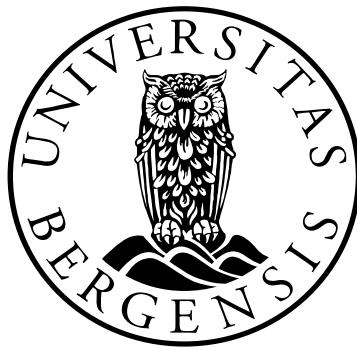# Planning, implementation and evaluation of a school program to promote oral health among Tanzanian adolescents

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Dissertation for the degree philosophiae doctor (PhD)

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List of Abbreviations

CI	Confidence Interval
CFI	Comparative Fit Index
CS-OIDP	Condition-Specific Oral Impacts on Daily Performance
DMFT	Decayed Missing Filled Teeth
DMFS	Decayed Missing Filled Surfaces
HPS	Health Promoting Schools
HSM	Hawa Shariff Mbawalla
ICIDH	International Classification of Impairment, Disabilities, and Handicaps
IM	Intervention Mapping
MM	Matilda Mtaya
OHE	Oral Health Education
OHI-S	Oral Hygiene Index-Simplified
OHRQoL	Oral Health-Related Quality of Life
OIDP	Oral Impacts on Daily Performance
OR	Odds Ratio
PASW	Predictive Analysis Software
RCT	Randomized Control Trials
SD	Standard Deviation
SES	Socioeconomic status
SSA	Sub-Saharan Africa
SPSS	Statistical Package for Social Sciences
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organization

Abstract

Background: The global burden of oral disease and risk behavior is concentrated in underprivileged and poor populations. HPS programs are promising methods for promoting health, including oral health. **Objective:** The present thesis aimed to collect information about the oral health status, oral health behavior, and oral health-related quality of life among school students and to use this information to implement and evaluate an HPS program that was directed at improving oral health, thereby reducing social inequalities among school adolescents in Arusha, northern Tanzania. **Methods:** The data in survey I (Papers I–IV) were collected in Arusha, from secondary school adolescents aged 12–21 years at baseline in 2009 and during a follow-up in 2011. Oral health education and demonstrations, wall posters, and the provision of toothbrushes were part of the HPS initiative implemented in April 2010, which was evaluated during March–May 2011. The data in Survey II (part of Paper III) were collected during 2005–2006 in Dar es Salaam from 1601 final year primary school pupils aged 12–14 years. Data were collected using a questionnaire and by clinical oral examinations. **Results:** In Paper I, 49.8% of boys and 46.8% of girls reported at least one OIDP. The corresponding mean OHI-S scores were 1.2 and 1.0, while the OHI-S and OIDP scores varied in the expected direction with socioeconomic status and health-related behaviors of children. Paper II reports differences in the prevalence scores and the overall mean generic Child-OIDP scores among groups with (DMFT > 0) and without caries (DMFT = 0), and with and without periodontal problems in Arusha and Dar es Salaam. Paper III, principal component analysis of seven health and oral health-related behaviors gave two factors with Eigen value >1, accounting for 45.8% of the variance. Confirmatory factor analyses, CFA, provided acceptable fit for the hypothesized two-factor model; CFI = 0.97. Paper IV reports the follow-up study in which 727 students were reexamined clinically. The mean number of teeth with caries increased statistically in both groups from the baseline to the follow-up. The mean number of teeth with gingival bleeding decreased (0.5 versus 0.4; $p < 0.05$) in intervention schools, whereas it increased in control schools. **Conclusion:** It may be possible to develop the HPS approach further to include oral health in resource-poor sociocultural settings. Overall, the HPS initiative was effective in reducing the gingival bleeding status of adolescents, but not dental caries, calculus, and plaque. **Consequences:** The challenge for future studies will be to achieve better and more sustainable results. Despite the limited effects of oral health promotion, its integration within HPS initiatives might be beneficial for Tanzanian secondary school students.

List of publications

This PhD thesis is based on the following original publications:

Paper I

Mbawalla HS, Masalu JR, Astrøm AN. Socio-demographic and behavioral correlates of oral hygiene status and oral health related quality of life, the Limpopo-Arusha school health project (LASH): A cross-sectional study. ***BMC Pediatr. 2010 Nov 30;10:87***.

Paper II

Mbawalla HS, Mtaya M, Masalu JR, Brudvik P, Astrom AN. Discriminative ability of the generic and condition-specific Child Oral Impacts on Daily Performances (Child-OIDP) by the Limpopo-Arusha School Health (LASH) project: a cross-sectional study. ***BMC Pediatr. 2011 May 26;11:45***.

Paper III

Åstrøm AN, Mbawalla H. Factor structure of health and oral health-related behaviors among adolescents in Arusha, northern Tanzania. ***Acta Odontol Scand. 2011 Sep;69(5):299-309. Epub 2011 Mar 30***.

Paper IV

Mbawalla H, Masalu JR, Masatu M, Åstrøm AN. Changes in adolescents' oral health status following oral health promotion activities in Tanzania. ***Acta Odontologica Scandinavica 0 (2012): 1-10. Epub 2012 May 08.***

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Tanzania

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1. Introduction

This thesis considers the planning, implementation, and evaluation of a school-based oral health promotion program (HPS) in Arusha, northern Tanzania. The target group in this study was school-going adolescents in Arusha and Dar es Salaam, Tanzania. The United Nations describes people aged 10–19 years as adolescents (1). In 2009, adolescents comprised 18% of the world's population and 15% of the world's total adolescent population was living in SSA (1, 2). The size and nature of this age group are of importance in terms of their future health status, the economy, and the development of the whole population (2, 3). Adolescence is a period of opportunities because individuals are perceived to be more healthy than other age groups during this period (4, 5). However, adolescents face particular challenges in SSA because the increase in noncommunicable diseases among the middle-aged and elderly population can be traced back to their engagement in health-related risk behaviors during adolescence (6).

In this thesis, an extensive needs assessment was implemented via cross-sectional baseline research to collect information on the oral health status of adolescents and its sociobehavioral determinants. The results of this needs assessment were presented in Papers I–III. Paper IV reports on the implementation of an HPS program and its impact on dental caries and the oral hygiene status of school students. The effects of the HPS initiative on student health and oral health-related behaviors will be presented in subsequent papers, which are not included in this thesis.

The first part of the thesis summarizes key concepts in oral health status, oral health-related behaviors, self-reported oral health, and OHRQoL, thereby providing important background information to facilitate the interpretation of the results presented in this thesis. This information relates to adolescents in SSA in terms of the prevalence, sociodemographic distribution, and development across time of dental caries, periodontal problems, oral health-related behaviors and self-reported oral health. In the second part, we discuss intervention strategies that promote oral health and the concepts of OHE, oral health promotion, and HPS. This is followed by a literature

review of the evaluation of school-based oral health promotion programs that target adolescents in low-income countries. The introduction to the thesis ends with a review of conceptual models and theories that guide the planning, implementation, and evaluation of behavioral interventions, and a brief justification for conducting HPS initiatives in Tanzania. The introduction is followed by the methods, results, and discussion sections. The date for the completion of the literature search presented in the summary was February 2012.

1.1 Dental caries in adolescents in sub-Saharan Africa

According to WHO, the most common oral diseases worldwide are dental caries and periodontal (gum) diseases. Approximately 60–90% of children worldwide experience dental caries (7). However, the global burden of oral diseases is concentrated in the underprivileged and poor populations (8). In SSA, oral diseases are perceived as less life threatening, although the impact of oral diseases on health and well-being has been acknowledged (9).

Adolescents in SSA have been reported to have lower levels of dental caries than comparable age groups in other parts of the world. Thus, the level of caries in most SSA countries is lower than the goals set by WHO, i.e., an average of 3.0 DMFT in 12-year-olds by 2000 (9, 10). However, the prevalence of caries is known to vary within countries. Thus, the prevalence of dental caries (DMFT > 0) and the mean DMFT are reported to vary from 13.9% to 80% and from 0.1 to 2.90, respectively (11-13). Table 1 provides a review of studies conducted between 2001 and 2010, which reported the prevalence and severity of dental caries in SSA adolescents (14).

Table 1: Dental caries prevalence and severity among SSA adolescents: a review of studies published between 2001 and 2010.

Country	Mean DMFT	Prevalence (%)	Sample size (n)	Age (yrs.)	Year of publication (reference number)
Tanzania	0.46–0.5	24	425	12–15	2001 (15)
South Africa	1.54	50	115	12	2001(16)
Ghana	0.30	16	422	13–16	2002 (17)
Nigeria	0.14	13.9	402	12	2003 (12)
Nigeria	0.65	33.0	358	12–15	2004 (18)
Burkina Faso	0.70	28.5	505	12	2004 (19)
Ethiopia	1.20	45.3	306	12–15	2004 (20)
Uganda	2.90	80	372	13–19	2004 (13)
Uganda	0.64	34.2	202	12	2004 (21)
Uganda	0.90	40.0	696	12	2005 (22)
Uganda	0.98	40.2	614	10–14	2006 (23)
Nigeria	0.72	23.8	600	11–16	2007 (24)
Tanzania	3.77 (DMFS)	NS	145	13.3	2007 (25)
Tanzania	0.39	22.4	1003	12–14	2009 (26)
Sudan	0.42	24.0	1109	12	2009 (27)
Tanzania	0.37	19.2	1780	10–19	2009 (28)
Kenya	0.92	44.5	292	12	2010 (29)
Mozambique	0.99	39.93	601	12	2010 (30)

The DMFT measure for SSA adolescents was composed mainly of the decayed teeth component (DT), whereas the filled teeth component (FT) was negligible (11, 16, 19, 22, 30-33) (Figure 1). The DT component constituted 90% and 80% of the DMFT scores for South African and Ugandan school-going adolescents, respectively (32, 34).

Figure 1: Distribution of DMFT components among adolescents in SSA.

The mean DMFT values were particularly large compared with the low prevalence of caries (DMFT > 0). This may imply that caries were accumulated in the oral cavities of the few individuals whose teeth were affected most. Among Ugandan adolescents with caries, up to 14 decayed and missed teeth were reported in one person (32).

During recent decades, many developing countries such as those in SSA have reported a decreased prevalence of caries-free adolescents and an increase in the mean DMFT scores (10). In Nigeria, Sofola et al. (11) reported a mean DMFT of 0.1 and the prevalence of caries-free adolescents was 85.6% in 2002. The corresponding figures in 2007 were 0.7 and 76.8% (24). The opposite effect has been documented in South Africa, where there was a decreasing trend among 12-year-olds from a mean DMFT of 2.5 in 1985 to a mean DMFT of 1.1 in 2000 (31, 35). According to available studies conducted in urban and rural areas of Tanzania between 1983 and 2008, the prevalence of caries has remained stable at low levels, by international standards (Figure 2). However, the absence of prospective cohort studies could mean that, while the results

of repeated cross-sectional studies might be attributable to period effects, they might also reflect differences in the cohorts investigated.

Figure 2: Mean DMFT among children and adolescents aged 8–15 years in Tanzania from 1983–2008.
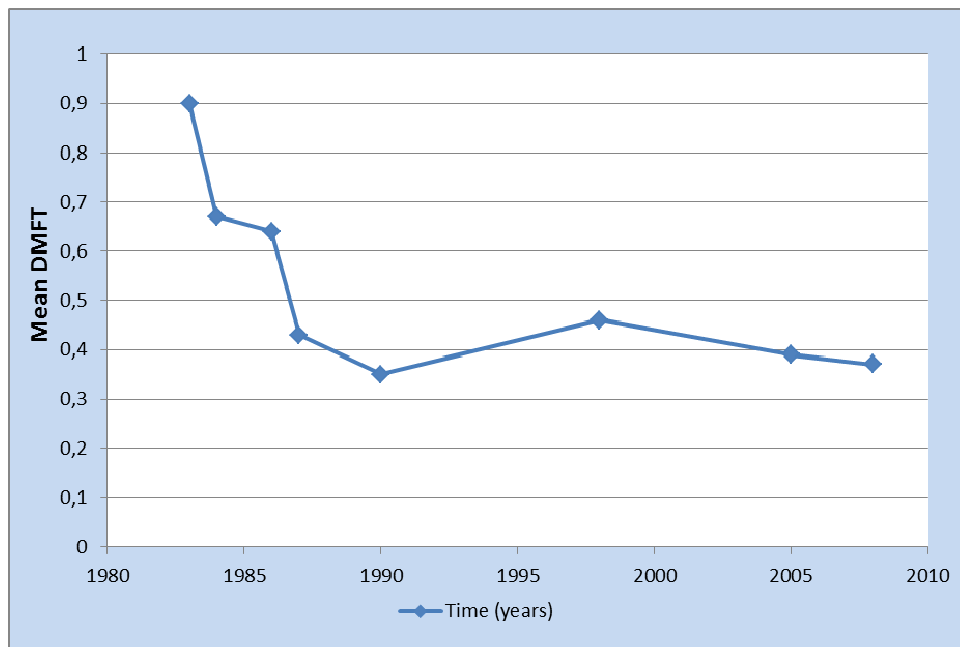
Based on data from references (15, 26, 36-39)

1.2 Periodontal conditions and oral hygiene among adolescents in sub-Saharan Africa

Adolescents may experience different periodontal problems (40, 41). Dental plaque-induced gingivitis is the most common problem and it is almost universal among children and adolescents (42-44). A less common periodontal disease is aggressive periodontitis, which is characterized primarily by the rapid loss of attachments and supporting bone (41, 45-47). Higher prevalence rates of aggressive periodontitis have been reported in African adolescents compared with American and European

adolescents (48). The prevalence of aggressive destructive periodontal disease among SSA adolescents has been reported to vary from 0.2% to 6.5% (49-51).

The etiological and risk factors of periodontitis are recognized as oral hygiene, microbiological diversity, host immune factors, genetics, age, race/ethnicity, gender, provision of dental care, sociodemographic level, and smoking (52). The incidence of generalized destructive periodontitis and the prevalence of clinical loss of attachment are known to be higher among older rather than younger adolescents (49, 53).

Significant proportions of SSA adolescents were assessed as having poor oral hygiene status based on their high levels of plaque and calculus (19, 54, 55). However, the prevalence varied between studies depending on the methods used for assessment. The prevalence of calculus was 99% among 18-year-olds in the Republic of Niger (54). The corresponding figures for Burkina Faso, Madagascar, and Mozambique were 93%, 91%, and 84%, respectively (19, 30, 55). Studies from Kenya, Uganda, Burkina Faso, Ghana, and Nigeria have shown that the prevalence of calculus and gingival bleeding among 12- to 19-year-olds varied from 53.9% to 67% (17, 22, 56, 57). Lower levels of poor oral hygiene and gingivitis have been reported in Tanzania. Among primary school adolescents, the prevalence of poor oral hygiene varied between 30.0% and 38.1%, while only 25% had gingivitis in the sextants examined (15, 26).

1.3 Subjective dimensions of oral health – oral health-related quality of life

There is an increasing focus in dentistry on assessing the subjective dimensions of oral health. A body of indices and scales has been developed to measure subjective oral health, which continues to evolve (58). In recent years, a number of OHRQoL instruments have been developed for use with children and adolescents (59-65) (for a review of the instruments developed, see Table 2). Most of these measures assess the frequency and or severity of functional, psychological, and social impacts that are associated with oral disorders. These measures have been referred to as sociodental indicators, subjective oral health status measures, patient-based outcome measures,

participant-based outcome measures, or OHRQoL measures (66). The term OHRQoL was used in the separate papers and the summary of the current thesis.

OHRQoL has been interpreted as the impact of oral conditions on daily functioning (67, 68). The concept of OHRQoL appeared in the early 1980s and it was defined as the impact of oral disorders on an individual's life as measured from their own viewpoint, which included people's expectations and values (69). Since the 1990s, instruments have been developed to assess OHRQoL that complement the conventional clinical oral indicators (70-74). In recent years, OHRQoL measures have been used in epidemiological surveys, studies to explore their potential use, and in clinical trials to measure the effectiveness of interventions. Depending on the context where OHRQoL measures are used and the study design employed, the main technical requirements for these measures are reliability, validity, and sensitivity to change (66). Recently, it was suggested that minimal important difference scores (MIDs), or "the smallest difference in score perceived as beneficial by the patient," should be calculated to improve the interpretability of OHRQoL scores when measuring differences between groups.

OIDP is an OHRQoL instrument that is commonly used in the empirical literature (74). OIDP has gained international recognition and it was shown to be valid and reliable across populations in occidental and nonoccidental contexts (75, 76). This inventory is based on a conceptual framework derived from the WHO ICIDH, which was amended for dentistry by Locker (77). ICIDH provides a basis for the empirical exploration of links between different dimensions or levels of consequence variables, i.e., impairments, functional limitations, pain and discomfort, and disability and handicap. Impairments refer to the immediate biophysical outcomes of disease, which are commonly assessed using clinical indicators. Functional limitations at the second level are concerned with the functioning of body parts, whereas pain and discomfort refer to the experiential aspects of oral conditions in terms of their symptoms. In addition to dissatisfaction with dental appearance, they comprise the intermediate impacts. Any of the dimensions in the first and second levels can lead to the third

level, which refers to any difficulties in performing the activities of daily living and to broader social disadvantages, i.e., "ultimate impacts," which correspond to WHO's and Locker's concept of disability and handicap (77, 78). A childhood version of the OIDP (Child-OIDP) was originally developed in Thailand (60) and it was shown to be a valid and reliable measure when applied to young people in different cultural settings (79-86). See Table 3 for a review of studies that have used the Child-OIDP.

Table 2: Oral health-related quality of life instruments for use with children and adolescents.

Instrument name	Year of publication (ref.)	Age (yrs)	Number of items	Conditions where used in dentistry
Infant/toddler quality of life questionnaire (ITQOL)	1994 (87)	0.16–5	103	Early childhood caries (88)
Child health questionnaire (CHQ)	1996 (89)	5–18	CHQ-PF50 CHQ-PF28 CHQ-CF 87	Temporomandibular disorders (90)
Pediatric quality of life inventory (PedsQL™)	1999 (91)	2–18	15	Dental caries (DMFT) (92)
Family impact scale (FIS)	2002 (93)	6–14	13	Variety of dental, orthodontic, and orofacial disorders
Child perception questionnaire (CPQ)	2002 (59)	11–14	36	Variety of dental, orthodontic, and orofacial disorders
Parental perception questionnaire (PPQ)	2003 (94)	6–14	31	Variety of dental, orthodontic, and orofacial disorders
Child-oral impacts on daily performance (Child-OIDP)	2004 (60)	11–15	8	Variety of dental and orofacial disorders
Early childhood oral health impact scale (ECOHIS)	2007 (95)	3–5	13	Early childhood caries (96)

Table 3: Prevalence of oral impacts in children and adolescents (Child-OIDP) during 2004–2010.

Author (year of publication) (ref.)	Country	Language	Age (yrs.)	n	Prevalence of OIDP (%)	Most reported oral impacts
Åstrøm et al. (2003) (97)	Uganda	English	13–19	1146	62.0	Eating, speaking, and cleaning mouth
Gherunpong et al. (2004) (98)	Thailand	Thai	11–12	1034	89.8	Eating, emotion, and cleaning mouth
Tubert-Jeannin et al. (2005) (81)	France	French	10	414	73.2	Eating, cleaning mouth, and smiling
Yusuf et al. (2006) (80)	UK	English	10–11	228	40.4	Eating, cleaning mouth, emotional stability, and smiling
Mtaya et al. (2007) (99)	Tanzania	Kiswahili	12–14	1003	28.6	Eating, cleaning mouth, and speaking
Castro et al. (2008) (100)	Brazil	Portuguese	11–14	342	80.7	Eating, emotional, cleaning mouth, and smiling
Krisdapong et al. (2009) (101)	Thailand	Thai	12	1066	85.2	Eating, cleaning mouth, and emotion
			15	815	83.3	
Mashoto et al. (2009) (28)	Tanzania	Kiswahili	10–19	1745	36.2	Eating and cleaning mouth
Bianco et al. (2010) (85)	Italy	Italian	11–16	530	66.8	Eating, cleaning mouth, and smiling
Nurelhuda et al. (2010) (86)	Sudan	Arabic	12	1109	54.6	Eating and cleaning mouth
Cortés-Martinicorena et al. (2010) (84)	Spain	Spanish	11–12	230	36.5	Eating, cleaning mouth, and smiling
			13–14	195	38.5	
Castro et al. (2011) (102)	Brazil	Portuguese	11–12	571	88.7	Eating, cleaning mouth, and smiling

Both the adult and child version of the OIDP can be used either as a *generic* or *condition-specific* (CS) measure. In contrast to other OHRQoL measures, the Child-OIDP was designed to assess specific oral problems with impacts, thereby linking impacts to an oral condition or problem that may require attention (60). This unique characteristic has allowed the condition-specific Child-OIDP (CS-Child-OIDP) to be used for need assessments and for prioritizing dental health care services (103). A few

studies have compared the generic and CS forms of the Child-OIDP, showing that the CS-Child-OIDP is better at discriminating among groups with or without normative dental treatment requirements for caries, malocclusion, periodontal disease, and traumatic dental injuries (103).

Relatively few studies have reported the OHRQoL for SSA adolescents (28, 86, 97, 99, 104). The prevalence of adolescents with at least one oral impact aged 13–19 years and 12 years in Uganda and Sudan were 62% and 54.6%, respectively (86, 97). Among Tanzanian adolescents, the prevalence of OIDP varied between 28.6% and 36% (28, 99, 104). OIDP is associated with dental caries, malocclusions, and dental fluorosis, as well as oral problems and perceived oral health, which indicates the validity of this measure among adolescents in nonoccidental cultural contexts (28, 86, 97, 99, 104).

The aim of OIDP is "to provide an alternative sociodental indicator which focuses on measuring the serious oral impacts on person's ability to perform daily activities" (74). OIDP is advantageous for measuring ultimate impacts, thereby reducing the possibility of overscoring, and for measuring behavioral rather than emotional states, while it is also a short questionnaire.

OIDP includes the following eight items.

- Eating and enjoying food
- Speaking and pronouncing clearly
- Cleaning teeth
- Sleeping and relaxing
- Smiling, laughing, and showing the teeth without embarrassment
- Maintaining the usual emotional state without being irritable
- Carrying out major work or a social role
- Enjoying contact with people

1.4 Sociodemographic distribution of oral health status among adolescents in sub-Saharan Africa

Despite the global improvement in oral health, oral diseases remain a worldwide problem and widening inequalities in oral health exist among different social groups between and within countries (105). Sociodemographic gradients in oral diseases occur among regions and age groups in children, adolescents, and adults in industrialized and nonindustrialized countries (106-109). Sociodemographic factors are reported to have a profound effect on the oral health status of SSA adolescents, including, age, gender, place of residence, parental educational levels, parental occupation, whether parents can afford dental care, household socioeconomic positions, and family possession of tangible assets (13, 19, 22, 27, 28, 30, 32, 39, 51, 57, 99, 110-112).

Studies focusing on SSA adolescents have indicated that the highest prevalence of dental caries, self-reported pain, and oral impacts occurs in urban dwellers, girls, and in those from higher socioeconomic backgrounds, although contradictory observations have also been reported (19, 27, 29, 32, 36, 39, 111, 113, 114). In Burkina Faso, Varenne et al. (19) reported mean DMFT values of 1.9 and 0.7 for 18- and 12-year-olds, respectively. Mashoto et al. (39) and Mapengo et al. (30) reported a higher caries prevalence in rural compared with urban adolescents. Mapengo et al. (30) reported that 12-year-olds from suburban areas were 1.5 times more likely to have caries than those from urban areas. A striking observation was the higher caries prevalence in subjects from less poor households compared with subjects from poor households (27, 39, 115). The most important geographical factor linked to dental caries in SSA adolescents was a high concentration of fluoride in the water (> 2 mg/L^{-1} fluoride) (16, 20, 116, 117).

A social gradient was also observed in the periodontal and oral hygiene status of adolescents. A higher prevalence of periodontal conditions and poor oral hygiene was reported in rural areas, older adolescents, boys, and the socioeconomically disadvantaged, compared with other groups (19). Ng'ang'a and Valderhaug (57) and Kolawole et al. (118) showed that Kenyan and Nigerian adolescents with a lower

socioeconomic status (SES) had a worse oral hygiene status compared with those from higher socioeconomic status groups.

1.5 Oral health-related behaviors of adolescents in sub-Saharan Africa

Behavioral risk factors for dental caries in adolescents include frequent sugar consumption, use of tobacco products, irregular dental attendance and tooth brushing, insufficient supply of topical fluorides, and dental anxiety (12, 119-125). Dental attendance, tooth brushing frequency, and tobacco use are also known to impact on the periodontal status of adolescents (126, 127). The significance of sugars in the etiology of dental caries was established many years ago. However, the importance of limiting sugar consumption in caries prevention was questioned recently (128-130). No studies have documented an association between increasing levels of sugar consumption and increasing caries incidence in SSA adolescents.

Evidence has demonstrated the effectiveness of using topical fluoridated toothpaste for the prevention of dental caries (131, 132). In the modern age, the weak association of sugar consumption with caries incidence can be explained by extensive fluoride exposure (133). Varenne et al. (134) reported that the use of fluoridated toothpaste was less frequent among 12-year-old adolescents (9%) compared with adults (18%) in Burkina Faso. However, 83.1% and 98% of Nigerian and Ugandan adolescents claimed to use fluoride-containing toothpaste when brushing their tooth (111, 118).

The frequency of the intake of sugary snacks and drinks has remained at a low level in SSA adolescents compared with their Western counterparts (135-137). Moreover, tooth brushing and mouth cleaning are common practices (138, 139). In Tanzania, Nörmark et al. (125) reported that 92% of rural primary schoolchildren and adolescents brushed their teeth every day. A more recent study focused on secondary school students reported a daily tooth brushing rate of 72.4% (140). Tooth brushing rates of at least twice a day were reported as 67.2% and 75.5% among Sudanese 12- to 15-year-olds (141). However, the quality of tooth brushing behavior has been

questioned. Among urban adolescents with confirmed daily tooth brushing, only 63% gave the correct reasons for performing the behavior (142).

In SSA, few adolescents and children ever visit a dentist or dental clinic during their lifetime and the main reason for a visit is therapeutic rather than for a dental checkup. In Nigeria, Adekoya-Sofowora et al. (12) reported that 83.1% of private school students and 90.6% of public school students had not visited a dentist in the previous three years. Among 12-year-olds in Burkina Faso, 93% had never been to a dentist while 4% had visited a dentist because of pain and discomfort (134). This figure was substantially lower than among Ugandans, where 56.4% of 10- to 14-year-olds reported no dental attendance during the previous three years (111).

The frequency of the intake of sugary snacks and drinks was higher among adolescents from less poor households, urban residents, girls, and those whose parents had higher education (39, 124, 143). Irregular tooth brushing and less frequent use of fluoridated toothpaste were higher among adolescents from the poorest households, rural areas, and boys (39). Dental attendance was found to be most frequent among adolescents from less poor households, urban residents, and boys (39). Ayo-Yusuf et al. (144) investigated South African eighth graders and found that the family environment and the psychological predisposition of children significantly influenced their tooth brushing behavior. However, Kolawole et al. (118) reported that the SES of a child had no relationship with the frequency of performing oral hygiene behavior in Nigeria.

1.6 Strategies for promoting oral health – individualistic and population-based approaches

A major challenge is to translate knowledge of oral diseases and their sociobehavioral and environmental determinants into effective oral health promotion strategies and to identify methods that achieve sustainable behavior change (145). Socioeconomic factors are powerful determinants of oral health, but influencing them requires public health actions and political decisions. A failure to focus on socioenvironmental factors

and the lack of a theoretical basis might explain why individualistic approaches to health promotion have been largely ineffective (146).

Traditionally, *a high-risk individualistic* strategy has been applied to the control of oral diseases. However, Hausen et al. (147) reported that a higher number of cavities developed in 80% of low-risk children compared with 20% of high-risk children during a three-year intervention period. This demonstrates that a greater number of people exposed to a small risk may generate more disease cases than a smaller number of people exposed to a high risk (148). Thus, it may be disadvantageous to focus entirely on high-risk approaches. As an alternative, the emphasis should be placed on *population-based approaches*, which help people to make healthier choices that are easier choices and by integrating the promotion of oral health and general health using a common risk factor approach (145, 149, 150). According to the WHO 2008–2013 action plan stating the global strategy for the prevention and control of noncommunicable diseases (151), the common major risk factors are the same in men and women throughout all the regions of the world, i.e., unhealthy diet, physical activity, tobacco, and alcohol. The key concept underlying a common risk factor approach is the promotion of health by controlling a small number of risk factors that have a major impact on a large number of diseases at a lower cost compared with more disease-specific approaches (151, 152).

1.6.1 Health education – health promotion

Traditional oral health education focuses on the etiology and prevention of oral diseases, which is considered an essential and basic part of oral health care services (153). However, systematic reviews suggest that oral health education has failed to achieve any sustainable improvements in oral health, which contrasts with public health policies such as legislation to support water fluoridation, the use of topical fluorides, and a healthy diet policy (145, 150, 154-160). According to Petersen's risk factor model (161) and Barton's health map (162), society and culture (i.e., distal factors) are linked to specific behavioral patterns (proximal factors) that influence oral

health and well-being. However, the control of distal environmental factors requires public health policies and legislation. A public health approach for the prevention of oral disease has been strongly suggested, particularly in developing countries, based on current evidence of the limited effect of oral health education approaches, limited health budgets, and poor dental care manpower.

Health promotion has been defined as the process of enabling people (i.e., making the hill less steep) to take control of their own health, thereby promoting its improvement (150, 163). Oral health promotion aims to achieve sustainable improvements in oral health and reduce social inequality via measures that target social determinants (150). Complementary approaches are combined in health promotion, including health education with a focus on lifestyle changes, legislation, advocacy, taxation, and organizational change. Five key areas for health promotion activities are: promoting health through public policy, creating supportive environments, developing personnel skills, strengthening community services, and reorienting health services (164). A health promotion approach for the prevention of oral diseases has been supported by the WHO Global Oral Health Program (164). There is an emphasis on the integration of oral health with general health promotion using a common risk factor approach, based on a recognition that oral diseases and other noncommunicable diseases share a set of common risk factors including tobacco smoking, inadequate hygiene, and a poor quality diet (152).

1.6.2   Health promoting schools

For several decades, schools have been recognized as a forum for health education, which provide an appropriate setting for promoting young people's health and oral health (165, 166). In 1989, the term "Health Promoting School" (HPS) was introduced, which was based on the general definition of "health promotion" stated in the Ottawa Charter (167). Some initiatives have the potential for oral health promotion, including an HPS network to improve environments and create a health promoting setting where the healthier choice is the easy choice (145). The Ottawa Charter was echoed in the WHO's definition of the aims of a health promoting school

as "…achieving healthy lifestyles for the total school population by developing supportive environments conducive to the promotion of health. It offers opportunities for, and requires commitments to, the provision of a safe and health-enhancing social and physical environment." Following this broad definition, HPS are often described as holistic and ecological. Denman et al. (168) suggest that five keys issues addressed by health promoting schools are: (i) the professional's roles and training; (ii) partnerships; (iii) personal, social, and health education, and citizenship; (iv) a safe and welcoming learning and working milieu; and (v) action competence. Thus, an HPS is not simply a school where individual health promoting activities take place, because schools should have the structure and capacity to identify and act upon health-related topics in the broader school community, as well as being a supportive and facilitating environment that facilitates healthy choices. WHO has integrated an oral health component into its HPS programs (165).

1.6.3 Evaluation of oral health promotion programs

The evaluation of oral health education and promotion programs is important for ensuring the appropriate use of resources and ethical principles (163). Criticisms that have emerged from systematic reviews of intervention activities include inappropriate study designs and various outcome measures with limited value (169, 170), which make direct comparisons between studies difficult. The debate has continued over the most appropriate methodology for evaluating oral health interventions (171). Unbiased analysis using randomized controlled trials (RCT) remains the gold standard methodology (172). Any failure to use RCTs might mean that the differences between groups at the baseline could bias the results.

According to Nutbeam (169), a variety of outcome measures could be used including: *health promotion outcomes* in terms of changes in policy measures and oral health-related knowledge and skills; *intermediate health outcomes,* such as changes in lifestyles and environments; and *health and social outcomes* such as disease markers and quality of life measures. Effectiveness reviews have shown that the majority of

oral health promotion programs have been targeted at schoolchildren (155, 159). Individual oral health promotion activities in schools have been widely evaluated (173-176). Positive outcomes have been reported in developing countries including oral cleanliness, gingival bleeding, and oral health knowledge after school-based oral health promotion activities. Table 4 provides an overview of school-based oral health promotion programs that have targeted adolescents in low- and middle-income countries, as defined by the World Bank.

Table 4: School-based oral health promotion programs targeted at children and adolescents in low- and middle-income countries (World Bank definitions) during 2001–2010.

Authors (year of publication)	Country	Target group (n)	Study design	Study period	Method of intervention	Main outcome of the study
Frencken et al. (2001) (177)	Zimbabwe	Primary school mean ages 8–10.1 yrs (965)	Purposive allocation	3.5 yrs	Educational intervention using schoolteacher-attended Ministry of Health workshop on oral health education	No significant differences in plaque scores and caries increase among groups
Hartono et al. 2002 (178)	West Java, Indonesia	Primary school children aged 8–12 yrs	Purposive allocation	1.5 yrs	Educational intervention using primary healthcare personnel and schoolteachers	Experimental groups had improved tooth brushing effectiveness, moderate positive effect on oral health knowledge, and reduced habitual plaque scores No significant differences in DMFT/DMFS increment between groups
Moysés et al. (2003) (179)	Curitiba, Brazil	Primary school children aged 12 yrs (1823)	Purposive allocation	Not stated	Specific schools health promotion project by the State and Municipal Education Sectors	Intervention groups had significantly higher percentages of caries-free children and fewer children with dental trauma
Mayer et al. (2003)(180)	São Paulo Brazil	Private school adolescents aged 13–16 yrs (186)	RCT	3.0 yrs	Comprehensive instructions on oral hygiene procedures for students and parents up to five years after termination of intervention	Comprehensive intervention groups retained oral health-related knowledge without long-term effects on oral health behavior
Petersen et al. (2004) (181)	China	Primary school children aged 6–7 yrs (803)	Purposive allocation	3.0 years	WHO (HPS): Integrating oral health education into the general curriculum	Experimental groups adopted more regular oral health behaviors and had reduced bleeding scores No significant differences in DMFT increment among groups
Peng et al. (2004) (182)	China	Primary school children aged 6–7 yrs (1342)	Purposive allocation	2.0 yrs	WHO (HPS): oral health education and sugar-free chewing gum tablets	Reduced caries increment in group with both oral health education and sugar-free chewing gum Significant reduction in gingival bleeding scores in all intervention groups compared with controls

Table 4 (continued): School-based oral health promotion programs targeted at children and adolescents in low- and middle-income countries (World Bank definitions) during 2001–2010.

Authors (year of publication)	Country	Target group (n)	Study design	Study period	Method of intervention	Main outcome of the study
Goel et al. (2005) (183)	India	Primary school children aged 10–13 yrs (500)	Before and after design with one group	1.0 yrs	Educational intervention using a single lecture on the basics of OHE	Postintervention improvement in dental health awareness
Hebbal et al. (2005) (184)	Davangere, India	School children aged 6–15 yrs (4500)	RCT	3 months	School-based intervention using dental screening and oral health education	Intervention groups had a significantly higher dental attendance rate
Tai et al. (2009) (185)	Yichang, China	Primary school children aged 6–7 yrs (1616).	Cluster randomized trial	3.0 yrs	WHO (HPS): oral health education, booklets, posters, oral examination, and provision of fluoride toothpaste	Experimental groups had favorable oral health habits, and a higher mean decrease in plaque and bleeding scores
Yazdani et al. (2009) (186)	Tehran, Iran	Public high school adolescents 15 yrs (417)	Cluster randomized trial	12 weeks	Educational intervention using leaflets and videotapes, dental models and script	Intervention groups had significant reductions in dental plaque and gingival bleeding scores
Saied-Moallemi et al. (2009) (173)	Tehran, Iran	Primary school children aged 9 years (457)	Cluster randomized trial	3 months	Educational intervention using oral hygiene instructions, classwork, leaflet and tooth brushing diary	Intervention groups where parents were involved had significantly healthier gingiva and acceptable oral hygiene
Yang et al. (2009) (187)	Pingtung, Taiwan	Junior high school adolescents (135)	RCT	8 weeks	Educational intervention using lectures, role-playing, small group discussions, and group contests	Intervention groups had a significant improvement in oral health knowledge, frequency of daily tooth brushing, and reduced cigarette smoking
Mashoto et al. 2010 (188)	Kilwa, Tanzania	Primary school children aged 12–19 yrs (1306)	Before and after design with three groups	6 months	School-based intervention using oral health education (OHE), atraumatic restorative treatment (ART), and tooth extractions	Postintervention reduction of reported Child-OIDP with an extensive effect among the group that received both ART and tooth extraction

Other studies have shown only a temporary effect on plaque accumulation, no effect on caries increase, limited effects on attitude, but a positive effect on the knowledge level (174). Systematic reviews have concluded a lack of convincing evidence for the effects of school-based oral health education on reduced plaque levels (160). Randomized controlled trials of Finnish and Swedish children and adolescents with a high risk of dental caries who lived in areas with an overall low level of caries have shown little effect on caries increase (147). A detailed evaluation of an HPS initiative in Brazil indicated positive effects on the level of dental caries and orofacial trauma among pupils attending schools with oral-health-supportive policies (179). Similar effects were reported by Ontario HPS initiatives launched in 2006 (189). A published review of HPS that targeted more than one health outcome only identified nine studies that met the review criteria and none had been conducted in African schools (190).

1.6.4   Theoretical perspectives

Effective interventions should be informed by theory, research, and practice (191). The importance of careful theory-based intervention planning has been recognized for several decades (146). Using theory to guide the planning, development and implementation of intervention programs requires the translation of abstract concepts about human behavior into practical activities and messages that ultimately lead to changes in behavior and health outcomes. Only a few interventions that have focused on adolescent oral health have based their strategies on theories related to human behavior (174, 192). Major planning conceptual models, such as the Precede–Proceed Model (193) and the intervention mapping framework (IM) (194), have been recognized as valuable in facilitating interventions. The IM framework was used as a planning model in the present study, as detailed below.

1.6.5 Use of IM in the planning, implementation, and evaluation of school-based oral health promotion

Bartholomew and Mullen (2011) presented an IM approach with five steps: 1) the identification of behaviors and social and personal behavioral determinants related to the prioritized health problem; 2) describing the hypothesized causal pathway from intervention through behavioral determinants and behaviors to primary outcomes in terms of changes in clinically assessed and self-reported oral health; 3) selection of theory-based intervention methods; 4) the evaluation of outcomes and intermediate variables of outcomes; and 5) reporting (194). According to IM, a needs assessment identifies the oral health problems to be addressed, the associated oral health behaviors that need to be changed, and the psychological, social, and environmental determinants that need to be translated into interventions. After a needs assessments, IM provides a stepwise approach that guides the selection of specific *program objectives* and the choice of intervention strategies and tools. In the present thesis, IM steps 1 to 3 correspond to Papers I–III, while IM steps 4 and 5 correspond to Paper IV.

In IM step 1, the *performance objectives* are identified, i.e., the behaviors that need to be modified to achieve the overall aim of the intervention program (in this case, improving health and oral health) (195). According to experimental and epidemiological evidence, valuable tools for the prevention of oral diseases include appropriate use of interdental measures, fluorides, dental services, tooth brushing, restricted sugar consumption, nonsmoking, and restricted use of alcohol (161). Dental caries are expected to increase in developing countries because of increased preferences for sugar and increased sugar consumption, lack of topical fluorides, limited access to dental health care services, and poor levels of oral hygiene (164).

IM Step 2 involves an in-depth examination of the requisite behaviors by specifying *learning objectives*, such as the importance of frequent tooth brushing and restricted sugar consumption, based on individual (i.e., awareness, self-efficacy, and attitudes) and environmental (i.e., social and environmental) support. Potential determinants of requisite behaviors might be identified in literature reviews, reviews of theoretical

models, and by new research (195). Thus, the learning objectives aim to answer the question, "What does the target group need to learn with respect to a specific behavioral determinant for the behavior to be accomplished." Recognizing the importance of these behaviors (attitudes), utilizing external sources (social support), and using personal skills to overcome barriers (self-efficacy) might be important learning objectives if Tanzanian secondary school students are to improve their oral health-related behavior. The theory of planned behavior (196) suggests that oral health behaviors are influenced by attitudes, subjective norms, and perceived behavioral control. In addition to cognitive factors, the theory of triadic influences (197) suggests that sociocultural, demographic, and environmental factors will influence oral health-related behavior. These theories specify behavioral determinants that might be targeted by interventions aimed at improving oral health.

IM step 2 exploits theory on selecting *educational methods and strategies* that match the learning objectives. Bandura's social cognitive theory (SCT) provides a framework for articulating learning objectives, and combining individual and social influence factors. According to SCT: 1) individuals with inadequate *knowledge* of oral health will not change or adopt the recommended practices; 2) individuals who consider themselves to be constantly *at risk of having oral diseases* will be facilitated in their decision to change oral health practices; 3) individuals who perceive that serious *disadvantages* are associated with the recommended behaviors will not change their behavior; 4) individuals with *relations/friends/colleagues* (e.g., family, teacher, dental health worker, and peers) who encourage improved oral health behavior patterns will more readily choose or adhere to the recommended behavior; and 5) individuals who lack *confidence* in their ability to carry out a recommended practice may adopt the practices in a customary manner. According to SCT (198), specific techniques such as information transfer, role modeling, skill building, social support, persuasion, and reinforcement might be used to develop or modify self-efficacy and other beliefs. These techniques have been applied widely and they can elicit behavioral changes (199, 200).

Step 3 of IM involves the development of the program and pretesting the materials, while Steps 4 and 5 cover program implementation and evaluation, respectively.

1.6.6 Alternative theories of oral health promotion

Some criticism has been directed toward psychological models because cognitive factors are weak predictors of actual health behavior and these models ignore socioenvironmental determinants of health behavior (201). As an alternative, Watt (192) proposed three theoretical approaches to support the development of health promotion practices based on an acknowledgment of the importance of social and environmental determinants of oral health.

1.6.7 Justification for conducting an HPS initiative among secondary school students in Tanzania

In Tanzania, dental diseases have remained at low to moderate levels and approximately 60–70% of the population is reportedly free of dental caries, irrespective of age (202, 203). However, children and adolescents with untreated dentinal lesions and dental pain have been cited as the main reason for seeking dental care (204). Poor oral hygiene is common and a substantial proportion of the youth population has calculus and gingivitis (15, 36). Exposure to dental health care services has been low and the dentist to population ratio is only 1:347273 (205). Bad oral hygiene and the anticipated increase in caries prevalence with economic progress and changed dietary habits should be addressed primarily through preventive efforts.

Oral health education is part of the primary school curriculum in Tanzania and for decades it has been an important way of dealing with the scarcity of dental professionals in the country (206). Since 1982, the oral health program had encouraged appropriate oral health behavior among schoolchildren under the guidance of primary school teachers. Most of the teachers lack training and motivation in the task, so the program has not been effective (207, 208). Poorly equipped teachers, a lack of

government or public leadership, and a lack of funds contribute to the ineffectiveness of the primary school-based oral health education. It has been argued that greater facilitation might lead to more successful implementation by teachers in the Tanzanian school system, such as appropriate learning resources including books, pamphlets, films, and guest speakers, and overcoming inhibitory constraints in terms of time and money. A prerequisite for the success of oral health interventions is to ensure acceptability by the target group of school students (209).

A key issue in health promotion is identifying the best time to deliver interventions (210). An important period is the transition from primary to secondary school. The school years are extremely influential because they are a period when lifelong beliefs and attitudes develop and when individuals are receptive to the adoption of health and oral health behaviors that might be sustained into adulthood (211). Seven years of primary education in Tanzania is followed by secondary education to ordinary level with four years of postprimary education, while advanced level requires a further two years postordinary level. Before 2006, only a small proportion of primary school graduates continued onto secondary education, largely because there were too few secondary schools. In 2006, Tanzania introduced a policy of universal secondary education with the aim of enrolling all pupils who passed the primary school exam. Thus, there has recently been a dramatic rise in the number of public secondary schools, from 828 in 2004 to 3283 in 2009 (212). The proportion of students progressing to secondary school in Tanzania increased substantially from 36.1% in 2004 to 51.6% in 2009 (71% of boys and 59% of girls), although there have been some fluctuations, e.g., 56.7% in 2007 (212). Other improvements include a substantial increase in the number of students passing examinations. The percentage of students who passed the Form II examination increased from 66.6% in 2004 to 91.9% in 2007. Thus, the secondary school years are "a window of opportunity" for interventions that might provide long-term benefits by promoting oral health and reducing social inequalities.

There are also important social and economic arguments for improving the health, oral health, and development of adolescents in Tanzania. This country is currently going

through a rapid social, political, and economic transformation, which is having profound impacts on the youth population (213). Adolescence is a vulnerable period that is characterized by major physical, psychological, and socioenvironmental changes, so it is a timely period for shaping habits that may contribute to a reduced likelihood of chronic diseases in adulthood. Improving the health of school-going adolescents might increase their enrolment and retention at school, and their cognitive achievements, thereby leading to improved productivity.

2. Aims

2.1 Overall aims

This study aimed to plan, implement, and evaluate an HPS program among secondary school students in Arusha, northern Tanzania. The present thesis contains information on the oral health status, oral health behavior, and the OHRQoL of school students. This information was used to plan, implement, and evaluate an oral health promotion program that was integrated into an HPS initiative to improve oral health and reduce social inequalities.

2.2 Research questions

Paper I: Socio-demographic and behavioral correlates of oral hygiene status and oral health related quality of life, the Limpopo-Arusha school health project (LASH): A cross-sectional study

Aims: 1) To assess the occurrence of poor oral hygiene status and OIDP using sociodemographic and behavioral indicators; 2) to determine whether socioeconomic and behavioral correlates of oral hygiene status and OIDP differed with gender; and 3) to determine whether the sociodemographic disparity in oral health outcomes was explained by oral health behaviors. It was hypothesized that sociodemographic factors

might influence oral health outcomes directly or indirectly via oral health-related behaviors.

Paper II: Discriminative ability of the generic and condition-specific Child-Oral Impacts on Daily Performances (Child-OIDP) by the Limpopo-Arusha school health (LASH) project: a cross-sectional study

Aim: This study focused on school students in Arusha and Dar es Salaam to compare the discriminatory capacity of the generic Child-OIDP for dental caries and periodontal problems among sociocultural diverse study sites in Tanzania. The discriminatory capacity of the generic and condition-specific Child-OIDP for dental caries, periodontal problems, and malocclusion was then compared for various clinical conditions.

Paper III: Factor structure of health and oral health-related behaviors among adolescents in Arusha, northern Tanzania

Aim: This study investigated the interrelationship between health- and oral health-related behaviors in secondary school students. It was hypothesized that responses to seven health-related (intake of fast food, hand washing after latrine use, hand washing before eating, and the use of soap when washing the hands) and oral health-related behaviors (tooth brushing, intake of sugared mineral water, and the intake of sugary snacks) could be explained by two underlying factors. Each behavior would have a stronger relationship to the factor it was designed to measure than the competing factors, while the two factors would be correlated and the two-factor structure would be invariant with gender. Guided by the conceptual framework of the Theory of Triadic Influences, this study identified possible distal and proximal social and individual factors that were associated with health and oral health behavioral patterns in Tanzanian school students.

Paper IV: Changes of adolescents' dental caries and oral hygiene status following one year of health promoting school activities

Aim: This paper evaluated a one-year HPS intervention implemented in 2010 that included oral health education. Specifically, this study assessed the impact of the program activities on the oral health status of secondary school pupils in a two-year follow-up, compared with the baseline. The following research questions were addressed: the extent to which dental caries, plaque, calculus, and bleeding on probing changes after a one-year health promoting school program; whether the observed changes in oral clinical indicators were associated with sociodemographic characteristics measured at baseline; whether the observed changes in dental caries were associated with corresponding changes in oral hygiene measures; whether students in the intervention and control schools differed in their clinical oral indicators between the baseline and the follow-up.

3. Methods

3.1 Study areas

The Arusha region was the main study site for the HPS initiative. This region is located in the northern part of Tanzania along the Great Rift Valley, where the fluoride concentration of drinking water was 3.6 mg/L^{-1} fluoride. Thus, dental fluorosis is endemic. In 2010, the population of Arusha was estimated as 1665000 (214). Arusha is less affluent and less populous than the capital city Dar es Salaam, but it has a significant role in the economy (tourism) and international politics, which means that the population has a higher SES compared with neighboring regions in northern Tanzania.

Dar es Salaam is the most economically and politically affluent, and densely populated area of Tanzania (estimated population of 3118000 people in 2010 and a land area of 1000 km²), and it is located in the eastern coastal region (214). It is the smallest region

in terms of land area and the drinking water fluoride concentration is low (0.05 mg/L^{-1} (215). This region is multicultural and multiethnic in nature, and many people migrate to Dar es Salaam from all over Tanzania to live and work. Dar es Salaam contains the majority of dentists practicing in the public and private sectors in Tanzania. Figure 3 shows the geographic location of the two study sites in Tanzania.

Figure 3: Study areas in Arusha and Dar es Salaam, Tanzania.
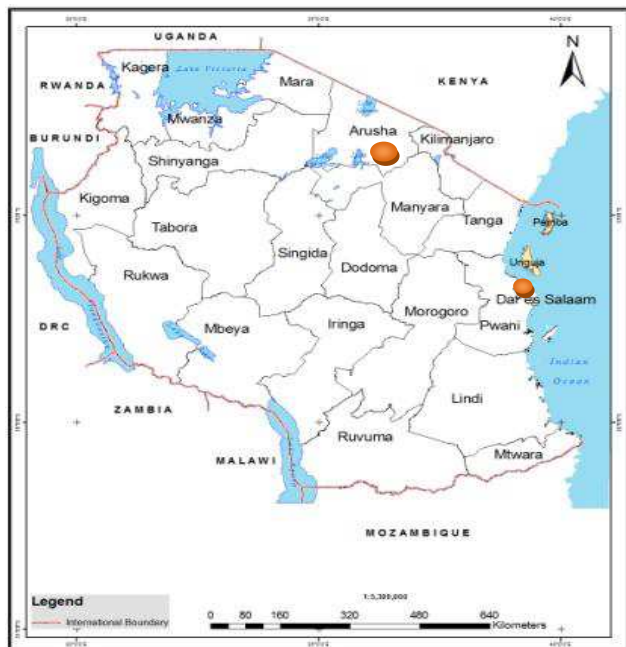
Courtesy of the National Bureau of Statistics, the United Republic of Tanzania

3.2 Surveys conducted in the present thesis: an overview

This thesis is based on two separate surveys. Survey I was a longitudinal school-based study conducted in Arusha, northern Tanzania between 2009 and 2011, which focused on students attending Forms I–IV in secondary schools. Survey I used data from the Arusha arm of a multicenter cluster randomized trial, which integrated oral health promotion into an HPS program, i.e., the Limpopo-Arusha school health project (LASH; http://www.med.uio.no/forskning/tematisk/globinf/LASH/) (inactive since the completion of the project in November 2011). A stratified one-stage cluster sample conducted in 2009 was used as the baseline survey, with schools as the primary sampling unit. A cluster RCT design was used to evaluate a one-year HPS initiative. Survey II was a cross-sectional survey conducted in Dar es Salaam, Tanzania during

2005–2006, which focused on schoolchildren in their final primary school year, i.e., class 7 (see Table 5).

Table 5: Surveys conducted in the present thesis.

Survey	Paper	Study group, study site, and analyses
I	Papers I–III	Arusha baseline Forms I and II student questionnaires (n = 2412)
		Oral examination subgroup (n = 1077)
	Paper IV	Two-year follow-up with Forms III and IV students, questionnaire survey (n = 1714)
		Oral examination (n = 727)
II	Paper III	Dar es Salaam primary schoolchildren Class 7 (n = 1601)

3.2.1 Survey I: Sampling procedures and study design

The data for Survey I (Tanzanian part of LASH), which was used in Papers I–IV, was collected in a two-year longitudinal survey carried out in the Arusha region, northern Tanzania. In November 2009, 31/59 public secondary schools in the area fulfilled the inclusion criteria, i.e., a public school with a student enrolment > 200 students. This study included several outcomes, so a separate sample size was calculated for each and the largest sample size was used. A sample size of 2000 students was calculated based on an absolute precision of 0.02, with a 95% CI and a design factor of 2. A similar calculation was not performed for the size of the subsample that underwent oral clinical examination.

A one-stage stratified (urban–rural) cluster design was used with secondary school as the primary sampling unit. A total of 11 urban schools (n = 7533, total student population) and 20 rural schools (n = 9141, total student population) comprised the sampling frame. We randomly selected 10 schools from the rural (k = 10/20) and urban (k = 10/11) schools using an *unequal sampling fraction*. All students present in Forms I and II in the selected schools on the day of the survey were invited to participate. In 2009, questionnaire surveys were completed by 1163 and 1249 students

from urban and rural schools, respectively (overall = 2412/2988, participation rate = 80.7%). Because of financial constraints and limited manpower resources, a full oral examination was conducted only in a subsample of 10 schools (five urban and five rural) (eligible number of students, n = 1333; participating students n = 1077).

In the evaluation study, a predetermined fixed number of 10 urban and 10 rural schools was randomly allocated to the intervention and control arms. Of the 10 urban schools, 3/5 control (n = 315/549) and 2/5 intervention schools (n = 214/614) received a full oral clinical examination and a baseline questionnaire. Of the 10 rural schools, 2/5 control schools (n = 188/593) and 3/5 intervention schools (n = 360/656) received a full oral clinical examination and a baseline questionnaire. Thus, 2/5 urban control schools, 3/5 urban intervention schools, 3/5 rural control schools, and 2/5 rural intervention schools completed only a baseline questionnaire. The study design is shown in Figure 4. This cluster randomization study was stratified based on the urban or rural location, before data assignment to a table of random numbers with clusters assigned in a 1:1 allocation ratio. In 2010, HPS activities and oral health education were implemented in 10 intervention schools from the year after the baseline study. Control schools continued their usual health education activities.

Figure 4: Study design for survey I.
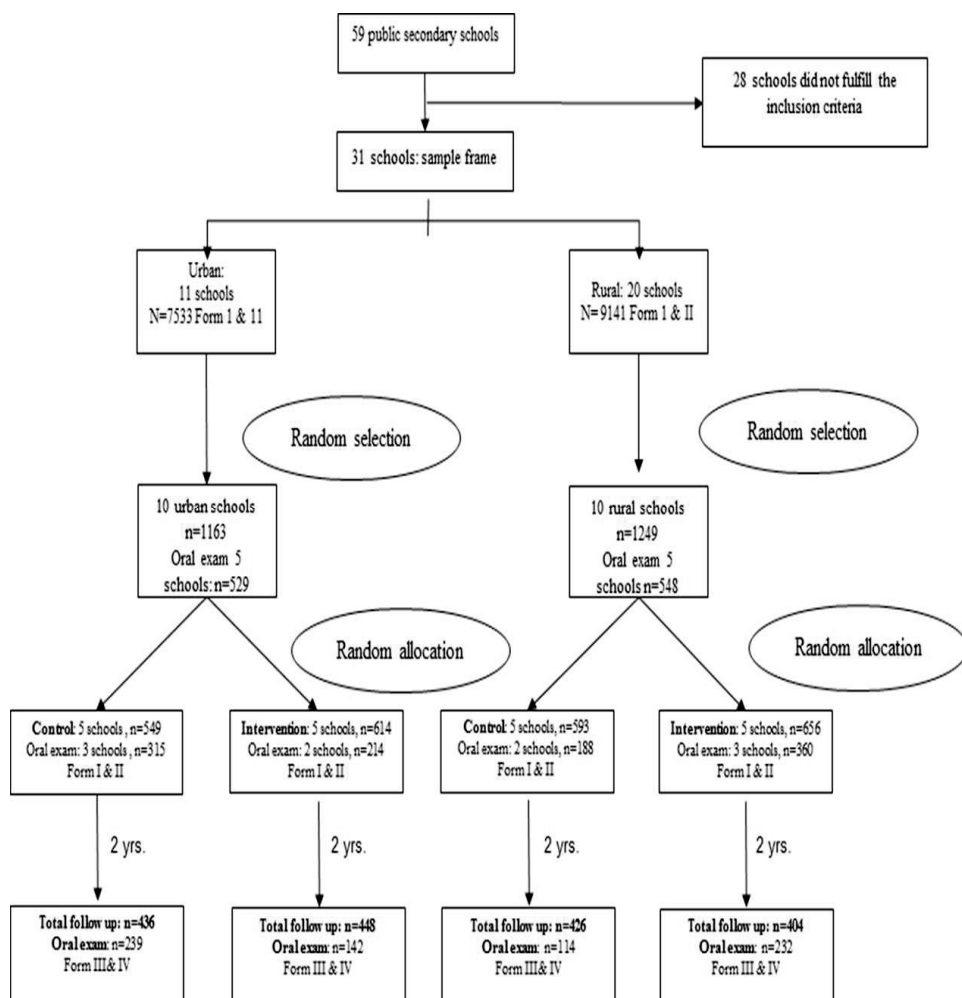
3.2.2 Survey I: Survey instruments and oral clinical examination

The same structured questionnaire was administered to students in classroom settings at baseline and follow-up. The questionnaire included 165 questions and it was constructed in English initially before being translated into Kiswahili (**Appendix I**), the official national language of Tanzania. It was subsequently back-translated into English by independent translators who were qualified in English and Kiswahili. After a pilot test, some modifications were made to ensure the clarification and simplification of words. The questionnaires were completed by students in a classroom setting under the supervision of trained research assistants.

Similar oral examinations were conducted at baseline and follow-up in a total of 10 schools (five intervention and five controls) by the author of this thesis (HSM), while dental assistants recorded the clinical observations. All members of the team were trained and calibrated for the clinical procedures. Caries occurrence was assessed according to criteria specified by WHO (216). Oral hygiene was assessed using the OHIS, which is recognized to be useful for the evaluation of dental health education in public school systems (217). The Gingival Bleeding Index (218) was used to assess gingival inflammation. For a detailed description of clinical indices, see Papers I, II, and IV and clinical form used (**Appendix II**).

3.2.3 Survey II: Sampling procedure and study design

The data in survey II (used for Paper II) were collected from November 2005 to June 2006. The study population comprised children attending class 7 (the final primary school year) in public primary schools in the Kinondoni and Temeke districts of Dar es Salaam. A *stratified proportionate two-stage cluster sampling design* was used with public primary schools as the primary sampling unit. Overall, 43 rural (n = 4809 class 7 pupils) and 78 urban primary schools (n =14725 class 7 pupils) were listed in Kinondoni. The corresponding numbers in Temeke were 22 rural (n = 1707 class 7 pupils) and 77 urban (n = 14103 class 7 pupils) schools. A sample size of 1200

schoolchildren aged 12–14 years was calculated as adequate for two-sided tests, assuming that the prevalence of malocclusion and oral impacts would be 0.40 and 0.50 in children with and without caries, respectively, using a significance level of 5%, 90% power, and a design factor of 2 (219). During the first stage, we selected four rural (4/43, n = 755 class 7 pupils) and six urban (6/77, n = 1157 class 7 pupils) schools in Kinondoni and one rural (1/22 n=184 class 7 pupils) and five urban (5/78, n = 949 standard 7 pupils) schools in Temeke by systematic random sampling, using a unified sampling fraction for each area. Of the 3045 standard 7 pupils that were available in the selected schools, approximately 100 students from each selected school (i.e., 1601 students who comprised 52.6% of all standard 7 students in the selected schools) met the inclusion criteria (12–14 years old) and they were selected randomly from classes. The participation rate was about 100% in each school. Further details of the sampling procedure, study design and instruments used may be found in previous publications and thesis (75, 99, 112).

3.2.4 Survey II: Survey instrument and oral clinical examination

Two trained research assistants administered a structured questionnaire to primary school pupils via face-to-face interviews, which included the Child-OIDP inventory and questions on their sociodemographic characteristics, general health status, oral health status, perceived treatment needs, and oral health-related behaviors. The interviews lasted approximately 5–7 minutes and privacy was ensured in the interaction between the researcher and interviewee. The questionnaire was translated from English into Kiswahili. A description of the translation process may be found in Paper II. The questionnaire was tested in a pilot study and adjusted before its use in the field.

A trained and calibrated dentist (MM) conducted all the clinical examinations in a classroom setting with natural daylight for illumination, while a trained assistant recorded the observations. Initially, the dentist practiced on orthodontic casts and their observations were compared with those of an experienced orthodontist, whose

malocclusion diagnosis served as the standard (gold standard) for comparison. The examiner (MM) was also trained in the routine clinical orthodontic examination (orthodontic diagnosis) of schoolchildren at the Orthodontic Clinic, Department of Clinical Dentistry, University of Bergen, where she was supervised by an orthodontist for one week. During the diagnosis of caries and oral hygiene examination, the examiner was compared with an experienced clinician. Caries were assessed according to the WHO criteria (216). Oral hygiene was assessed using OHI-S (217). Malocclusion was assessed according to Bjørk et al. (220) and the modifications of Al-Emran et al. (221).

3.3 HPS initiatives in Arusha, Tanzania

Based on WHO directives (167), the LASH project developed a protocol describing the interaction with schools and the support provided during their progress to an HPS. LASH provided support by identifying available interventions when a school decided to become an HPS based on their own needs assessment. The main HPS activities were sexual and reproductive health education, which focused on family planning and the prevention of STDs, book donations, and the distribution of 2000 L water tanks. Oral health education sessions were conducted in all 10 intervention schools. A team of two research assistants and a dentist conducted the oral health education sessions, allowing participants to ask questions if they needed clarification. The sessions lasted 45 minutes and they were attended by students and schoolteachers. The key oral hygiene messages included: brush with fluoride toothpaste, brush for three minutes at least twice a day, and replace a toothbrush when the bristles start to lose their shape. Each participant was given supervised tooth brushing instructions and a toothbrush for use at home. Information was provided on the oral health consequences of frequent consumption of sugary products and drinks between meals. A wall poster explaining the key oral health messages was offered to each intervention school, which acted as a reminder after the oral health educational session was completed.

3.4 Data characteristics and statistical procedures

Data were analyzed using the PASW statistical package version 19.0 and AMOS version 10.0, while the design effects were adjusted using STATA 10.0 with the survey command. The statistical tests are described in detail in the separate papers. Table 6 summarizes the statistical methods used in the papers. Statistical significance was set at $p < 0.5$.

Table 6: Statistical methods and tests used in Papers I–IV

Statistical method (package used)	Paper I	Paper II	Paper III	Paper IV
Principal components analysis (PASW)	+	+		
Confirmatory factor analysis (AMOS)		+		
Chi-square statistics (PASW)	+	+	+	+
Kappa statistics (PASW)	+			
Logistic regression (PASW)	+	+	+	+
Cochran's Q (PASW)			+	
Friedman's test (PASW)			+	
Effect size statistics (PASW)			+	
Mann–Whitney U test (PASW)			+	
One-way ANOVA (PASW)				+
General Linear Model (repeated measures) (PASW)				+
Paired t-test (PASW)				+
McNamara's test (PASW)				+
Cluster survey design (STATA)				
Complex analysis (PASW)				+

3.5 Ethical considerations

Survey I: Parents and students gave written informed consent to participate in the study at the baseline. Permission to conduct the study was granted by the school authorities

and the Ministries of Education and Health. Ethical clearance was obtained from Muhimbili University of Health and Allied Sciences (MUHAS) and the National Institute for Medical Research (NIMR) in Tanzania, and REK VEST in Norway (**Appendix III**).

Survey II: Ethical clearance was obtained from all relevant persons, authorities, and committees in Tanzania, including written permission and clearance from the Research and Publication Committee at MUHAS. Permission to work with schoolchildren was obtained from Kinondoni and Temeke municipalities, their respective educational authorities, school administrators, and parents. Only consenting subjects were included in the studies and informed verbal consent was obtained from all participating primary schoolchildren and their parents. Ethical clearance was not obtained from REK VEST in Norway because the study was performed before this type of ethical clearance was required by law in Norway (Forskningetikklov av 1.Juli, 2007, §2. avsnitt) (http://www.lovdata.no/all/tl-20060630-056-0.html#4).

4. Results

4.1 Sample characteristics

Survey I participants in Arusha comprised 2412 eligible secondary school attenders with a participation rate of 80.7%. Participants in the baseline questionnaire survey were aged 12–21 years with a mean age 15.3 (1.3), while 47.9% were boys. Of these, 1077 students received a full oral clinical dental examination (participation rate = 80.7%; mean age = 14.98 years, SD = 1.4; 46.6% boys). The participants were predominately from rural areas (51.8%) and their parents had received low levels of education (54.7% and 65%), but with a high family SES (76.5%) and 94.2% were nonsmokers. Survey II comprised 1601 primary school pupils aged 12–14 years (mean 13 years) with 60.5% girls. For a detailed description of the sample characteristics, see Papers I–IV.

4.2 Main results

Paper I: Socio-demographic and behavioral correlates of oral hygiene status and oral health related quality of life, the Limpopo-Arusha school health project (LASH): A cross-sectional study

Results: Questionnaires and clinical oral data were obtained for 2412 (mean age = 15.2 years) and 1077 (mean age = 14.9 years) students, respectively. Overall, 49.8% of boys and 46.8% of girls reported at least one OIDP, while the corresponding mean OHIS scores were 1.2 and 1.0. As expected, the OHIS and OIDP scores were correlated with SES and health behaviors. Tooth brushing and dental attendance were most frequent among urban residents and subjects with a high SES. Sugary mineral water consumption and hand washing were highest in females and older students, whereas those from low SES families whose parents could not afford dental care and who had a low educational level reported more frequent oral impacts, poor oral hygiene, irregular tooth brushing, lower dental attendance, and lower consumption of sugar-sweetened drinks. Stepwise logistic regression showed that any OIDP reporting was independently associated with older age groups, parents who could not afford dental care, smoking, lack of dental visits, and lower consumption of sugar-sweetened drinks. Behavioral factors partly accounted for the association between low family SES and OIDP. Stratified logistic regression analyses revealed that parental ability to afford dental care (OR = 1.6; 95% CI = 1.2–2.4), dental attendance (OR = 0.4; 95% CI = 0.3–0.8) and smoking (OR = 2.6; 95% CI = 1.4–5.1) were significant correlates of OIDP in males, whereas family SES (OR = 1.7; 95% CI = 1.1–2.7), parental ability to afford dental care (OR = 1.6; 95% CI = 1.2–2.3), and sugar-sweetened soft drink consumption (OR = 0.7; 95% CI = 0.4–0.9) were significant correlates of OIDP in females. In both genders, sociobehavioral factors associated with a higher OR for poor OHIS were older age, belonging to the poorest household category, and parents who could not afford dental care.

Paper II: Discriminative ability of the generic and condition-specific Child-Oral Impacts on Daily Performances (Child-OIDP) by the Limpopo-Arusha School Health (LASH) Project: a cross-sectional study

Results: There were significant differences in the prevalence and overall generic Child-OIDP mean scores among groups with (DMFT > 0) and without caries (DMFT = 0), and periodontal problems (OHIS > 1) in Arusha and Dar es Salaam. In Dar es Salaam, differences were found in: the generic and CS Child-OIDP scores between groups with and without dental caries; the generic Child-OIDP scores between groups with and without periodontal problems; the CS Child-OIDP scores between groups with and without malocclusion. The adjusted OR for the association between dental caries and CS Child-OIDP attributed to dental caries was 5.4. The adjusted ORs for the association between malocclusion and CS Child-OIDP attributed to malocclusion varied from 8.8 to 2.5.

Paper III: Factor structure of health and oral health-related behaviors among adolescents in Arusha, northern Tanzania

Results: Principal components analysis (PCA) of seven health- and oral health-related behaviors (tooth brushing, hand washing after using a latrine, hand washing before eating, using soap, intake of sugared mineral water, intake of fast food, and intake of sweets) yielded two factors with eigenvalues > 1, which accounted for 45.8% of the variance. Tooth brushing, washing the hands before eating, washing the hands after latrine use, and using soap had the highest loadings in factor 1, whereas intake of sugared mineral water, intake of sweets, and intake of fast food had the highest loadings in factor 2. Confirmatory factor analyses (CFA) indicated an acceptable fit of the hypothesized two-factor model (CFI = 0.97). Multiple group CFA across genders found no statistically significant difference in the fit of the unconstrained and constrained models (*p* = 0.203).

The two factors were identified as hygiene and snacking behaviors, which were confirmed by 59.4%, and 47.5%, respectively. Logistic regression showed that the ORs for hygiene behaviors were 1.5, 0.5, 1.5, 1.5, and 0.6 for the factors female,

current smoker, reported good relationship with school, access to hygiene facilities, and low life satisfaction, respectively. The ORs for snacking were 1.3, 1.4, 0.4, and 0.5 for female, least poor household quartile, low family SES, and high perceived control, respectively.

Paper IV: Changes in adolescents' oral health status following one year of health promoting school activities in Tanzania

Results: A total of 1077 secondary students received an oral examination at the baseline. In 2011, the follow-up reexamined 727 students. The mean number of teeth with caries increased statistically significantly from the baseline to the follow-up in the intervention (mean score = 1.0 versus 1.7; $p < 0.001$) and control arms (mean score = 1.2 versus 1.7; $p < 0.001$). GLM repeated measure tests indicated no statistically significant interaction between the change in the scores and group membership. The mean number of teeth with plaque decreased in the intervention (mean = 3.3 versus 2.0; $p < 0.001$) and control arms (mean = 3.3 versus 2.2; $p < 0.001$). In the intervention arm, the mean number of teeth with bleeding decreased (mean = 0.5 versus 0.4; $p < 0.05$), whereas this clinical parameter increased in the control group.

GLM showed that the increase in the mean number of decayed teeth from baseline to follow-up was highest among those whose plaque and bleeding scores declined and lowest among those whose scores improved.

5. Discussion

5.1 A critical view of the choice of methods and techniques – methodological considerations

The major methodological problems are discussed in detail in Papers I–IV. Additional considerations are discussed below.

5.1.1 Sample surveys

The data used in this thesis were generated by one longitudinal (Survey I) and one cross-sectional sample survey (Survey II), using interviews, structured self-administered questionnaires and oral clinical examinations. The sample surveys were designed to provide estimates of the population characteristics (222). The study population in Survey I consisted of urban and rural secondary school students (age range 12–21 years at baseline) in Arusha, while the study population in Survey II consisted of primary schoolchildren in Dar es Salaam aged 12–14 years. The main strengths of the sample survey approaches were that they yielded information on many variables for a large number of subjects at a relatively low cost (222). However, sample surveys might be subject to various sources of error that might bias the results and the conclusions (223, 224). Bias is any systematic error in data, which can be classified into two major categories. *Selection bias* comes from the study participants, e.g., resulting from the sampling procedure or nonresponders, while *information bias* or misclassification derives from errors in the information collected from participants, e.g., recall bias or social desirability bias.

5.1.2 Comments on sampling error – external validity or generalizability

External validity describes whether the findings from a sample can be generalized to a wider population (222).

An urban–rural *stratified, disproportionate* (using an unequal sampling fraction), *one-stage cluster sample* design was used in Survey I (222). If an equal sampling fraction had been used to obtain a self-weighted sample in the urban and rural areas of Arusha municipality, this would have provided an insufficient sample size for the urban area, which would have caused difficulties in the stratified analyses. The Arusha sample was not self-weighted, so the sample weights could have been used to adjust for the unequal sampling probabilities whenever results were presented for the overall urban/rural study group. In contrast, the proportionate (using an equal sampling fraction), stratified two-stage cluster sample used in Survey II provided a self-weighted

sample with respect to the urban and rural subjects in each district investigated. Thus, it was unnecessary to weight the within-district results to adjust for different urban/rural probability selections. However, the sample was not self-weighted for the combined population of Kinondoni and Temeke because of the unequal sampling fractions in the two districts, so sample weights were used to obtain unbiased estimates of clinical and self-reported oral health parameters (222).

The results of the present thesis might be representative of primary schoolchildren in the two districts of Dar es Salaam and secondary school students in Arusha municipality, given the probability sampling utilized, the good response rates, and the fact that most school-going children and adolescents are currently enrolled in primary and secondary schools in Tanzania (212). In Survey II, a comparison of the sample characteristics with the districts' child populations in terms of gender and parental education suggested that the study participants were fairly representative of the population in that age group. Nevertheless, the possibility of nonresponder bias and selection bias cannot be ignored. A bias toward health-conscious participants is a well-known problem in studies of volunteers (223). Both surveys obtained a good response rate (> 80%) in terms of the guidelines published for determining the adequacy of response rates in sample surveys (223). This response rate might be because group-administered supervised questionnaires were used in Survey I, while personal interviews were performed in Survey II. These high response rates probably resulted from the clear and appropriate information given to respondents and the preliminary test. The lack of information about nonrespondents prevents any definitive conclusions regarding any potential selection bias, so claims of the external validity (representativeness) of the results should be treated with caution.

The use of a cluster sampling design was advantageous because of its simplicity, cost-effectiveness, and applicability to developing areas with a low frequency of population registration (225). The use of schools as the primary sampling unit simplified and reduced the cost of the fieldwork. In Survey II, the random sampling of school pupils in each selected school (i.e., primary sampling unit) during the second stage ensured that clusters had an equal size, which reduced the overall size and maintained the

standard errors within a set limit. In Survey I, all the available pupils in the schools selected in the first stage were invited to participate in the study, which led to relatively large clusters.

5.1.3   Comments on measurement issues, internal validity, and reliability

The internal validity describes whether a true measure is obtained from the subjects under study (226). Common threats to the validity of self-reported oral health indicators are *social desirability* and *recall bias*. To overcome this problem, interviews and questionnaires were completed before the clinical oral examinations. It is recognized that valid and reliable information can be obtained from children and adolescents with appropriate questionnaires (63).

There is a possibility of misclassification and the underreporting of prevalence estimates when using a field method for clinical data collection. To reduce these possible biases, the dentists who conducted the examinations were calibrated and trained to ensure consistency (intraexaminer reliability). In Survey I, duplicate clinical examinations yielded Kappa values in the range 0.66–0.78 for the clinical parameters. In Survey II, the Kappa values were in the range 0.74–0.97 for the clinical parameters and 0.7–1.0 for the eight OIDP items. A single dentist performed all the clinical examinations during each survey (MM in Survey II and HSM in Survey I). All clinical examinations adhered to the standard criteria set by WHO (1997), Greene and Vermillion (1964), Bjørk (1964), and Ainamo (216-218, 221).

5.1.4   Cluster randomized trial to evaluate the HPS initiative

Cluster trials are those where research subjects are not randomly allocated independently, but as groups. The members within a cluster will be more alike than members between clusters (227). The magnitude of the effect of clustering is measured by the design effect ($deff = 1 + (m–1) \times ICC$), which depends on the cluster size, m, and the intracluster correlation (ICC), i.e., the correlation between pairs of subjects

chosen at random from the same cluster. In Surveys I and II, the cluster effects were considered after calculating the sample sizes (by multiplying the standard formula for the sample size calculation by a factor of 2) with adjustments during data analyses using the Survey command in STATA (Papers I–III) and the Complex sample command in PASW (Paper IV). A range of statistical approaches that consider ICC are available for analyses at the individual level such a s adjusted standard errors using complex samples, robust variance estimates, general estimated equations, and multilevel modeling (228-230).

A true RCT design is considered to be the best method (gold standard) of demonstrating clear causal relationships and for ensuring that all sources of bias are minimized (172). Recent reviews have highlighted the lack of RCT design use in oral health intervention programs, which means the evidence underpinning oral health promotion is rather weak (157). However, the cluster RCT design used in Survey I to randomize schools into intervention and control groups is utilized increasingly for the evaluation of health service delivery interventions (229). This design was used primarily to avoid contamination between subjects in different arms, but also for logistical and economic reasons. A strong logistical reason for the use of a cluster RCT in the present study was to prevent members of the same school being assigned to different arms and the nature of the HPS initiative itself. The present study was also designed to satisfy the health authority's requirements that all subjects should potentially benefit from the intervention. Thus, a delayed intervention was implemented in the control schools after the follow-up data were collected.

Compared with RCTs using the same number of individuals, cluster trials are inefficient and they have less statistical power and higher minimum detectable differences (225). In Survey I, a relatively large sample (2412 individuals) was distributed among the limited number of clusters available, i.e., the 20 schools in Arusha municipality that agreed to participate in the HPS initiative. In a recent paper by Hemming et al. (225), considerations are given to the limitations imposed when a fixed number of clusters is available. According to the feasibility check proposed by

Hemming et al. (225), the formula k > n × ICC (k = number of clusters, n = sample size for individual randomization, ICC = intracluster correlation) can be used to determine whether the 10 clusters that were available per arm were sufficient to detect a certain amount of change in the clinical parameters. With 10 clusters per arm and an ICC in the region of 0.02 (0–0.1 is usually reported in the medical literature), the minimum detectable difference with 80% power was a change of 10 percentage points. Thus, the number of clusters required would range between 1.9 and 8, assuming ICC = 0.005–0.02 and a calculated sample size for individual randomization of n = 385 (assuming a change of 10 percentage points and 80% power). This is fewer than the 10 clusters used in the study, although in many cases there were fewer than five clusters per arm. However, the ICC of the clinical parameters used in Paper IV was unknown and it could have been as high as 0.15–0.2 (231). Thus, the statistical power might not have been adequate.

Although the Medical Research Council has recognized that cluster trials with ≥ 5 clusters is acceptable (232), the randomization of a small number of clusters is controversial because it makes the results prone to bias. Cluster trials are also challenging because they present a number of difficult ethical issues that have yet to be addressed satisfactorily (233). Some imbalances were observed at the baseline between the intervention and control arms in terms of the sociodemographic and clinical measures (Paper IV), which might represent possible confounding factors. Moreover, the subgroups of 5 schools in the intervention and control arms that were used to evaluate clinical indicators were not randomized, so the design of the study presented in Paper IV is suboptimal in terms of being recognized as a cluster RCT (234). Thus, the clinical oral indicators evaluation study described in Paper IV does not fully satisfy the requirements of an RCT, because it was focused on a subgroup of schools within a group of schools that was originally randomized into intervention and control groups (227).

A major challenge of all prospective studies is dealing with participants who fail to complete the intervention. In Survey I, the follow-up rate was 71% for the

questionnaire survey and 68% for the clinical examination. The follow-up missed more males than females, more rural than urban residents, and more older than younger students (Paper IV). Although the attrition rate was moderate, the losses that occurred during the follow-up were not a random process and they might have consequences for the interpretability of the findings. However, withdrawals were not included in the analyses and they were treated as if they were still in the arm to which they were originally assigned (i.e., intention to treat). The explanatory approach (per protocol analysis) used in Paper IV is less common than the intention-to-treat analysis, but it was implemented with the aim of enhancing the understanding of the process involved (224).

5.2 Comments on the main findings

Evidently, there has been a shift in interest during the last decade from a focus on oral health promotion among adolescent populations to a focus on oral health promotion among preschool children. This shift in focus has been attributed to the limited success of previous oral health education and promotion programs that specifically targeted adolescents (155, 157) (see reviews). Nevertheless, evidence that the behavior of adolescents is likely to continue into adulthood and that health behaviors are malleable among young people justified the HPS approach applied in this thesis (174).

The main results of this thesis will be discussed with reference to the two main phases of the interventions, i.e., the planning stage and the evaluation stage.

5.2.1 Planning school-based interventions

Table 7 shows the main baseline results, their plausible explanations, and their implications for planning school-based interventions.

Table 7: Findings of the exploratory planning study in Survey I.

Main findings	Potential explanation	Implications
Paper I		
About 50% of the students had fair/poor oral hygiene and OIDP impacts; about 40% had caries experience, 80%, 70%, and 30% had plaque, calculus, bleeding, respectively		Room for improvement in oral health status, self-reported oral health, and oral health-related behaviors
Tooth brushing frequent, sugar intake moderate, and dental attendance poor		
Sociodemographic disparities in clinical indicators and oral health-related behaviors; higher in females than in males		Need to reduce social inequality in oral health and oral health-related behaviors
		Need to focus on gender differences during oral health interventions
Behavioral factors accounted for the association between low family SES and OIDP	Social differences in oral health-related behaviors mediate social differences in oral health	Social disparities in oral health might be reduced by behavioral interventions
		Gender differences
Paper II		
Generic OIDP discriminated equally well between students with and without dental caries and poor oral hygiene in Arusha and Dar es Salaam	Generic OIDP equally effective among study sites with respect to dental caries and oral hygiene	CS Child-OIDP better suited to supporting clinical indicators when estimating the oral health needs of children
Generic OIDP and CS-OIDP discriminated between subjects with and without dental caries, and with and without poor oral hygiene, whereas CS-OIDP alone discriminated between subjects with and without treatment requirements for various malocclusions	CS-OIDP more effective at discriminating between subjects with and without malocclusion	Condition-specific impacts can be integrated with normative measures for appropriate needs assessment when conditions are nonprogressive such as gingival inflammation and malocclusions

Table 7 (continued): Findings of the exploratory planning study in Survey I.

Main findings	Potential explanations	Implications
Paper III		
Two factors explained differences in the seven health- and oral health-related behaviors within each arm		The two factors suggest that behaviors within each arm might be addressed jointly by health promoting programs
There was a positive relationship between hygiene and snacking behaviors within schools		Access to hygiene facilities and the provision of healthy snacks at school might have a role in health promotion

Table 7 provides an overview of the main results from the baseline studies (needs assessment during the planning phase and IM steps 1 and 2 presented in Papers I–III, and some plausible explanations and implications based on these findings. The development of interventions includes the movement from early planning and problem identification through to dissemination and evaluation. Thus, the use of a planning model such as IM is strongly recommended (235). At the outset, the identification and prioritization of oral health needs, as defined clinically or by self-assessment, were an important element of the program. According to Paper I, secondary school students had a high frequency of poor oral hygiene (80%, 70%, and 30% had plaque, calculus, and gingival bleeding, respectively), low caries occurrence, and a high prevalence (about 50%) of oral impacts (OIDP), which was consistent with previous studies of SSA adolescents. The students also had high rates of daily tooth brushing and a moderate intake of sugary snacks and drinks (Paper III). This assessment identified the need for improvement. The baseline findings identified social disparities in oral hygiene, OIDP, and oral health-related behaviors. It was evident (Paper I) that the association between oral health and SES was explained partially by socioeconomic differences in oral health behaviors, while a direct link between SES and oral health remained unexplained (236, 237). This indicated the importance of looking beyond psychosocial behavioral interventions by focusing on "upstream" public health

measures, including the development of a social environment that could actively promote oral health (150).

In the present study, the IM framework guided the choices of behavior theory, which indicated the route from theory to intervention strategies. In Paper III, the Theory of Triadic Influences (TTI) was used to identify possible distal and proximal social and psychological determinants of behavioral patterns (238). Two behavioral domains were identified in Paper III, i.e., hygiene behavior and snacking, and it was suggested that behaviors in these domains might be approached jointly by health promoting programs. Life dissatisfaction appeared to decrease the possibility of performing hygiene behaviors including tooth brushing, whereas self-efficacy was an important determinant of sugar avoidance. Moreover, having a good relationship with school and access to hygiene facilities increased the likelihood of hygiene behavior. In addition to the identification of sociopsychological and personal determinants as targets for school-based interventions, Paper III confirmed the sociodemographic disparities in the behavioral patterns of students, which were identified in Paper I. Thus, the affluence aspect of snacking was notable, because this behavioral pattern was most frequently conducted by students who received food at school, who had low perceived control over snacking avoidance, whose parents had received higher education, and who came from the least poor families. However, the use of TTI to predict and understand behavioral patterns provided little or no guidance on the targets of intervention. Other theories might be needed for this purpose. The present study used Bandura's social cognitive theory (198), which suggests that guided practice, verbal persuasion, and role modeling might enhance the self-efficacy and skills of students with respect to oral health promoting behaviors.

5.2.2 Evaluating school-based interventions

Table 8 shows the changes in dental caries, plaque scores, calculus scores, and gingival bleeding following a one-year HPS program, and their potential explanations and implications.

Table 8: Main findings of the efficacy research part of Survey I.

Main findings	Potential explanation	Implications
Intervention: 67–86% confirmed receiving OHE	Controlled intervention	Controlled supervised intervention may be more reliable
Control: 50–82% confirmed receiving OHE	Possibly attributable to differences at the baseline	
Intervention arm: urban/rural differences at baseline in dental caries and calculus were not present during the follow-up		
Overall study group: mean DT increased and the plaque score decreased	Caries increase with age; calculus increase with age; limited access to dental care	
	Decrease in plaque	
No difference in between intervention and control groups for caries increase, calculus increase and decreased plaque scores	Possibly attributable to imbalanced groups at the baseline or the low power of the analysis; could be interpreted as a lack of intervention effect	Increased cluster samples, i.e., a larger number of smaller clusters was more efficient
Bleeding increased in the control group but decreased in the intervention group	Real intervention effect, i.e., a reliable indicator of plaque status	More emphasis on methods that are suited to a particular age group
Changes in dental caries associated with changes in oral hygiene measures	Caries development influenced by oral hygiene	Caries also prevented by improving plaque status in adolescents

Table 8 provides an overview of the main results after the evaluation of oral health promotion via the HPS initiative (Paper IV). Only the primary outcomes have been evaluated in terms of the clinically assessed oral health status, because the corresponding assessment of changes in possible mediating intervention variables,

such as behavioral determinants and actual behaviors, has been delayed. Assessing the mediating factors will be equally important for understanding the effectiveness of the intervention or why it might have failed. Thus, a caveat of this thesis is that we have yet to focus on the processes whereby any changes in clinical outcomes may have occurred (239).

Paper IV partially confirmed the overall hypothesis of better oral health in schools where HPS activities were supported compared with unsupported schools. The support of HPS led to more homogeneous sociodemographic oral health outcomes during the follow-up, although the intervention did not significantly reduce sociodemographic disparities in terms of the oral health indicators recorded at baseline. Thus, there was less evidence that HPS differentially improved the health of disadvantaged subjects or that this initiative was particularly effective in disadvantaged areas (179). However, HPS has been strongly recommended as a strategy for reducing inequalities in health and oral health (240).

Compared with the baseline assessments, students who experienced supportive and unsupported HPS had lower bleeding and plaque scores, but higher calculus and caries scores, during the follow-up. Paper IV shows that the proportion of students with dental caries (DT > 0) increased significantly from 43% to 52%, whereas the proportions of students with plaque and bleeding decreased from 57% to 45% and from 33% to 26%, respectively. The categorization of sum scores for dental caries, plaque, calculus, and bleeding using percentage calculations indicated the loss of information, which reduced the accuracy of these measurements and increased the possibility of measurement errors (174). Moreover, it should be noted that the expression of effectiveness as percentages may not reflect the clinical impact (66). This was because a higher baseline score required a smaller change to produce a significant result (174). Focusing solely on the mean changes might also be limiting, because some individuals in the intervention and control arms had positive changes in their scores, while others had negative or no changes. Thus, the same mean change in the score might reflect relatively smaller changes in the same direction in the overall

group, or larger changes in one direction for some subjects and opposite changes in others (66). A comprehensive picture of the results is presented in Paper IV, which shows the mean scores, change scores, and the percentage of students with decreased, improved, and stable clinical scores.

Significant changes were assessed for all clinical indicators when considering the overall study group, but there were no increases in the number of decayed teeth and calculus or reductions in the number of teeth with plaque with the intervention status. This suggests that the HPS activities had no clear effect on these clinical parameters. In contrast, the HPS initiative had a favorable effect on the gingival bleeding status of students. Oral hygiene procedures are recognized for their value in improving gingival health more than preventing tooth decay, so these results suggest that compliance with an oral hygiene program was enhanced in students attending supportive schools, which reflected their improved awareness and oral hygiene habits (241). According to Paper IV, the percentage of students who received information on health-related topics during the last school year was highest in the supportive HPS, indicating an increased level of awareness of the HPS concept in the intervention arm. Thus, the provision of reading material, water tanks, toothbrushes, and health education seemed to be an effective strategy for raising awareness and improving oral hygiene among secondary school students in Arusha. Consistent with the findings of Paper IV, previous studies conducted in developing countries have reported positive outcomes in terms of oral cleanliness, gingival bleeding, and oral health knowledge following school-based oral health promotion programs (Table 5 in this thesis).

The study site at Arusha had a high fluoride content in the drinking water, but the absence of any effect on dental caries might be attributable to the absence of professionally applied topical fluorides. According to a recent Cochrane Review (242), the overall benefit of professionally applied preventive measures in reducing the rate of caries has been estimated as 26% for permanent and 33% for temporary dentition. The effectiveness of oral health promotion has been attributed to the pharmacological effects of fluoride rather than lifestyle changes (159). The calculus status was already

the highest in the supportive HPS group at the baseline and there was limited access to dental health care in this area, which might partly explain the failure of the intervention with respect to this clinical parameter. The lack of effect of the HPS initiative on some clinical indicators might also be attributed to methodological aspects, such as the limited number of clusters, suboptimal design, and the lack of sufficient statistical power to detect minimal intervention effects. Alternatively, the results could demonstrate the lack of effect because of various aspects of the intervention method.

Previous evidence suggests that a more comprehensive school curriculum leads to a greater probability of students achieving better oral health (180). In the present study, greater emphasis could have been placed on interaction and participatory learning activities within schools and the community (for a review see 179). Few previous studies have investigated whether the education and health outcomes are better or worse in schools that use an HPS approach compared with those that use a standard classroom-based approach (179, 243). A limitation of the present study was the short time frame between the preintervention and postintervention measures. Another caveat is the fact that almost one year elapsed between the baseline and the implementation of the intervention activities, which increased the possibility that some changes had already occurred before the intervention started. Changes within schools are expected to take time and one year is unlikely to have been adequate for changes to occur in health and other health promoting outcomes.

Acceptability refers to how well an intervention is received by the target population; the extent to which the intervention meets the needs of the target population is known as adoptability (209). To increase acceptability, approaches have been suggested for the establishment of productive partnerships between researchers and members of the target population. The National Institutes of Health (NIH) has recommended the use of qualitative or mixed methods (i.e., qualitative and quantitative) to inform intervention development and to ensure that measures are understood and well received by the intended audience (209). Appropriate language translation of any important measures

also enhances acceptability. The translation and adaptation of the OIDP instrument into Kiswahili for use by Tanzanian adolescents ensured conceptual and linguistic equivalence, and cross-cultural adaptation, after focus group discussions reported in Paper II and previous studies (28, 99). However, the acceptability of an intervention approach does not guarantee its use or compliance (244). The schools that participated in Survey I had reviewed and discussed their health needs, but few had independently prioritized their health and oral health needs or developed their own action plan. The short duration of the HPS initiative (one year), the limited duration of lectures of 4–5 hours per school, and the lack of qualitative methods during the planning stage of the needs assessment, might have made this HPS approach a limited tool in terms of its effects on secondary school students.

6. Conclusions

Despite methodological limitations, this thesis provides useful information on the planning, implementation, and evaluation of an oral health promotion program, which was integrated into an HPS initiative that targeted adolescents in resource-poor settings. The research described in this thesis reached the following conclusions.

- There were sociodemographic and behavioral disparities in terms of oral hygiene status and OIDP among adolescents in relation to age, the ability to afford dental care, smoking, sugar consumption, and gender differences, which should be considered in intervention studies. Social disparities in oral health might be reduced by targeting socioeconomic differences in modifiable oral health behaviors.

- The generic Child OIDP discriminated equally well between subjects with and without dental caries and periodontal problems among socioculturally different study sites in Tanzania. The CS Child-OIDP discriminated most strongly between subjects with and without dental caries and malocclusion. This method

was better suited to supporting clinical indicators during the estimation of oral health needs in school-going adolescents.

- Seven health- and oral health-related behaviors reflected two underlying domains and behaviors within each domain should be addressed jointly in health promotion programs. The equivalent factor structure identified among males and females rendered the interpretation of gender differences in behavioral patterns appropriate and unbiased. Oral health promotion programs should address broader patterns of behavior rather than focusing on single individual actions. Gender and socioeconomic disparities in behavioral domains facilitate the identification of vulnerable groups. Positive relationships with the school and access to hygiene facilities had a role in the promotion of hygiene behaviors. The provision of healthy snacks at school and improved behavioral control or self-efficacy might restrict snacking during school hours.

- The integration of oral health promoting activities in a general HPS initiative had no clear effects on dental caries, calculus, and plaque. However, beneficial changes were observed in terms of gingival bleeding on probing after the intervention compared with the control arm, suggesting a positive effect of the HPS activities on the oral hygiene status of students. The intervention effects were limited, but the actual figures indicated that the integration of oral health promotion within HPS initiatives in Tanzanian secondary schools may be relevant.

7. Future perspectives

This study has important implications for future school-based oral health intervention programs directed toward adolescents in Tanzania. There is the potential for the further development of an HPS approach including oral health in the context of resource-poor sociocultural settings. The overall HPS initiative was effective with respect to the oral hygiene status of adolescents, although the limited improvement achieved in gingival bleeding presents a challenge where future studies need to achieve better and

sustainable results. The use of a cluster RCT in the evaluation addressed many methodological problems. However, more rigorous methodological planning and longer follow-up periods should be considered in future studies, including strict power calculations and a satisfactory number of clusters for randomization. Future oral health promotion activities should replicate the findings of the present study and further explore the preferred educational activities of secondary school pupils to increase their involvement, attention, and interest (173, 186). Greater insights into pupil preferences, more intensive and extended methods, the use of peer educators and repeated instruction, could make future oral health promotion programs more efficient. Future studies should also explore parental involvement and develop strategies that improve parental involvement to make interventions more successful. Identifying opportunities for parental involvement in school matters is a challenge that merits further research.

The cost of implementing interventions should always be considered and using the school system to provide information to students and parents appeared to be efficient and cost-effective (83, 245). In this study, the level of involvement of the broader school community, including health services, was not known and this is an aspect that should be explored further in subsequent studies. Community involvement is known to be difficult and time-consuming, but there is some evidence that this type of support can enhance health (179, 245).

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