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ORIGINAL ARTICLE

Changes in adolescents' oral health status following oral health promotion activities in Tanzania

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Abstract

Objective. To assess the impact of oral health promotion integrated with a health promoting school (HPS) initiative on the oral health outcomes of secondary school students. ***Materials and method.*** Using an urban–rural stratified cluster randomized approach, the intervention was applied to secondary school students in Arusha, Tanzania. In the urban, three control ($n = 315$) and two intervention ($n = 214$) schools performed oral clinical examination and questionnaires at baseline. In rural the corresponding figures at baseline were two ($n = 188$) and three ($n = 360$) schools. After 2 years, 374 and 358 students remained in the intervention and control arms. ***Results.*** Mean number of decayed teeth (DT) increased in the intervention (mean score 1.0 vs 1.7, $p < 0.001$) and control schools (mean score 1.2 vs 1.7, $p < 0.001$). Mean number of teeth with plaque decreased significantly in intervention and control schools. No significant difference in caries increment and plaque decline scores was observed between groups. Mean number of teeth with bleeding decreased (0.5 vs 0.3, $p < 0.05$) in intervention schools, whereas no change was observed in the control schools (0.4 vs 0.5, $p = 0.051$). Increment in mean number of DT between baseline and follow-up was largest and smallest in students who, respectively, deteriorated and improved their plaque and bleeding scores. ***Conclusion.*** The intervention activities did not show any effect with respect to dental caries, calculus and plaque status among the students investigated. Compared with the control group, more favorable changes in the intervention group occurred with respect to bleeding on probing, suggesting a weak but positive effect on students' oral hygiene status.

Key Words: *health promoting schools, adolescents, oral health status*

Introduction

In Tanzania, as in other Sub-Saharan African (SSA) countries, oral diseases have remained at low-to-moderate levels by international standards (for review see [1]). Approximately 30–40% of the population irrespective of age is reportedly free from dental caries [2]. A number of cross-sectional epidemiological studies have reported low levels of dental caries in the child and adolescent populations [1–3]. Longitudinal studies have shown that caries lesions progress more slowly than previously expected [2]. However, children and adolescents with untreated caries lesions and dental pain has been cited as the main reason for seeking dental care [4,5]. Poor oral hygiene is common, with a substantial proportion of youth having calculus and gingivitis [6,7]. Evidence suggests that schoolchildren have inappropriate knowledge and deficient tooth brushing skills [8]. As the capacity of the Tanzanian oral healthcare services is limited, it seems unrealistic to manage oral diseases by traditional curative strategies [9]. Poor oral hygiene conditions and anticipated increase in caries prevalence following economic progress and changed dietary habits should be challenged primarily through preventive efforts.

Traditionally, health and oral health education has been part of the Tanzanian primary school curriculum. This activity has been recognized as a priority mean to comply with the scarce number of dental professionals in the country [9]. The school oral health education program implemented since

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1982 aims at fostering proper oral health behavior among school-age children [10]. Poorly equipped teachers to handle oral health subjects and lack of leadership and funds from the government might have contributed to the ineffectiveness of the Tanzanian school oral health education program [11]. So far, little is known about the outcomes of school-based oral health promotion in Tanzania and other Sub-Saharan African countries.

Although improved gingival health and oral health knowledge follow from traditional school-based intervention programs, many studies have revealed only a temporary effect on plaque accumulation, no discernable effect on caries increment and only short-term impacts on attitudes, knowledge and behavior related to oral health [12–15]. As an alternative, theory-based and appropriately evaluated public health approaches have been suggested to be a powerful tool in promoting oral health among adolescents [16,17]. One possible public health approach is the 'Health Promoting Schools (HPS)' initiative introduced by the World Health Organization, WHO, in 1989 [18]. Recently, oral health was integrated into the HPS program [19]. The Ottawa Charter is echoed in WHO's definition of the aims of a HPS as '... achieving healthy lifestyles for the total school population by developing supportive environments conducive to the promotion of health'. Denman et al. [20] suggested that, within the perspective of a HPS, the five key issues are (i) the professional roles and training, (ii) partnerships, (iii) personal, social and health education and citizenship, (iv) safe and welcoming learning and working milieu and (v) action competence. Thus, a HPS is not a place where only single health-promoting activities take place, but rather schools that have a 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 enables healthy choices. In support of HPS initiatives, Peters et al. [21] identified five effective elements of school health promotion to be similar across various behavioral domains, suggesting that programs addressing those behavioral domains simultaneously may be feasible. A few HPS initiatives in Brazil and China have revealed positive effects on dental caries development of pupils attending schools with supportive policies [22,23]. A synthesis of existing reviews concludes that no HPS initiative including oral health outcomes has been conducted in Sub-Saharan Africa [24].

If an oral health promotion integrated with a HPS initiative is successful in improving oral health status, this might be an effect that is mediated by corresponding improvements in oral health knowledge, attitudes and behavior. Such an improvement might be of relevance for large-scale implementation of oral health interventions in the Tanzanian school system. This paper evaluates oral health promotion activities integrated with a HPS initiative and implemented among secondary school pupils in Arusha, Tanzania. Specifically, this study assessed the joint interventional impact on oral health indicators at short-term follow-up from baseline.

Aims

The overall objective of this study was to test the hypotheses that there would be differences in caries increments and in the development of oral hygiene indicators between students who have and who have not attended HPS supporting schools. The following research questions were addressed; to what extent is dental caries, plaque, calculus and gingival bleeding subject to change following a 1-year HPS program; to what extent are socio-demographic differences in clinical parameters subject to change; to what extent do changes in clinical parameters differ between students belonging to the intervention and control arms of the HPS program; and are observed changes in dental caries associated with corresponding changes in dental plaque, calculus and bleeding on probing?

Methods

Sampling procedure

The present study, entitled the Limpopo-Arusha school health project, LASH, was conducted in Arusha, Northern Tanzania between April/June 2009 and March/April 2011. Arusha has a fluoride concentration in drinking water amounting to 3.6 mg fluoride/l and fluorosis is endemic in the area. A baseline survey was conducted in 2009 1-year ahead of the implementation of HPS activities and was repeated as a follow- up evaluation in 2011. The design of the study is presented in Figure 1. As this study included several outcomes, the size of the baseline sample was calculated separately for each of them and the largest sample size required was adopted. A sample size of ~ 2400 individuals was calculated to be satisfactory for the baseline study using an absolute precision of 0.02, 95% CI and design factor of 2. At baseline a total of 59 public secondary schools were listed, of which 31 schools fulfilled the inclusion criteria of being a public school, having student enrolment of more than 200 students and accepting to participate in the project of becoming a HPS. A one staged stratified cluster sampling was utilized with 11 urban schools (n = 7533 in forms I and II) and 20 rural schools (n = 9141 in forms I and II) constituting the sampling frame. Ultimately, 2412 (1163 urban and 1249 rural) Form 1 and II students completed the baseline questionnaire survey in 2009.

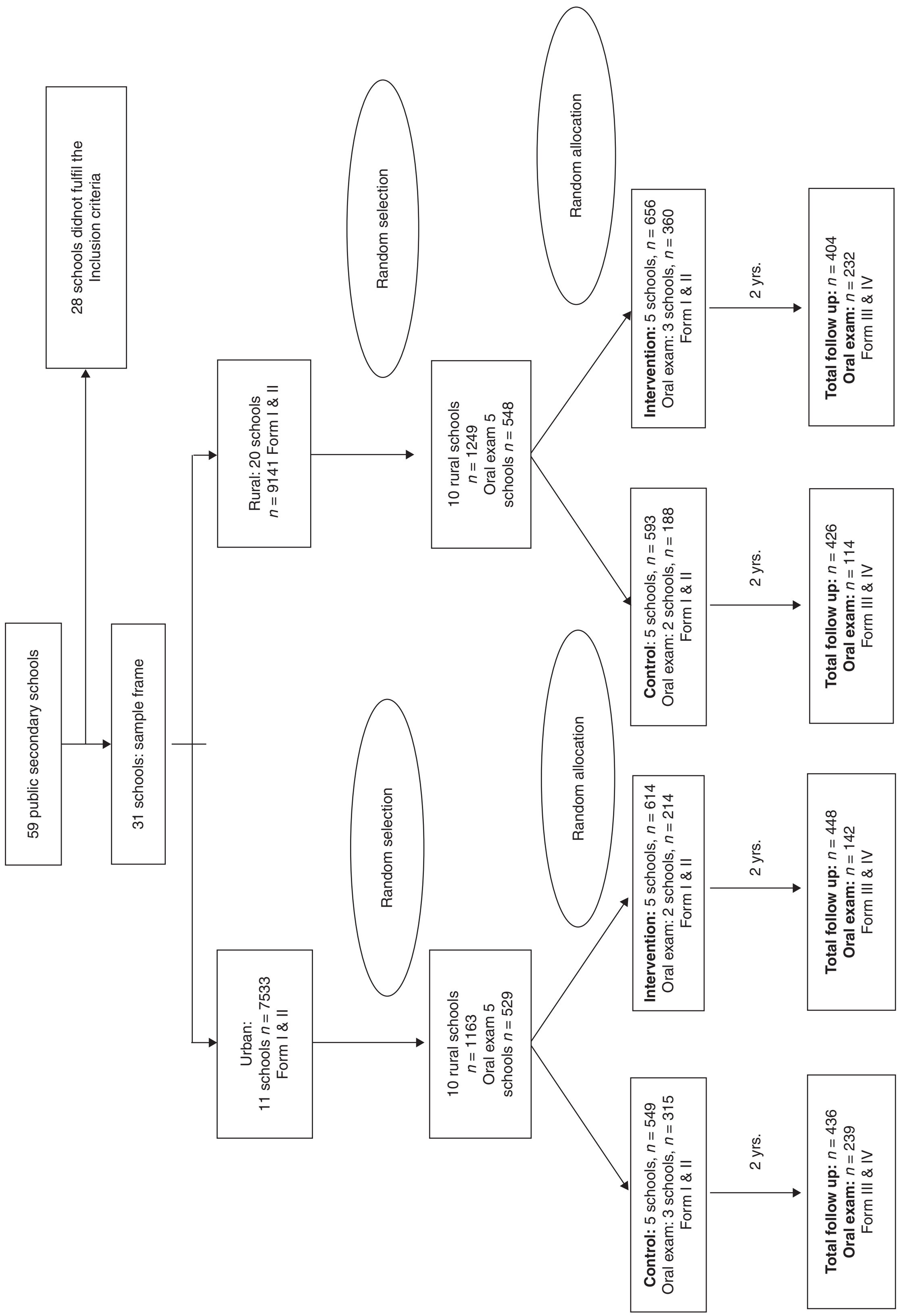

Figure 1. Flow chart of a cluster randomized intervention focusing on secondary school students in Arusha, Tanzania.

Due to financial constraints and limited manpower resources, a full mouth clinical oral examination was conducted as part of the baseline survey targeting a random sub-sample of 10 schools (participating students, n = 1077). Following the baseline survey, a pre-determined fixed number of 10 urban and 10 rural schools were randomly allocated to intervention and control arms; in urban: five control schools (n = 549) and five intervention schools (n = 614) of which, respectively, three (n = 315) and two schools (n = 214) completed a full mouth oral clinical examination and a self-administered questionnaire at baseline, in rural: five control schools (n = 593) and five intervention schools (n = 656) of which, respectively, two (n = 188) and three schools (n = 360) completed a full mouth clinical examination and a questionnaire at baseline. In the urban sample two control and three intervention schools completed only questionnaires at baseline, whereas this was the case in three control and two intervention schools in the rural sample. This cluster randomization was stratified according to urban/rural location and assigned with a table of random numbers with clusters assigned in a 1:1 allocation ratio. In 2011, 1714 - students (follow-up rate 71.5%) in Forms III and IV were followed up with a questionnaire survey, whereas 727 of the 1077 (follow-up rate 67%) baseline students underwent a questionnaire survey and a clinical oral re-examination (Figure 1). As this study focuses the clinical results emanating from a sub-group of 10 schools within the originally randomized 20 schools, it does not completely satisfy the requirements of a controlled cluster randomized field trial [25]. Parents and students gave written informed consent to participate in the study at baseline. Permission to conduct the study was granted by the school authorities and ministries of Education and Health. Ethical clearance was sought from Muhimbili University of Health and Allied Sciences (MUHAS), National Institute for Medical Research (NIMR) both from Tanzania and REK VEST in Norway. For detailed descriptions of the sampling procedures and baseline survey see Mbawalla et al. [26].

Questionnaires

The identical baseline- and follow-up questionnaires were initially constructed in English and translated into Kiswahili, the national language of Tanzania. It was subsequently back-translated into English by independent translators qualified in English and Kiswahili. Following a pilot test, some modifications in terms of clarification and simplification of wording were done. The questionnaires were completed by students in a classroom setting under the supervision of trained research assistants.

Oral clinical examination

For a total of 10 schools (five intervention and five controls), similar oral examinations were conducted at baseline and follow-up by one of the authors of this paper (HM), whereas dental assistants recorded the clinical observations. All members of this team were trained and calibrated for the clinical procedures [26]. Caries experience was assessed according to the criteria described by the WHO [27]. Oral hygiene was assessed using the Simplified Oral Hygiene Index (OHIS), recognized to be useful for evaluation of dental health education in public school systems [28]. To assess gingival inflammation, the Gingival Bleeding Index (GBI) [29] was utilized. For each individual, the decayed-, plaques-, calculus- and bleeding scores of each index tooth were summed for use in the analyses (range 0–13 for plaque and calculus, range 0–5 for bleeding and range 0–11 for decayed teeth). Sum scores were categorized as 1 = presence, 0 = absence with cut-off points, DT >0, sum calculus score >2, sum plaque scores >2 and sum bleeding scores >0. Change scores for decayed teeth, plaque, calculus and bleeding were constructed by subtracting follow-up scores from baseline scores. Negative change scores were categorized as a deteriorated condition, zero change scores as a stable, no change condition and positive change scores as improved condition.

HPS activities

Based on WHO's principles [19], the LASH project developed a protocol for how to interact with schools to support them to become a HPS. At the time when the schools decided to become a HPS based on their own need assessment, LASH provided support by identifying available interventions. The main HPS activities implemented were sexual and reproductive health education focusing family planning and prevention of STDs, donation of books and distribution of water tanks of 2000 l capacity. Oral health education sessions were conducted in all 10 intervention schools. A team of three research assistants conducted the oral health educational sessions, giving room for participants to ask questions when they needed clarification. The sessions lasted 45 min and were attended by both students and school teachers. The key oral hygiene messages included: brush with fluoride toothpaste, brush for 3 min at least twice a day and replace toothbrush when bristles start to get out of shape. Each participant was given supervized tooth brushing instructions and a toothbrush to be used at home. Information was provided regarding oral health consequences of frequent between-meal consumption of sugared products and drinks. A wall fit poster with key oral health messages was offered to each intervention

Table I. Distribution of socio-demographics and clinical indicators by intervention and control groups at baseline clinical sub-sample (n = 1077).

Variable	Intervention group n (%)	Control group n (%)	p-value
Age			
12–15 years	345 (63.9)	288 (59.6)	
16–21 years	195 (36.1)	196 (40.4)	0.176
Sex			
Male	228 (39.7)	274 (54.6)	
Female	346 (60.3)	229 (45.5)	0.001
Residence			
Urban	214 (37.3)	315 (62.6)	
Rural	360 (62.7)	188 (37.4)	0.001
House SES			
High	446 (78.9)	379 (76.0)	
Low	119 (21.1)	120 (24.0)	0.240
DT, M (SD)	1.1 (1.6)	1.2 (1.9)	0.083
Bleeding score, M (SD)	0.6 (0.9)	0.4 (0.7)	0.001
Plaque score, M (SD)	3.3 (2.7)	3.1 (2.6)	0.259
Calculus, M (SD)	3.8 (3.1)	2.8 (3.1)	0.001

school to act as a reminder after the oral health educational session had been completed.

Statistical analysis

Statistical package PASW 18.0 was used for data analyses. To account for cluster effect (i.e. the subjects were clustered within the unit of randomization) confidence intervals were adjusted using a Complex sample. The main analyses, testing for effect of intervention activities, were conducted per protocol, i.e. including pupils who participated both at baseline and follow-up (cohort n = 727). Differences in socio-demographic- and clinical indicators at baseline between the intervention and control arms as well as the variation in socio-demographics and clinical indicators by participation status were tested using one-way ANOVA and Chi-square tests. Changes form baseline to follow-up with respect to clinical oral health indicators were tested using paired t-test, Cochrane's Q and General Linear Models. To quantify changes, effect size statistics were calculated by dividing the mean change scores by the SD of the corresponding baseline score. Cohen [30] described effect size statistics of <0.2 to indicate a small, clinically meaningful magnitude of change, effect size statistics in the range 0.2–0.7 to indicate moderate change and effect size statistics of >0.7 to indicate large change. GLM repeated measures were used to analyze the association between changes in decayed teeth on the one hand side and changes in calculus, plaque and bleeding scores on the other hand side. As some respondents had missing values on some variables the numbers presented in the tables might vary slightly.

Cluster RCTs with a large number of clusters available and sufficient numbers of individuals per cluster are capable of detecting small changes [31]. For trials like the present one, with a fixed limited number of clusters per arm, the available power was limited. A re-calculation as suggested by Hemming et al. [31] was performed to determine whether the available five clusters per arm were sufficient to detect a certain amount of change in the clinical parameters. Assuming the required sample size per arm under individual randomization at 80% power to detect a minimum difference of 10 percentage points is n = 385. With ICC ranging from 0.005 – 0.02, the number of clusters sufficient per arm should be in the range between 1.9–8, being less than five clusters per arm in many cases.

Results

Baseline findings

Baseline differences between students belonging to the intervention and control arms occurred with respect to sex, place of residence and mean calculus and bleeding scores (Table I). As shown in Table II, drop outs were more likely to belong to the oldest age group and were more often males and rural residents compared with subjects that were not lost to follow-up.

Table II. Socio-demographics and clinical variables at baseline by response status.

Variable	Loss to follow-up, % (n)	Responders, % (n)
Age		
12–15 years	54.2 (179)	65.3 (454)
16–21 years	45.8 (151)	34.7 (241)**
Sex		
Male	51.1 (179)	44.4 (323)
Female	48.9 (171)	55.6 (404)*
Residence		
Urban	42.3 (148)	52.4 (381)
Rural	57.7 (202)	47.6 (346)*
House SES		
High	74.3 (255)	79.1 (570)
Low	25.7 (88)	20.9 (151)
DT, M (SD)	1.2 (1.8)	1.1 (1.7)
Bleeding score, M (SD)	0.4 (0.7)	0.5 (0.9)
Plaque score, M (SD)	3.1 (2.7)	3.3 (2.6)
Calculus, M (SD)	3.4 (3.2)	3.3 (3.1)

*$p < 0.05$.
**$p < 0.001$.

Responders and non-responders did not differ at baseline with respect to clinical oral health indicators.

Reproducibility

Repeated clinical oral examinations were carried out at baseline on a randomly selected sub-sample of 25 individuals considered to be representative of the study subjects. The Kappa statistics were 0.78, 0.67 and 0.83 with respect to calculus-, OHIS- and DMFT-scores.

Follow-up findings

Totals of 86.6%, 86.9%, 67.1% corresponds to hand washing and 79.3% of the students in the intervention arm confirmed having received information regarding healthy food, oral hygiene and tobacco during the previous school year. Corresponding figures among students in the control arm were 82.1%, 81.3%, 52.0% and 69.0% ($p < 0.001$) (not in table). As shown in Table III, gender differences in clinical oral indicators were more extensive in the control than in the intervention arm both at baseline and follow-up. In the intervention arm, urban–rural differences in caries experience at baseline (0.8 vs 1.1, $p < 0.05$) were not present at follow-up (1.4 vs 1.7), with caries increment being most pronounced among rural students. Urban–rural differences at baseline with respect to calculus (4.2 vs 3.5, $p < 0.05$) were not present at follow-up, with the increase in calculus being most pronounced among urban students. In the control group, urban–rural differences in calculus scores at baseline (4.2 vs 3.5, $p < 0.05$) were not present at follow-up, whereas sex and urban rural differences in bleeding scores not present at baseline appeared at follow-up.

For the study group as a whole, the mean number of teeth with caries and calculus increased from baseline to follow-up, whereas the mean number of teeth with plaque and bleeding upon probing decreased during that period (Table IV). Totals of 43% vs 52% ($p < 0.001$), 57% vs 45% ($p < 0.001$), 52% vs 49% (ns) and 33% vs 26% ($p < 0.05$) had, respectively, dental caries, plaque, calculus and bleeding upon probing at baseline and follow-up (not in table). Effect sizes varied from −0.2 (decayed teeth) to 0.5. The majority of students remained stable with respect to

Table III. Socio-demographic variation in clinical measures at baseline and follow-up separately in intervention and control arms (cohort $n = 727$).

	Intervention		Control	
	Boy	Girl	Boy	Girl
Baseline				
Decayed teeth	1.1 (1.7)	0.9 (1.5)	1.3 (2.0)	1.2 (1.9)
Plaque	3.6 (2.6)	3.1 (2.7)	3.4 (2.7)	3.1 (2.5)
Calculus	4.0 (3.0)	3.7 (3.2)	3.4 (3.3)	2.3 (2.7)**
Bleeding	0.5 (0.8)	0.6 (1.0)	0.3 (0.6)	0.6 (0.8)*
Follow-up				
Decayed teeth	1.7 (2.7)	1.6 (2.2)	1.8 (2.3)	1.6 (2.2)
Plaque	2.2 (2.6)	1.9 (2.5)	2.6 (2.8)	1.7 (2.2)**
Calculus	4.6 (4.1)	4.3 (3.7)	3.6 (3.5)	3.6 (3.5)
Bleeding	0.3 (0.6)	0.3 (0.6)	0.7 (1.2)	0.4 (0.8)*
	Urban	Rural	Urban	Rural
Baseline				
Decayed teeth	0.8 (1.4)	1.1 (1.5)*	1.2 (1.9)	1.3 (1.9)
Plaque	3.6 (2.8)	3.1 (2.6)	3.2 (2.5)	3.6 (2.8)
Calculus	4.2 (3.1)	3.5 (3.0)*	2.4 (3.0)	3.9 (3.2)**
Bleeding	0.6 (0.9)	0.5 (0.9)	0.5 (0.7)	0.4 (0.6)
Follow-up				
Decayed teeth	1.4 (2.1)	1.8 (2.2)	1.6 (2.2)	2.0 (2.2)
Plaque	1.9 (2.3)	2.1 (2.7)	2.1 (2.6)	2.4 (2.5)
Calculus	4.3 (3.6)	4.6 (3.6)	3.5 (3.7)	3.8 (3.4)
Bleeding	0.4 (0.8)	0.2 (0.6)	0.3 (0.7)	1.0 (1.8)**

**$p < 0.001$; *$p < 0.05$.

Table IV. Mean scores (SD) of decayed teeth, plaque, calculus and bleeding at baseline (T1) and follow up (T2), effect sizes and percentages who deteriorated, were stable and improved clinical indicators in the total study group (n = 727).

	Mean (SD)[a]	Effect size[b]	% (n) deteriorated	% (n) stable	% (n) improved
Decayed teeth (T1)	1.1 (1.7)				
Decayed teeth (T2)	1.7 (2.2)**	−0.4	29.2 (212)	67.8 (493)	3.0 (22)
Plaque (T1)	3.3 (2.6)				
Plaque (T2)	2.1 (2.5)**	0.5	27.1 (197)	15.0 (109)	57.9 (421)
Calculus (T1)	3.3 (3.0)				
Calculus (T2)	4.1 (3.6)**	−0.2	51.2 (372)	12.0 (87)	36.9 (268)
Bleeding (T1)	0.5 (0.9)				
Bleeding (T2)	0.4 (1.1)*	0.4	17.3 (126)	58.2 (423)	24.5 (178)

[a]Paired t-test.
[b]Effect size is mean change score divided by SD in baseline score.
**$p < 0.001$, *$p < 0.05$.

decayed teeth (52.5%) and bleeding (58.2 %), improved with respect to plaque (57.9%) and deteriorated with respect to calculus (44.2%).

According to Table V, the mean number of teeth with caries increased statistically significantly from baseline to follow-up in the intervention (mean score 1.0 vs 1.7, $p < 0.001$) and control arms (mean score 1.2 vs 1.7, $p < 0.001$). Mean number of teeth with plaque decreased in the intervention (3.3 vs 2.0, $p < 0.001$) and control arms (3.3 vs 2.2, $p < 0.001$), whereas mean number of teeth with calculus increased in both arms. In the intervention arm only, the mean number of teeth with bleeding decreased (0.5 vs 0.4, $p < 0.05$), whereas a slight non-significant increase was observed in the control group. General Linear Models (GLM) with Complex sample revealed no statistically significant differences in mean change scores between the intervention and control group regarding decayed teeth, plaque and calculus. In contrast, the mean change scores differed statistically significantly between intervention (mean change score 0.3) and control groups (mean change score (−0.1), $p < 0.001$.

As shown in Table VI, GLM repeated measures revealed that the increment in mean number of decayed teeth was statistically significantly larger in students who deteriorated their plaque (mean score 1.3 vs 2.2, $p < 0.001$) and bleeding scores (mean scores 1.2 vs 2.2, $p < 0.001$) from baseline to follow-up compared with students who improved plaque (mean score 1.1 vs 1.7, ns) and bleeding scores (mean score 1.2 vs 1.7, $p < 0.001$) during that period.

Discussion

To our knowledge, this is the first study implemented in SSA that has investigated effects on clinical oral health indicators following oral health promotion activities integrated within a HPS initiative and targeting secondary school students. The present results confirmed, partially, the hypothesis of better oral hygiene in schools where HPS activities were

Table V. Mean scores of clinical indicators at baseline (T1) and follow-up (T2) in intervention and control group. Mean change scores (adjusted for socio-demographics) by intervention and control group (n = 727).

			Intervention	Control
	Intervention M (SD)	Control M (SD)	Mean change[a] (95% CI)	Mean change[a] (95% CI)
Decayed teeth (T1)	1.0 (1.5)	1.2 (1.9)		
Decayed teeth (T2)	1.7 (2.2)**	1.7 (2.2)**	−0.7 (−0.9, −0.5)	−0.6 (−0.7,- −0.2)
Plaque (T1)	3.3 (2.7)	3.3 (2.6)		
Plaque (T2)	2.0 (2.5)**	2.2 (2.5)**	1.2 (0.9, 1.5)	1.1 (0.7, 1.4)
Calculus (T1)	3.7 (3.0)	2.9 (3.1)		
Calculus (T2)	4.3 (3.7)	3.7 (3.5)	−0.5 (−0.1, −0.07)	−0.8 (−1.3, −0.3)
Bleeding (T1)	0.5 (0.9)	0.4 (0.7)		
Bleeding(T2)	0.3 (0.6)**	0.5 (1.1)*	0.3 (0.1, 0.5)	−0.1 (−0.2, 0.03)*

[a]Negative change scores indicate deteriorated condition, positive change scores improved condition.
**$p < 0.001$, *$p < 0.05$.

Table VI. Mean scores for decayed teeth at baseline (T1) and follow-up (T2) by change scores of plaque, calculus and bleeding ($n = 727$).

	Plaque deteriorated	Plaque stable	Plaque improved	
	M (SD)	*M* (SD)	*M* (SD)	Factor × group
Decayed teeth (T1)	1.3 (1.9)	0.6 (1.2)	1.1 (1.7)	
Decayed teeth (T2)	2.2 (2.6)**(0.8)	1.0 (1.6)**(0.3)	1.7 (2.1)	$p = 0.008$
	Calculus deteriorated	Calculus stable	Calculus improved	
Decayed teeth (T1)	0.8 (2.0)	0.6 (1.1)	0.5 (0.9)	
Decayed teeth (T2)	1.2 (2.6)**	0.7 (1.2)*	0.7 (1.4)*	$p = 0.179$
	Bleeding deteriorated	Bleeding stable	Bleeding improved	
Decayed teeth (T1)	1.2 (1.6)	1.0 (1.7)	1.2 (1.8)	
Decayed teeth (t2)	2.2 (2.3)**	1.6 (2.1)**	1.7 (2.3)**	$p = 0.007$

**$p < 0.005$; *$p < 0.05$.

supported compared with non-supportive schools, thus being in line with the results of previous more traditional school-based intervention programs [12–15]. Positive outcomes regarding oral cleanliness and gingival bleeding following school-based oral health education have been reported from other developing countries [23]. Although supportive HPS presented with socio-demographically more homogeneous oral health outcomes at follow-up, the intervention activities did not significantly reduce sex- and residence status-related oral health differences, as recorded at baseline. Students attending supportive HPS had worse calculus status as compared to students in non-supportive schools at follow-up. The fact that calculus status was highest in supportive schools already at baseline and that access to dental healthcare is limited in this area might partly explain the absence of intervention effect with respect to this clinical parameter. Nevertheless, increments in number of decayed teeth and calculus and reduction in number of teeth with plaque did not vary significantly by intervention status. A small increment in caries development indicates that living in Arusha with high fluoride content in drinking water might be recognized as a caries protective factor. The absence of effect following intervention activities might be explained by a limited number of clusters and lack of statistical power preventing the detection of small but true effects [32]. Alternatively, the results demonstrate absence of effect due to various aspects of the intervention approach itself. Although table posters with key educational messages and illustrations were provided to each intervention school, the lecture duration of 4–5 h per school and the limited intervention period of 1 year considered might have made this approach a less successful tool for reaching secondary school pupils. Nevertheless, improvement in oral hygiene of children and adolescents following oral health promotion activities has been demonstrated after short intervention periods of 4–12 months, for instance by Redmond et al. [33], Worthington et al. [34] and Saied-Moallemi et al. [35]. Future studies should focus on the long-term consequences of HPS initiatives and on what educational activities secondary school pupils prefer in order to increase their attention and interest [36,37]. Better insight into pupils' preferences, more intensive and long lasting educational methods, use of peer educators and repeated instructions could make future oral health interventions more efficient. Nevertheless, the HPS activities did show a favorable effect on gingival bleeding status (Table IV). This suggests compliance on behalf of students and might reflect improved awareness and oral hygiene habits. As plastic toothbrushes were delivered to all students in supportive HPS, the improved oral hygiene status might be only temporary. It is also possible that, although the immediate effect of improved oral hygiene habits on bleeding status was small, this impact might be more substantial over time.

The present results agree with previous findings of school-based oral health promoting programs in both developed and developing countries where significant improvements in gingival health of children and adolescents has been reported [15,33–35,38]. Anttonen et al. [39] presented quite opposite results in terms of decreased toothbrushing frequency and no oral hygiene benefits for children in the intervention group. Previous school-based oral health promotion programs conducted in Tanzania and elsewhere have demonstrated no improvements in the clinical parameters whatsoever [40,41]. In this study, a sub-group of the initially randomized schools was analyzed, whereby imbalances between supportive and non-supportive schools at baseline were accounted for in the statistical analyses. As with other areas of healthcare, the use of cluster randomized trials is currently increasing [42] when randomization of individuals is not feasible, such as for instance in school-based health education, family-based interventions and community-based health promotion. In spite of the advantage of this design such as overcoming problems of contamination between subjects within the same school [32], participants in this study, coming from supportive and non-supportive HPS, had the opportunity to meet during leisure time in the afternoon. Thus, some contamination might have happened, particularly in the urban areas explaining the findings that not only students in intervention arms but also their counterparts in the control arm improved their plaque status from baseline to follow-up. Kay and Locker [14] noted that oral health education might improve knowledge, but that this improvement might not necessarily be accompanied by a health gain. In this study, the largest and smallest increments in caries were observed in students who, respectively, deteriorated and improved their plaque, calculus and bleeding status. Evidently, plaque control in newly erupted teeth reduces the development of caries lesions in those teeth significantly [43].

Some strengths and weaknesses of this study should be considered. Student's caries-, oral hygiene- and bleeding status were assessed at both occasions by one trained and calibrated dentist according to reliable measures that are commonly used [27–29]. Due to easy fluctuation of presence of plaque in the mouth and due to students having the possibility to brush their teeth just ahead of the oral examination, gingival bleeding is a more reliable indicator of oral hygiene status than is the plaque situation. According to the present results, caries experience at baseline amounting to 43% agreed with most previous reports considering school students of similar age groups in SSA [4]. Although the feasibility check by Hemming et al. [31] indicated a sufficient number of clusters in this study and although the Medical Research Council has accepted trials with five clusters as advisable, few clusters are still controversial due to the randomization of a small number of units [44]. In addition to being ineffective by having less statistical power compared with randomized controlled trials (RCTs) including the same number of individuals, there is an increased possibility of introducing biases. It has been argued, however, that studies of limited power are of importance as they contribute to the evidence framework by ultimately becoming parts of systematic reviews. More males than females, more rural than urban residents and more older than younger students were lost to follow-up (Table III). Although the attrition rate was moderate, loss to follow-up was not a random process and might, thus, have consequences for the interpretability of the findings [26]. Finally, cluster RCTs are challenging by raising a number of ethical issues that have not yet been addressed adequately [45].

In conclusion, oral health promotion integrated with a HPS initiative had no effect with respect to the dental caries, calculus and plaque situation among secondary students in Arusha, Tanzania. However, more favorable changes occurred in the intervention compared to the control arm with respect to bleeding on probing, suggesting a positive effect on students' oral hygiene status. However, the limited effect on gingival bleeding presents a challenge for future studies to achieve better and sustainable results. In spite of the intervention effects being limited, the positive effect on bleeding scores and students recognizing having received oral health information to a larger extent in the intervention than in the control group suggest that oral health promotion integrated within HPS initiatives in Tanzanian secondary schools might be of relevance. Thus, there is a potential to develop this interventional approach further within the context of resource-poor sociocultural settings.

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