population areas of Tanzania. This study also confirmed socioeconomic and oral clinical disparities in OIDP, some of which differed according to ethnicity. Caries experience and self-reported TMD pain associated more strongly with OIDP among the non-Maasais than among the Maasais. These results are important for public oral health decision makers who plan strategies for optimal primary oral health care and quality of life among adolescents belonging to minority groups in Tanzania.

Keywords: Adolescents, Maasai population areas, Oral diseases, Oral impacts on daily performance, And sociodemographic factors

Background

In a global perspective, oral health among adolescents has improved during recent decades. However, oral diseases like dental caries and erosion as well as dental fluorosis and periodontal diseases still prevail in certain groups and particularly so in underprivileged societies [1–3]. Studies have confirmed that oral diseases have a negative impact on the quality of life and well-being of adolescents [4–6]. Evidence suggests a gap between professional and subjective evaluations of oral health, possible affecting for example treatment need [7].

Recognizing the growing importance of quality of life measures in health care, oral health related quality of life (OHRQoL) inventories are available to address functional, psychological and social consequences of oral diseases and also to complement clinical measures and evaluate treatment outcomes [8–10]. Adulyanon et al. [11] developed the Oral impact on daily performance (OIDP) inventory, one of the most commonly used OHRQoL instruments, to be used either as a generic or a disease specific measure of oral health related quality of life. The OIDP inventory is based on the conceptual framework of the World Health Organization's International Classification of Impairments, Disabilities and Handicaps, ICIDH [12], and has been amended for use in dentistry by Locker [13]. This inventory covers the ultimate disability and handicap dimensions in the ICIDH model and includes 8 items assessing physical, psychological, and social dimensions of daily living [11]. Two versions of the OIDP inventory have been applied in the literature, one for adults and another one for children and adolescents. The Child OIDP was developed to fit children's cognitive stage of development and was initially tested among 11–12 year old school children in Thailand [14]. This inventory has been widely applied across low and high-income countries [15–17] and has shown acceptable psychometric properties when applied to adolescent populations globally [6, 15, 18].

However, its application in minority groups, such as the Maasai, is scarce although indigenous populations around the world experience disproportionate burden of oral diseases and conditions [16]. Moreover, the clinical and socio-demographic distribution of OIDP have not been investigated to the same extent in adolescents as in adults [17]. Thus, information of the performance of OHRQoL instruments across socio-cultural minority groups within and across countries has been requested [6].

The Maasai is a unique and popular tribe due to their long preserved culture. Despite education, civilization and western cultural influences, the Maasai people have clung to their traditional way of life [19]. In Tanzania, The Maasais are considered socially disadvantaged because the Maasai reside in a semi-arid ecology prone to erratic rainfall and periodic drought [20]. Such vulnerability may lead to high food insecurity and poor health outcomes [21]. In addition, the Maasai communities tend to live in remote rural areas and also have a relatively poor command of Swahili, the national language of Tanzania. These factors decrease opportunities for obtaining good health services and educational attainment and might thus affect their well-being and quality of life [22].

To the best of our knowledge, no retrievable data/information considers evaluation of OHRQoL in adolescents living in Maasai populated areas of Tanzania. Focusing on Maasai and non-Maasai adolescents and using the Child OIDP inventory, this study aimed to estimate the prevalence of oral impacts and to identify important clinical- and socio-demographic covariates. In addition, this study compares Maasai and non-Maasai adolescents regarding any association of socio-demographic and clinical covariates with oral impacts on daily performances.

Methods

Study design and participants

A cross-sectional study was conducted among 12–14-year-old adolescents in Maasai populated areas of Monduli and Longido districts, in the Arusha region, Tanzania, from June to November 2016. A list of all primary schools was obtained from both districts (including 100 schools). Urban and private schools were excluded due to the reason that the majority of Maasais live in rural remote areas and are relatively poor and therefore

won't be able to bring their children in private schools which are relatively expensive. The inclusion criteria were therefore, the adolescents expected to be in age ranging from 12 to 14 year old attending rural public primary schools of Monduli and Longido districts. The exclusion criteria were adolescents attending urban and private primary schools, those who were absent during the interview/oral examination day and those with difficulties in learning. After excluding urban and private schools, 23 (13 from Monduli and 10 from Longido) from a total of 66 (38 from Monduli and 28 from Longido), eligible rural public primary schools were randomly selected using a one-stage cluster sample design with school as the primary sampling unit. A class expected to contain adolescents aged 12–14 years was identified (6th grade) in each selected school. All adolescents available in the identified classes were invited to participate. The sample size was estimated based on the assumption that the prevalence of dental erosion among adolescents was 50%. The estimated minimum sample size for this study, 845 adolescents was obtained by assuming a margin error of 5% and, confidence intervals of 95%. Details about the sampling technique have been described elsewhere [23]. Thus, in this study, we did a secondary analysis of a study planned for other purposes. Briefly, we invited a total of 989 adolescents to participate in the study and 930 of them accepted this invitation. The final sample included 906 adolescents after having excluded 24 due to too low or high age, giving a response rate of 91.6%.

Interview and questionnaires

Closed- and open-ended questions were used to assess information in face- to- face interviews. The interview schedule was constructed in English, translated into Swahili and back-translated to English independently by qualified translators from the University of Dar Es Salaam, Tanzania. A pilot test was performed with a group of 50 adolescents aged 12–14 years who were not included in the main study. Two trained medical nurses performed face-to-face interviews in Swahili/Maa (Maasai language) in a school setting. Each adolescent was interviewed separately, inside a classroom or outside the classroom (under a tree), in order to achieve privacy.

Socio-demographic factors were assessed in terms of age, ethnicity, sex, place of residence, mother's education, household socio-economic status (perceived affluence of my household) and household wealth index [24]. Ethnicity was assessed by asking "what is your ethnic group?" During analysis, the response ethnical categories 1 = Maasai, 2 = Meru, 3 = Arusha and 4 = others were dichotomized to 1 = Maasai (from option 1) and 2 = non-Maasai (from option 2, 3 and 4). Parents' education was assessed by asking *what is the highest level of school your mother/father has attended?* Response categories were (0) none, (1) she/he started but did not complete primary school, (2) completed primary school (3) she/he started but did not complete secondary school, (4) she/he completed secondary school, (5) she/he started but did not complete college/university, (6) completed college/university, (7) I don't know. For analyses, the options were dichotomized as (0) for low education (from options 0, 1, 2, 3 and 7) and (1) for high education (from options 4, 5 and 6). The wealth index was constructed by assessing the presence of durable household assets which indicate family wealth (i.e. radio, television, refrigerator, mobile telephone, cupboard, bicycle and motorcycle). These were recorded as (Yes) "available and in working condition" or (No) "not available and/or not in working condition" and then the principle component analysis (PCA) method was used to construct a wealth index [24]. Using the first component, we categorized the wealth index into 1st quartile, 2nd quartile, 3rd quartile and 4th quartile implying the poorest, poorer, less poor and least poor, respectively. The wealth index is a measure of a household's cumulative living standard, usually calculated by summing up data on a household's ownership of selected assets. PCA works best when the household asset variables are correlated to each other and when the distribution of variables varies across the households. It is those assets that are more unequally distributed between households that are given more weight [25]. For example, assets owned by majority of households would exhibit no variation between households and would be zero weighted and thus of no use in differentiating the wealth of a particular family. Therefore in our study we excluded some of the assets eg animals they had due to the reason that they were owned by majority of communities.

Oral health related quality of life was measured using a Kiswahili (Tanzania national language) version of the eight item Child OIDP inventory, previously shown to be reliable and valid when applied to adolescents in Tanzania [6]. The Child OIDP frequency index referred to difficulty carrying out eight daily life activities *"During the past 3 months, how often have problems with your mouth or teeth caused you any difficulty with; eating and enjoying food, speaking and pronouncing clearly, cleaning teeth, sleeping and relaxing, smiling and laughing, emotional status, socialization and contact with people.* The original responses were (0) never, (1) once or more a month, (2) once or more a week and (3) every day/nearly every day. In the statistical analyses, the items were dichotomized as 0 not affected (comprising original responses 0) and 1 affected (comprising original responses 1, 2 and 3). A Child-OIDP simple count (SC) score (range 0–8) was constructed by summing the dichotomized frequency items of (0) not affected and (1)

affected and subsequently dichotomized into 0 (no impacts) and 1 (at least one impact). In its original form, OIDP scores are calculated by multiplying frequency and severity scores of daily performances [26]. However, evidence suggests the use of either frequency or severity scores for reasons of simplicity and efficiency [26]. The internal consistency reliability (Cronbach's alpha based on standardized items) for the child OIDP inventory was 0.82, which is in agreement with previous figures (0.84 to 0.85) from Tanzania [5, 27]. Validity of OIDP is further confirmed in this study by associations with clinical variables in the expected direction.

The two epidemiological questions regarding temporomandibular disorder pain (2Q/TMD), were: *"Do you have pain in your temple, face, jaw or jaw joint once a week or more?"* and *"Does it hurt once a week or more when you open your mouth or chew?"* The response was either *"yes"* or *"no"* and positive answer to any of the two questions was considered affirmative to self-reported TMD pain diagnosis [28]. Thus, a positive answer to one or both of the two epidemiological questions was recorded as 2Q/TMD > 0 and a negative answer to both epidemiological questions was recorded as 2Q/TMD = 0.

Oral clinical examination

All clinical examinations were performed by the first author (LS) under natural day light with the adolescent sitting on a chair. The teeth were cleaned and dried by sterile gauze and isolated by cotton rolls. Disposable mouth mirrors and probes were used. The examiner was trained and calibrated at the Department of Clinical Dentistry, University of Bergen, Norway.

Details considering the clinical oral examination have been described elsewhere [23]. Oral hygiene was assessed using the Simplified Oral Hygiene Index (OHI-S) [29]. Plaque and calculus was assessed on teeth (16, 11, 26, 36, 31 and 46). The scores were (0) for no plaque/calculus present, (1) for plaque or supra-gingival calculus covering not more than one third of the tooth surface, (2) for plaque or supra-gingival calculus covering more than one third but less than two thirds of the tooth surface, and (3) for plaque or supra-gingival calculus covering more than two thirds of the tooth surface. For each individual, the plaque and calculus scores were summed up and divided by total number of teeth examined to obtain the Simplified Debris Index (DI-S) and simplified calculus index (CI-S). The OHI-S was constructed by summing up the DI-S and CI-S. During analysis the OHI-S scores were dichotomized into 1 = good oral hygiene (OHI-S < 1) and 2 = poor oral hygiene (OHI-S ≥ 1). Gingival health was assessed by Gingival Bleeding Index (GBI) and was recorded as positive or negative following a gentle probing on gingival sulcus of the index teeth after 10 s [30]. Dental caries was assessed according to criteria specified by WHO [31] and was recorded as 0-Sound, 1-Decayed, 2-Filled, with decay, 3-Filled, no decay, 4-Missing due to caries, 5-Missing for other reason, 6-Fissure sealant, 7-Bridge abutment, special crown or veneer/implant, 8-Unerupted tooth (crown)/unexposed root, 9-Not recorded. Dental fluorosis was assessed by Thylstrup- Fejerskov - index (TF-index) [32] and was recorded as score 0 to 9 score with score 0 – not affected and score 1–9 showing varying degree of dental fluorosis. Dental erosion on palatal and facial surfaces of maxillary anterior teeth was recorded according to Johansson et al. [33], recording as score 0 to 4, with score 0 not affected by erosion and score 1–4 affected by dental erosion at different levels. Grading of first molar cuppings by Hasselkvist et al. [34], recorded as score 0 to 4, with score 0 no cupping and score 1–4 varying degree of cuppings. Tooth wear was graded as a full mouth recording of occlusal/incisal surfaces according to Carlsson et al. [35], recorded as score 0 to 4, with score 0 no tooth wear and score 1–4 varying degree of tooth wear.

The inter-examiner (between LS and AKJ) Cohen's Kappa for dental erosion in all examined teeth surfaces was 82.4%. Duplicate clinical examinations (intra-examiner concordance), 3 weeks apart, including 93 randomly selected participants, gave a Kappa value for caries experience (DMFT> 0), dental fluorosis (TF-index) and dental erosion of 98.3, 86.8 and 69.4, respectively.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) for PC version 24 (IBM corporation, Armonk, NY, USA) was used to analyze the data. STATA 14.2 (Stata corporation, Lakeway drive college station, Texas, USA) was used to adjust for cluster effect of school. Bivariate analysis was performed by cross tabulations and Pearson's chi-square statistical test. Inter- and intra-examiner concordances were determined using percentage agreement and Cohen's Kappa. Internal consistency reliability was assessed using Cronbach's alpha. Stepwise multiple variable logistic regression analysis (Odds Ratio and 95% CI) was conducted with OIDP regressed on sociodemographic and oral clinical variables that were statistically significantly associated with OIDP in crude (unadjusted) analysis. In each step Nagelkerke's R^2 was calculated which denotes a pseudo R square that generalize the coefficient of determination with values between 0 and 1 where 0 denotes that the model do not explain anything of the variation- whereas 1 denotes a model explaining all variation in the dependent variable. The effect of two –way interaction terms between ethnic group and socio-demographic- and clinical variables on OIDP was tested to explore whether any association of socio-

demographic- and clinical variables with OIDP differed between the ethnic groups.

Results

Sample profile

A total of 906 (56.1% females), 12–17-year-old (mean age 13.4 years SD 1.2) adolescents attending grade 6 were interviewed and underwent an oral clinical examination at school. Out of these 906, 479 (52.9%) were from Monduli district, 721 (79.6%) belonged to the Maasai- and 185 (20.4%) to the non-Maasai ethnic groups. Table 1 depicts the percentage distribution of study participants' sociodemographic- and clinical characteristics in the pooled sample and according to Maasai and non-Maasai ethnicity. A majority (91.2%) of the adolescents were dental caries free (DMFT = 0) and 48.6% of the adolescents had severe dental fluorosis (TF score 5–9). A total of 11.8% of the adolescents self-reported Temporomandibular Disorder pain (2Q/TMD > 0). Most sociodemographic and clinical characteristics differed statistically significantly by ethnic group (Table 1).

OIDP by socio-demographic and oral clinical features

A total of 143/906 (15.8%) of adolescents investigated reported at-least one oral impact on daily performances (OIDP > 0). The frequency of the reported impacts was: eating and enjoying food (7.9%), speaking and pronouncing clearly (4.4%), cleaning teeth (10.5%), sleeping and relaxing (3.9%), smiling and laughing (2.0%), maintaining usual emotional state (2.1%), carrying major school work or social role (2.2%) and enjoying contact with people (2.1%) (not presented in table).

As depicted in Table 2, socio-demographic and clinical features in terms of district of residence, ethnicity and wealth index and oral hygiene status, DMFT (Decayed Missing Filled Teeth), dental fluorosis and self-reported TMD pain status associated statistically significantly with oral impacts (OIDP> 0). Oral impacts were more frequently reported by adolescents from Monduli districts than among those from Longido (21.9% versus 8.9%, $p < 0.001$). Oral impacts were most frequently reported among participants with poor oral hygiene status, caries experience (DMFT> 0) and self-reported TMD pain.

Table 3 depicts adjusted odds ratios (OR) and 95% CI for OIDP (Oral Impacts on Daily Performace) by socio-demographic features and oral diseases/problems. District of residence, sex, ethnicity and wealth index were entered in step 1, providing a model fit of Nagelkerke's $R^2 = 0.103$, Model Chi-Square = 55.407, df = 4 and $p < 0.001$. District, ethnicity, wealth index and age were statistically significantly associated with OIDP in the first step of the model. Entering oral hygiene status, DMFT> 0, dental fluorosis (TF 5–9) and 2Q/TMD > 0 in the second step improved model fit to Nagelkerke's $R^2 = 0.199$, model Chi-square = 110.178, df = 8 and $p < 0.001$. In the second step of the model, district (OR = 0.4, CI 0.3–0.7), ethnicity (OR = 1.6, CI 1.1–2.3), wealth index (OR = 2.0, CI 1.2–3.3), oral hygiene status (OR = 0.7, CI 0.5–0.9), DMFT > 0 (OR = 3.1, CI 2.1–4.5) and 2Q/TMD > 0 (OR = 3.9, CI 2.4–6.2) were significant covariates of OIDP> 0. Adjusting for cluster effect did not change the ORs, but there was a small widening of the confidence intervals, only.

Statistically significant effects of two-way interactions, occurred for ethnicity x age (OR = 4.4, 95% CI 1.7–11.3), ethnicity x dental caries (OR = 4.6, 95% CI 2.1–10.0) and ethnicity x self-reported TMD pain (OR = 8.0, 95% CI 3.6–17.8) (Table 4). As shown in Table 5, stratified logistic regression analysis by ethnic group revealed that among non-Maasais only, older adolescents were more likely than their younger aged counterparts to report at least one OIDP (OR = 3.7, 95% CI 1.1–12.8). Adolescents with (dental caries) DMFT> 0 were 2.8 (95% CI 1.4–5.5) and 3.3 (95% CI 1.2–9.0) times more likely to report oral impacts in the Maasai and non-Maasai groups, respectively. Maasai and non-Maasai adolescents with self-reported TMD pain were more likely to report oral impacts than their counterparts with no self-reported TMD pain. The corresponding OR and 95% CI were 3.0 (1.7–5.2) and 9.0 (3.3–25.0), respectively.

Discussion

This study is among the first to estimate the prevalence- and socio-demographic- and clinical covariates of oral impacts on daily performances among adolescents living in Maasai population areas of the Arusha region in Tanzania. The prevalence of OIDP was moderate and amounted to about 15 and 20% among the Maasai and non-Maasai ethnic groups, respectively. Independent of ethnic group belongingness, adolescents who were the least poor according to the wealth index utilized and those who presented with oral diseases were most likely to report oral impacts. The present findings revealed significant differences by ethnic groups in the relationships between socio-demographic- and clinical covariates and oral impacts. Older adolescents were more likely than their younger counterparts to report oral impacts among the non-Maasais only. Dental caries experience and self-reported TMD pain was significantly associated with oral impacts among both ethnic groups but more strongly among the non-Maasais than among their Maasai counterparts.

In this study, about 16% reported at least one oral impact on daily performance during the past 3 months (15% among Maasais and 20% among non-Maasais). These prevalence rates are lower than those reported previously among adolescents of similar ages in sub Saharan Africa ranging from 29 to 62% [4–6, 36]. Higher

Table 1 Frequency distribution of sociodemographic and clinical characteristics in a total sample ($n = 906$) and by ethnicity

Variable	Total % (n)	Maasai % (n)	Non-Maasai % (n)	*P-value
District of residence				
Monduli	52.9 (479)	58.0 (418)	33.0 (61)	
Longido	47.1 (427)	42.0 (303)	67.0 (124)	< 0.001
Sex				
Male	43.9 (398)	43.1 (311)	47.0 (87)	
Female	56.1 (508)	56.9 (410)	53.0 (98)	0.341
Age				
12–14 years	87.3 (777)	86.5 (610)	90.3 (167)	
15–17 years	12.7 (113)	13.5 (95)	9.7 (18)	0.173
Wealth index				
Poorest	48.8 (438)	57.3 (408)	16.2 (30)	
Least poor	51.2 (459)	42.7 (304)	83.8 (155)	< 0.001
Mother's education				
Low (≤ primary school)	861 (95.0)	96.8 (698)	88.1 (163)	
High (≥ secondary school)	45 (5.0)	3.2 (23)	11.9 (22)	< 0.001
Oral hygiene status				
Poor	65.6 (594)	68.5 (508)	54.1 (100)	
Good	34.4 (312)	31.5 (213)	45.9 (85)	< 0.001
Gingival bleeding				
No	59.1 (535)	55.6 (401)	72.4 (134)	
Yes	40.9 (371)	44.4 (320)	27.6 (51)	< 0.001
DMFT				
DMFT = 0	91.2 (826)	92.6 (668)	85.4 (158)	
DMFT > 0	8.8 (80)	7.4 (53)	14.6 (27)	0.002
Dental fluorosis				
TF score 0–4	51.4 (466)	47.9 (345)	65.4 (121)	
TF score 5–9	48.6 (440)	52.1 (376)	34.6 (64)	< 0.001
Dental erosion				
Grade 0	69.8 (632)	73.2 (528)	56.2 (104)	
Grade > 0	30.2 (274)	26.8 (193)	43.8 (81)	< 0.001
Tooth wear				
Grade 0	54.0 (489)	55.1 (397)	49.7 (92)	
Grade > 0	46.0 (417)	44.9 (324)	50.3 (93)	0.194
TMD pain				
2Q/TMD = 0	88.2 (799)	88.8 (640)	85.9 (159)	
2Q/TMD > 0	11.8 (107)	11.2 (81)	14.1 (26)	0.289

*Pearson's Chi-square test

prevalence of OIDP has also been reported among the adolescents from other countries, for example Brazil (37%), Italy (67%), China (46%) and Thailand (85%) [37–40]. The relatively low prevalence of oral impacts among Maasai- and non-Maasai adolescesnts is most likely related to the low occurrence of oral diseases generally and dental caries particularly observed in those populations. In accordance with some previous reports from sub Saharan Africa, difficulties with eating food and cleaning teeth were the most frequent oral impacts affecting adolescents in this study [4–6].

The present differences in OIDP across sociodemographic- and clinical variables confirm the social and clinical gradients observed in oral health of adolescent/adult populations worldwide [41, 42]. Although Longido district was most populated with non-Maasai

Table 2 Distribution of OIDP according to sociodemographic features and clinical indicators of oral diseases/problems

Variable	Categories	OIDP > 0% (n)	*P*-value*
District of residence	Monduli	21.9 (105)	
	Longido	8.9 (38)	< 0.001
Sex	Female	14.2 (72)	
	Male	17.8 (71)	0.133
Age	12–14 years	15.2 (118)	
	15–17 years	22.1 (25)	0.061
Ethnicity	Maasai	14.6 (105)	
	Non-Maasai	20.5 (38)	0.047
Wealth index	Poorest	11.9 (52)	
	Least poor	19.4 (89)	0.002
Mother's education	Low (≤ primary school)	15.4 (133)	
	High (≥ secondary school)	22.2 (10)	0.224
Oral hygiene status	Poor	18.2 (108)	
	Good	11.2 (35)	0.006
Gingival bleeding	No	14.8 (79)	
	Yes	17.3 (64)	0.313
DMFT	DMFT = 0	13.7 (113)	
	DMFT > 0	37.3 (30)	< 0.001
Dental fluorosis	TF score 0–4	11.4 (53)	
	TF score 5–9	20.5 (90)	< 0.001
Dental erosion	Grade 0	16.8 (106)	
	Grade > 0	13.5 (37)	0.215
Tooth wear	Grade 0	14.9 (73)	
	Grade > 0	16.8 (70)	0.445
TMD pain	2Q/TMD = 0	12.3 (98)	
	2Q/TMD > 0	42.1 (45)	< 0.001

*Pearson's Chi-square test

adolescents, Longido residents were less likely to report oral impacts than their counterparts in Monduli district. This difference might be attributed to variation in prevalence and severity of oral diseases as well as differences in the socio-demographic distribution between the two districts. Non-Maasais had higher odds of reporting any OIDP than the Maasais and ethnic group was strongly and independently associated with oral impacts after adjustment for oral diseases and socio-demographic factors. Although comparable studies from sub Saharan Africa are lacking, reports from high income countries have shown that non-White individuals or minority ethnic groups are more likely to have oral impacts than their white majority ethnic group counterparts [43, 44]. The influence of ethnicity on oral health is linked to, socioeconomic, behavioral and psychosocial factors that varied across the ethnic groups [45]. In this study, most adolescents were from poor families and lived in rural remote areas where social services are limited. All these exposed them to various risk factors of oral diseases and affected their psychological, social and quality aspects of their life¨ Moreover, the present findings and also previous ones have shown that non-Maasai adolescents are more frequently affected by oral diseases than their Maasai counterparts [23]. Those from the least poor families were more likely to report oral impacts than those from the poorest families. This is contrary to other studies reporting that the poorest families report most oral impacts [4, 46]. In this study, adolescents from the least poor families might have the easiest access to sugary foods and thus being those most exposed to development of dental caries. In accordance with the present findings, a previous study reported that Tanzanian adolescents from least poor families, according to the family wealth index, reported dental pain and other oral problems more frequently than their counterparts from the poorest families [5].

In accordance with previous studies but contrary to others, the present one demonstrated a strong and independent association between indicators of oral health

Table 3 Logistic regression for the association between adolescents' social and clinical characteristics and OIDP, odds ratios (OR) ad 95% confidence interval (CI)

Variable	Step 1 OR (95% CI)	Step 2 OR (95% CI)
District of residence		
Monduli	1	1
Longido	0.3 (0.2–0.4)[b]	0.4 (0.3–0.7)[b]
Age		
12–14 years	1	1
15–17 years	1.4 (1.0–2.1)	1.2 (0.9–1.8)
Ethnicity		
Maasai	1	1
Non-Maasai	1.7 (1.1–2.7)[b]	1.6 (1.1–2.3)[b]
Wealth index		
Poorest	1	1
Least poor	2.0 (1.4–3.0)[b]	2.0 (1.2–3.3)[b]
Oral hygiene status		
Poor		1
Good		0.7 (0.5–0.9)[b]
DMFT		
DMFT = 0		1
DMFT > 0		3.1 (2.1–4.5)[b]
Dental fluorosis		
TF 0–4		1
TF 5–9		1.5 (0.9–2.4)
TMD pain		
2Q/TMD[a] = 0		1
2Q/TMD > 0		3.9 (2.4–6.2)[b]

Step 1: model fit Nagelkerke's $R^2 = 0.103$, Model Chi-Square = 55.407, df = 4, $p < 0.001$
Step 2: model fit Nagelkerke's $R^2 = 0.199$, model Chi-square = 110.178, df = 8, $p < 0.001$
[a]2Q/TMD Two epidemiological questions regarding TMD pain
[b]Statistically significant

Table 4 Statistically significant effects of two-way interactions between adolescents' social and clinical characteristics and OIDP (cluster adjusted), odds ratios (OR) ad 95% confidence interval (CI)

Variable	Step 2 OR (95% CI)
Ethnicity x age	
Maasai × 12–14 years	1
Non Maasai × 15–17 years	4.4 (1.7–11.3)[b]
Ethnicity x DMFT	
Maasai x DMFT = 0	1
Non Maasai x DMFT> 0	4.6 (2.1–10.0)[b]
Ethnicity x TMD pain	
Maasai x 2Q/TMD[a] = 0	1
Non-Maasai x 2Q/TMD > 0	8.0 (3.6–17.8)[b]

[a]2Q/TMD Two epidemiological questions regarding TMD pain
[b]Statistically significant

status, namely dental caries and self-reported TMD pain, and oral impacts [6, 27, 47–49] (Table 3). Moreover, adolescents with good oral hygiene had lower odds than those with poor oral hygiene to report oral impacts. This finding is contrary to other studies from Tanzania which found no significant differences in oral impacts according to level of oral hygiene status [4, 6]. Poor oral hygiene is an outcome of irregular tooth cleaning and may lead to gingivitis and increase the risk for periodontitis [50], which has a negative impact on oral health related quality of life [51, 52]. Dental caries, if left untreated, can affect adolescent's quality of life through dental pain leading to deterioration in oral functioning, emotional state as well as social roles [53]. The positive association observed between self-reported TMD pain and oral impacts supports findings from previous studies [54–56]. The similarity in these findings indicates that self-reported TMD pain affects OHRQoL across various populations. The OIDP index measures only ultimate impacts and statistically significant relationships can be difficult to demonstrate when the prevalence of one of the covariates is low. Thus, it is noteworthy that the observed associations between clinical indicators and oral impacts were statistically significant despite a relatively low prevalence of oral impacts in the present study population. The prevalence of tooth wear/dental erosion in this population was relatively low and did not associate with oral impacts on daily performance. Similar negative findings between oral health related quality of life indicators and low prevalence of tooth wear have been reported elsewhere [57]. On the other hand, if prevalence and severity of tooth wear increases in the future caused by changes in behavioral pattern and/or socioeconomic conditions, it could result in an impact on oral health related quality of life as reported by others [58]. In the studied society, it is likely that today's traditional lifestyle and relatively low prevalence oral diseases will be subjected to a change into a more modern way of living in the future. In this regard, harmful choices of behavior may arise which may increase the risk for development oral diseases. This perspective has to be considered in future public dental health planning.

Study limitations

The present study used a large sample size providing more reliable results with greater precision and power. In addition, the study provided a detailed oral clinical examination and used an oral quality of life inventory previously validated for use in Tanzanian and other non-occidental context. Although schools were selected randomly and in spite of a high response rate, the possibility of selection bias cannot be overlooked. The rigorous

Table 5 Logistic regression for the association between adolescents' social and clinical characteristics and OIDP, according to ethnic belongingness (cluster adjusted). Odds ratios (OR) ad 95% confidence interval (CI)

Variable	Maasai		Non-Maasai	
	Step 1 OR (95% CI)	Step 2 OR (95% CI)	Step 1 OR (95% CI)	Step 2 OR (95% CI)
District of residence				
Monduli	1	1	1	1
Longido	0.2 (0.1–0.4)[b]	0.4 (0.2–0.7)[b]	0.7 (0.3–1.7)	0.8 (0.3–2.5)
Age				
12–14 years	1	1	1	1
15–17 years	1.1 (0.6–2.0)	0.9 (0.5–1.7)	3.1 (1.0–9.1)	3.7 (1.1–12.8)[b]
Wealth index				
Poorest	1	1	1	1
Least poor	2.0 (1.3–3.0)[b]	1.9 (1.2–2.9)[b]	1.4 (0.4–4.5)	1.7 (0.5–6.3)
Oral hygiene status				
Poor		1		1
Good		0.6 (0.3–1.0)		0.6 (0.3–1.5)
DMFT				
DMFT = 0		1		1
DMFT > 0		2.8 (1.4–5.5)[b]		3.3 (1.2–9.0)[b]
Dental fluorosis				
TF 0–4		1		1
TF 5–9		1.7 (1.0–2.9)		1.0 (0.4–2.7)
TMD pain				
2Q/TMD[a] = 0		1		1
2Q/TMD > 0		3.0 (1.7–5.2)[b]		9.0 (3.3–25.0)[b]

[a]2Q/TMD Two epidemiological questions regarding TMD pain
[b]Statistically significant

selection criteria utilized might have resulted in a recruited study population that was not strictly representative of the general adolescent population in the study area. The structured interviewer-administered schedule used to assess self-reported data might be subject to social desirability, acquiescence, and recall biases. Attempts were made to minimize these biases by informing the participants that their responses were confidential and that no-one could link their names to their responses. Furthermore, the cross-sectional design utilized makes it difficult to establish causal relationships. In addition, our plan was to invite all adolescents aged 12–14 years. However, during interview we invited all available adolescents without separating them according to age. During analysis we realized that the age range was between 11 to 26 years. So to reduce this wide age range we decided to exclude those below 12 years and above 17 years.

Conclusion

The prevalence of oral impacts was moderate but higher among the non-Maasai-than Maasai- adolescents, attending rural primary schools in the Maasai population areas of Tanzania. This study also confirmed socioeconomic and oral clinical disparities in OIDP, some of which differed according to ethnicity. Caries experience and self-reported TMD pain associated more strongly with OIDP among the non-Maasais than among the Maasais. The results are important for public oral health decision makers who plan strategies for optimal oral health and quality of life among adolescents belonging to minority groups in Tanzania. This is important for the prevention of oral diseases and improvement of oral health related quality of life among the adolescents of the under privileged ethnic groups.

Abbreviations

2Q/TMD: Two epidemiological Questions regarding Temporomandibular Disorder pain; 2Q/TMD > 0: A positive response to any or both of the two epidemiological questions regarding Temporomandibular Disorder pain; 2Q/TMD = 0: A negative response to both epidemiological questions regarding Temporomandibular Disorder pain; CI: Confidence interval; C-OIDP: Child-oral impact on daily performance; CI-S: Simplified calculus index; D: Design effect; DI-S: Simplified Debris Index; DMFT: Decayed Missing Filled Tooth; GBI: Gingival Bleeding Index; OHI-S: Simplified Oral Hygiene Index; OHRQoL: Oral health related quality of life; OIDP: Oral impact on daily performance; OIDPSC: Oral Impact on Daily Performance Simple Count score;

OR: Odds Ratio; PCA: Principal Component Analysis; SD: Standard deviation; SPSS: Statistical Package for Social Sciences; TF-index: Thylstrup-Fejerskov-index; TMD: Temporomandibular disorder; WHO: World Health Organisation

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Authors' contributions
LS: principal investigator, designed the study, collected the data, performed the statistical analyses, and wrote the manuscript. AKJ: main supervisor, designed the study, guided the statistical analyses and writing the manuscript. AJ: participated in the design of the study, guided the statistical analyses and writing the manuscript. IK: Co-supervisor, participated in the design of the study and provided valuable guidance in the data collection and writing the manuscript. ANA: Co-supervisor, designed the study, guided the statistical analyses and writing the manuscript. The author(s) read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on request.

Ethics approval and consent to participate
Ethical clearance was obtained prior to study from the ethical research committee in Norway (REK VEST, reference number 2015/2477) and the Medical Research Coordinating Committee of Ministry of Health and Social Welfare in Tanzania (reference number NIMR/HQ/R.8a/VOL.IX/2214). Permission to work with adolescents was obtained from Ministry of Education and Vocational Training through Monduli and Longido district councils and their respective educational authorities. Participation was voluntary and without compensation. Prior to the participation, informed written signed consent was obtained from their parents. Only adolescents who assented and with signed consent from their parents were invited to participate in the study. If needed relevant advice and/or referral to the district hospital were given free of charge.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Publisher's Note

Errata

Paper I Page 12 of 14: “informed signed/verbal consent” corrected to “informed signed consent”

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