European Journal of Orthodontics 31 (2009) 467–476
doi:10.1093/ejo/cjn125
Advance Access Publication 31 March 2009

Prevalence of malocclusion and its relationship with socio-demographic factors, dental caries, and oral hygiene in 12- to 14-year-old Tanzanian schoolchildren

Matilda Mtaya*,**, Pongsri Brudvik* and Anne Nordrehaug Åstrøm*
*Department of Clinical Dentistry, University of Bergen, Norway and **Department of Preventive and Community Dentistry, Muhimbili University of Health and Allied Sciences, Tanzania

SUMMARY The aim of this study was to assess the prevalence of malocclusion and its association with socio-demographic characteristics, caries experience, and level of oral hygiene in 12- to 14-year-old schoolchildren residing in two socio-economically different districts of Tanzania. A total of 1601 children (mean age 13 years, 60.5 per cent girls) attending 16 primary schools in Kinondoni and Temeke districts participated in a clinical examination and were interviewed in school settings. Chi-square and multiple logistic regression models were used to test for statistically significant differences between different groups.

The results showed that 63.8 per cent (62.6 per cent in Kinondoni and 66.0 per cent in Temeke) of the subjects had at least one type of anomaly, with a midline shift (22.5 per cent), spacing of at least 2 mm (21.9 per cent), and an open bite (16.1 per cent) being the most frequently recorded. The majority (93.6 per cent) of the children showed a Class I molar relationship. Class II and Class III malocclusions were registered in 4.4 and 2.0 per cent, respectively. Multiple logistic regression analyses, controlling for socio-demographic factors, showed that the odds ratio for having an open bite was 1.8 if residing in a less socio-economically privileged district. Subjects with decayed, missing, and filled teeth (DNFT) (>0) were 1.7, 2.1, 2.4, and 1.7, respectively, more likely to be diagnosed with a malocclusion, a midline shift, Angle Class II and III, and an open bite. Schoolchildren with fair/poor oral hygiene were less likely than their counterparts with good oral hygiene to be diagnosed with a midline shift.

Malocclusions were prevalent in the Tanzanian children investigated and were associated with environmental factors in terms of caries experience and residing in a less affluent district. Preventive programmes to combat the prevalence of malocclusion are recommended.

Introduction

Planning orthodontic treatment within a public health system requires information on the prevalence and distribution of malocclusions (Foster and Menezes, 1976). A malocclusion is defined as an irregularity of the teeth or a malrelationship of the dental arches beyond the range of what is accepted as normal (Walther *et al.*, 1994). Malocclusion is one of the most common dental problems in mankind, together with dental caries, gingival disease, and dental fluorosis (Dhar *et al.*, 2007). Malocclused teeth can cause psychosocial problems related to impaired dentofacial aesthetics (Kenealy *et al.*, 1989), disturbances of oral function, such as mastication, swallowing, and speech (Proffit and Fields, 2000), and greater susceptibility to trauma (Grimm *et al.*, 2004) and periodontal disease (Greiger, 2001).

Numerous studies have been published regarding the prevalence of malocclusion in various populations. The results have shown wide variations, with the reported prevalence ranging from 39 to 98 per cent (Table 1). Differences in the age ranges of the populations studied, ethnicity, and the number of subjects examined could explain some of the variations (Abu Alhaija *et al.*, 2005). Moreover, differences in the registration methods are probably the most important factors explaining these variations.

In Tanzania, a number of epidemiological studies have provided evidence of the prevalence of malocclusion in the child population. Kerosuo *et al.* (1988) examined schoolchildren aged 11–18 years in the city of Dar es Salaam and found that 96 per cent of the 642 children had a Class I molar occlusion, whereas 3, 1, and 16 per cent had a distal occlusion, mesial occlusion, and crowding, respectively. The overall prevalence of malocclusion was reported to be 45 per cent (Kerosuo *et al.*, 1991). In a sample of 353 12-year olds from Bukoba and Moshi (townships in the northern parts of Tanzania), a Class I occlusion was observed in 90 per cent while a large overjet (>3.5 mm), deep bite (≥3.5 mm), and spacing were found in 35, 35 and, 50 per cent, respectively (Mugonzibwa *et al.*, 1990). Another study in Dar es Salaam examined 698 schoolchildren aged 6–18 years. In all, 93–96 per cent of the children showed a Class I molar occlusion, 9–13 per cent an anterior open bite (AOB), and more than 33 per cent spacing (Mugonzibwa,

Table 1 Percentage distribution of malocclusions in children and adolescents in different ethnic groups.

Authors	Population	Subjects		Registration	%
		n	Age		
Thilander and Myrberg (1973)	Swedish	5459	13	Björk *et al.* (1964)	73.8
al-Emran *et al.* (1990)	Saudi Arabian	500	14	Björk *et al.* (1964)	62.4
Kerosuo *et al.* (1991)	Finnish	458	12–18	Angle classification	88
Kerosuo *et al.* (1991)	Tanzanian	642	11–18	Angle classification	45
Lew *et al.* (1993)	Chinese	1050	12–14	Foster and Day (1974)	92.9
Ng'ang'a *et al.* (1996)	Kenyan	919	13–15	Björk *et al.* (1964)	72
Silva and Kang (2001)	American–Latino	507	12–18	Angle classification	93
Thilander *et al.* (2001)	Colombian	1441	13–17	Björk *et al.* (1964)	88
Mugonzibwa *et al.* (2004)	Tanzanian	869	3½–16	Björk *et al.* (1964)	Up to 51
Onyeaso (2004)	Nigerian	636	12–17	Angle classification	76
Abu Alhaija *et al.* (2005)	Jordanian	1003	13–15	Björk *et al.* (1964)	92
Behbehani *et al.* (2005)	Kuwaiti	1299	13–14	Angle classification	86
Ciuffolo *et al.* (2005)	Italian	810	11–14	Criteria by US National Health and Nutrition Examination Survey (Brunelle *et al.*, 1996)	93
Gábris *et al.* (2006)	Hungarian	483	16–18	Dental Aesthetic Index (Cons *et al.*, 1986)	70.4
Rwakatema *et al.* (2006)	Tanzanian	289	12–15	Björk *et al.* (1964)	97.6
Dhar *et al.* (2007)	Indian	812	11–14	World Health Organization (1999)	38.9

1992). In a further study (Mugonzibwa *et al.*, 2004) considering 869 schoolchildren (3–16 years) in Dar es Salaam, found an overall prevalence of malocclusion of up to 51 per cent. Recently, the overall prevalence of malocclusion among 289 schoolchildren (12–15 years) in Moshi was reported to be 97.6 per cent (Rwakatema *et al.*, 2006). Thus, earlier reports indicate a wide variation in the prevalence of malocclusion among Tanzanian children.

Previous attempts to investigate a possible association of malocclusion and dental caries have shown conflicting or inconclusive results (Helm and Petersen, 1989a; Stahl and Grabowski, 2004). While some authors reported a positive association between malocclusion and dental caries (Gábris *et al.*, 2006; Nobile *et al.*, 2007), others could not establish any significant relationship (Helm and Petersen, 1989a; Stahl and Grabowski, 2004). Moreover, conflicting results have been obtained in studies considering a possible relationship between malocclusion and various oral hygiene measures (Ramfjord, 1987). The presence of a positive association between malocclusion and periodontal health has been described by Helm and Petersen (1989b) and Gábris *et al.* (2006), yet, other studies found no association when the amount of plaque, calculus, gingivitis, or pocketing was related to various indices of malocclusion (Katz, 1978; Buckley, 1980).

The relationship between dental caries, oral hygiene, and malocclusion has not yet been investigated in Tanzania. Since the Tanzanian oral health policy gives priority to children as a target group for oral health care services (Ministry of Health, 2002), such information is worthy of consideration. Knowledge concerning the distribution of malocclusion in the child population and the identification of predisposing factors and associated conditions might help in understanding its occurrence and assist public health policy makers improve interventions (Frazão and Narvai, 2006). Considering the varying prevalence of malocclusion that has been reported among Tanzanian children, the wide age ranges and mixed ethnicity of the investigated groups, the relatively small sample sizes employed, and the fact that many studies have been confined to only one district, a large-scale epidemiological study was, therefore, conducted focusing on schoolchildren aged 12–14 years residing in two socio-economically different districts of Tanzania. This study aimed to assess the prevalence of malocclusion and its distribution by socio-demographic characteristics, dental caries experience, and oral hygiene status.

Subjects and methods

Subjects

The study was carried out in Kinondoni and Temeke districts of the Dar es Salaam region in Tanzania (Fig. 1). These two districts differ in that Kinondoni (with a higher employment rate, literacy rate, and proportions of the population using electricity) is more affluent than Temeke (National Bureau of Statistics, 2004). A stratified proportionate two-stage cluster sampling design with public primary schools as the primary sampling unit was utilized. One thousand six hundred and one (632 boys, 969 girls) primary schoolchildren aged 12–14 years were randomly selected from 16 schools from a total of 220 public schools. The schools were selected from urban and rural areas of the two districts covering different socio-economic background. Lists of all

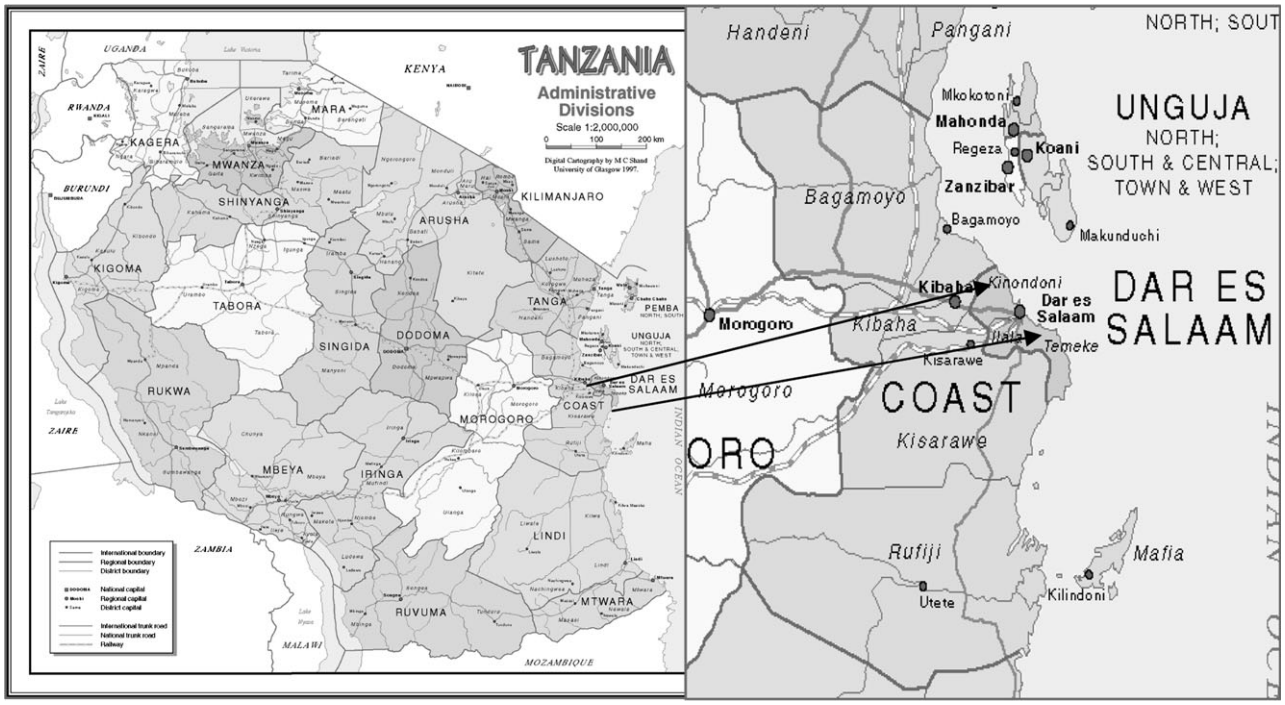

Figure 1 Map of Tanzania showing Kinondoni and Temeke districts of the Dar es Salaam region.

schoolchildren in the 16 selected schools with information on age and gender were collected from the schools. Selected children fulfilled the inclusion criteria of being in the defined age range of 12–14 years and in the permanent dentition. Only consenting subjects were included in the study and none of the pupils invited for participation had a history of orthodontic treatment (either interceptive or elective). A detailed description of the sampling procedure has been published previously (Mtaya *et al.*, 2008). Ethical approval was obtained from all relevant persons, authorities, and committees in Tanzania. These included written permission from the Research and Publication Committee of the Muhimbili University of Health and Allied Sciences. Permission to work with school children was obtained from Kinondoni and Temeke municipalities, their respective educational authorities, school administrations, parents, and the children.

Interview

Before being clinically examined, the participants completed a questionnaire in a face-to-face interview undertaken by two trained research assistants. The content and performance of the interview has been described in detail previously (Mtaya *et al.*, 2007).

Clinical examination

One trained and calibrated examiner (MM) conducted all clinical examinations in a classroom setting with natural daylight as the source of illumination and with an assistant recording the observations. Participants identified with problems that needed treatment were referred or advised to seek treatment at the two municipal hospitals of Kinondoni and Temeke districts. Oral health education sessions were provided for all participants. Before commencing the present investigation, a pilot study on 63 children was performed. Caries experience was assessed in accordance with the criteria by the World Health Organization (1997). Oral hygiene was assessed using the simplified oral hygiene index (OHI-S) (Greene and Vermillion, 1964). This index was developed to assess oral hygiene status, by combining the average individual or group debris and calculus scores (Greene and Vermillion, 1964). Occlusion was registered according to Björk *et al.* (1964), with some modifications by al-Emran *et al.* (1990).

Sagittal molar occlusion. The basic Angle classification was used. The intermaxillary relationship of the first permanent molars was registered as Class I (normal/neutral) when the mesiobuccal cusp of the maxillary first permanent molar occluded with the mesiobuccal groove of the mandibular first permanent molar. A Class II (distal) or Class III (mesial) molar occlusion was recorded when there was deviation of at least one-half cusp width distally or mesially to Class I, respectively. It was recorded as Class I (CL I = 1), II (CL II = 2), and III (CL III = 3) and dichotomized into 0 (CL I) and 1(CL II and III) for use in cross-tabulation and logistic regression analysis. No registration was made when the first permanent molars were missing.

Overjet. Overjet is the distance from the most labial point of the incisal edge of maxillary right central incisor to the most labial surface of the corresponding mandibular incisor measured to the nearest half millimetre, using a metal ruler parallel to the occlusal plane. A positive value (maxillary overjet) was recorded if the upper incisor was ahead of the lower incisor and a negative value (mandibular overjet) when the upper incisor was behind the lower incisor.

Maxillary overjet was categorized as 1, 1–4.9 mm (grade 1); 2, 5–8.9 mm (grade 2); and 3, ≥9 mm (grade 3). It was considered increased when the value exceeded 5 mm and dichotomized into 0 < 5 and 1 ≥ 5 mm for use in cross-tabulation and logistic regression analyses.

Mandibular overjet was coded as 0, absent; 1, <0 to −1.9 mm (grade 1); and 2, ≤−2 mm (grade 2) and recoded into 0 = absent and 1 = present (1 and 2).

Overbite. Overbite is the vertical overlap of incisors, measured to the nearest half millimetre vertically from the incisal edge of the maxillary right central incisor to the incisal edge of the corresponding mandibular right incisor. If the right central incisor was missing or fractured, it was substituted by the left central incisor. It was coded as 1, 0.1–2.9 mm (grade 1); 2, 3–4.9 mm (grade 2); and 3, ≥5 mm (grade 3) and then recoded into 0 = absent (<5 mm) and 1 = present (≥5 mm). It was considered as a deep bite when the value exceeded 5 mm.

Open bite. An AOB was recorded when there was no vertical overlap of the incisors, measured to the nearest half millimetre. A visible space between antagonistic fully erupted canines, premolars, or molars was registered as a lateral open bite. An open bite was coded as 0, absent; 1, 0–1.9 mm (AOB grade 1); 2, ≥2 mm (AOB grade 2); and 3, lateral open bite and recoded into 0 = absent and 1 = present (1, 2, and 3).

Lateral crossbite. A lateral crossbite was registered when one or more buccal cusps of the mandibular canines, premolars, and/or molars occluded bucally to the buccal cusps of the maxillary antagonists, recorded as 1, absent; 2, present unilaterally; or 3, present bilaterally. It was then dichotomized into 0 = absent (1) and 1 = present (2 and 3).

Scissor bite. A scissor bite was registered when any of the maxillary premolars and/or molars totally occluded to the buccal surface of the opposing mandibular teeth, recorded as 1, absent; 2, present unilaterally; or 3, present bilaterally. It was then dichotomized into 0 = absent (1) and 1 = present (2 and 3).

Midline shift. A midline shift was defined as non-coincident upper and lower midlines when the posterior teeth were in maximum intercuspation. It was coded as 1, absent and 2, present when the displacement was at least 2 mm or more. It was then recoded into 0 = absent (1) and 1 = present (2).

Crowding. Crowding was recorded when the total sum of slipped contacts measured in the segment was at least 2 mm. It was coded as 1, absent; 2, present upper jaw; 3, present lower jaw; and 4, present both jaws. It was then recoded into 0 = absent (1) and 1 = present (2, 3, and 4).

Spacing. Spacing was recorded when the total spacing was at least 2 mm in a segment. It was coded as 1, absent; 2, present upper jaw; 3, present lower jaw; and 4, present both jaws. It was then recoded into 0 = absent (1) and 1 = present (2, 3, and 4).

A sum score of malocclusions was constructed for use in cross-tabulation and logistic regression, based on the diagnosis of the absence (0)/presence (1) of the following recordings: maxillary overjet, mandibular overjet, Class II and Class III molar occlusions, open bite, deep bite, lateral crossbite, scissor bite, midline shift, crowding, and spacing.

Statistical analyses

Data were analysed using the Statistical Package for Social Sciences version 14.0 (SPSS Inc., Chicago, Illinois, USA). Test–retest reliability for the clinical parameters was assessed using Cohen's weighted kappa statistics. Cross-tabulation and chi-square statistics were used to assess bivariate relationships. Multivariate analysis was conducted using multiple logistic regression analysis. The *P* value for statistical significance was set at 0.05.

Test–retest reliability

Duplicate clinical examinations were carried out by the same examiner (MM) on a randomly selected subsample of 71 participants considered to be representative of the study subjects, after a time interval of 3 weeks. Analyses performed on the duplicate examination recordings gave Kappa values of 0.78, 0.79, 0.82, 0.93, and 0.97 for midline shift, deep bite, mandibular overjet, maxillary overjet, and spacing, respectively. The Kappa values for open bite, sagittal molar relationship, crossbite, scissor bite, and crowding were 1. Intraexaminer consistencies for decayed, missing, and filled teeth (DMFT) and OHI-S scores gave Kappa values of 0.93 and 0.74, respectively. These figures indicate very good intraexaminer reliability (World Health Organization, 1997).

Results

Sample profile

A total of 1003 children from Kinondoni (63.5 per cent urban, 58.9 per cent girls, mean age 13.1 years) and 598

children from Temeke (82.3 per cent urban, 63.2 per cent girls, mean age 13.0 years) completed an extensive personal interview and underwent a full-mouth clinical examination. The mean DMFT scores were 0.37 [standard deviation (SD) = 0.86] and 0.39 (SD = 0.84) in Kinondoni and Temeke, respectively. Corresponding OHI-S scores were 1.0 (SD = 0.53, range 0.0–3.3) and 1.2 (SD = 0.54, range 0.0–4.2). Finger sucking was reported by 12.1 per cent of the total sample. The percentage distribution of participants' socio-demographic characteristics, DMFT scores, OHI-S score, and sucking habits according to the district of residence are shown in Table 2.

Table 2 Distribution of socio-demographic characteristics, decayed, missing, and filled teeth (DMFT), simplified oral hygiene index (OHI-S) status, and sucking habits in Kinondoni and Temeke districts.

Variables	Categories	Kinondoni % (*n*)	Temeke % (*n*)	*P* value
Gender	Male	41.1 (412)	36.8 (220)	0.050
	Female	58.9 (591)	63.2 (378)	
Age	12 years	26.1 (262)	23.9 (143)	0.033
	13 years	41.9 (420)	48.5 (290)	
	14 years	32.0 (321)	27.6 (165)	
Parental education	Both low	38.5 (210)	53.8 (149)	<0.001
	One low/one high	24.2 (132)	20.9 (58)	
	Both high	37.2 (203)	25.3 (70)	
Place of residence	Urban	63.5 (637)	82.3 (492)	<0.001
	Rural	36.5 (366)	17.7 (106)	
DMFT	0	78.3 (785)	77.6 (464)	0.399
	≥1	21.7 (218)	22.4 (134)	
OHI-S score	Good	68.0 (682)	61.9 (370)	0.007
	Fair/poor	32.0 (321)	38.1 (228)	
Sucking habit	No	88.5 (888)	86.8 (519)	0.301
	Yes	11.5 (115)	13.2 (79)	

Prevalence of malocclusion

Overall findings. As shown in Figure 2, dentitions without any irregularity were found in 36.2 per cent of the children. Thus, 63.8 per cent (62.6 per cent in Kinondoni and 66 per cent in Temeke) of the children had one or several types of the anomalies. The majority of children had one (33 per cent) or two anomalies (21.5 per cent), whereas more than five anomalies were registered in 0.2 per cent of the sample.

Sagittal molar occlusion. A Class I (normal/neutral) occlusion was observed in 93.6 per cent of the total sample, while Class II (distocclusion) and Class III (mesiocclusion) were recorded in 4.4 and 2.0 per cent, respectively (Table 3). There were no significant differences in diagnoses between the districts or genders. In 141 schoolchildren, the molar relationship could not be registered due to missing first molars, and they were excluded from the sagittal molar occlusion analysis.

Maxillary overjet. A majority of the children (73.3 per cent) in the total population had a maxillary overjet <5 mm, and the proportion was significantly greater in children from Kinondoni than in those from Temeke (76.4 versus 68.2 per cent, $P < 0.001$). Overall, an overjet ≥5 mm occurred in 11.1 per cent and a severe increased overjet (≥9 mm) was registered in 0.4 per cent. A mandibular overjet was found in 8.4 per cent of the schoolchildren and 6.8 per cent had an edge-to-edge bite (Table 3).

Overbite. A normal overbite (grade 1, 0.1–2.9 mm) was recorded in 65.9 per cent of the total sample, while grade 2 (3–4.9 mm) and deep bite (grade 3, ≥5 mm) were registered in 17.9 and 0.9 per cent, respectively. Furthermore, children in Kinondoni had significantly more overbite grade 2 (3–4.9 mm) than in Temeke ($P < 0.001$, Table 3).

Open bite. An AOB was recorded in 15 per cent of the entire sample (Table 3). An AOB <2 mm was found less often in Kinondoni (7.4 per cent) than in Temeke (11.5 per cent, $P < 0.001$). Moreover, the occurrence of an AOB of <2 mm was significantly higher in girls (10.6 per cent) than in boys (6.3 per cent, $P < 0.05$). A lateral open bite was registered in 1.1 per cent of all children (Table 3).

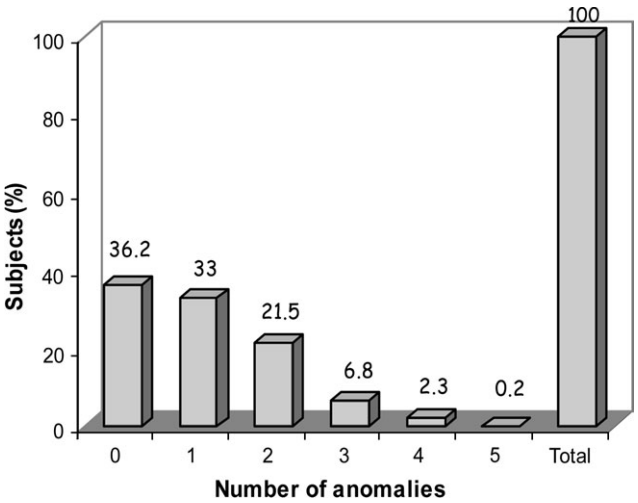

Figure 2 Percentage of schoolchildren according to the number of anomalies registered.

Transverse anomalies. Of the transverse anomalies, a midline shift (≥2 mm) was recorded in 22.5 per cent of the whole sample (Table 3). In addition, Temeke schoolchildren experienced more midline shift (27.4 per cent) than Kinondoni children (19.6 per cent, $P < 0.001$). A posterior crossbite was found in 5.1 per cent, while a scissor bite was registered in 14.3 per cent of all children.

Space discrepancies. Overall crowding (≥2 mm) was found in 14.1 per cent of the sample. No gender or district

Table 3 Percentages and number (*n*) of occlusal and space characteristics in Tanzanian schoolchildren according to district and gender.

	District		Gender		
	Kinondoni	Temeke	Boys	Girls	Total
	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Occlusal					
Sagittal					
Molar relationship					
Class I	93.8 (855)	93.2 (511)	93.4 (539)	93.7 (827)	93.6 (1366)
Class II	3.8 (35)	5.5 (30)	4.3 (25)	4.5 (40)	4.4 (65)
Class III	2.4 (22)	1.3 (7)	2.3 (13)	1.8 (16)	2.0 (29)
Maxillary overjet					
1–4.9 mm	76.4 (766)**	68.2 (408)	75 (474)	72.2 (700)	73.3 (1174)
5–8.9 mm	11.1 (111)	11.2 (67)	11.2 (71)	11.0 (107)	11.1 (178)
≥9 mm	0.2 (2)	0.8 (5)	0.6 (4)	0.3 (3)	0.4 (7)
Mandibular overjet					
0–1.9 mm	8.8 (88)	7.2 (43)	9.5 (60)	7.3 (71)	8.2 (131)
≥2 mm	0.1 (1)	0.5 (3)	0.3 (2)	0.2 (2)	0.2 (4)
Vertical					
Overbite					
0.1–2.9 mm	65.4 (656)	66.7 (399)	66.9 (423)	65.2 (632)	65.9 (1055)
3–4.9 mm	21.1 (212)**	12.5 (75)	19.0 (120)	17.2 (167)	17.9 (287)
≥5 mm	0.9 (9)	1.0 (6)	0.9 (6)	0.9 (9)	0.9 (15)
Anterior open bite					
0–1.9 mm	7.4 (74)**	11.5 (69)	6.3 (40)*	10.6 (103)	8.9 (143)
≥2 mm	4.8 (48)	8.2 (49)	6.0 (38)	6.1 (59)	6.1 (97)
Lateral open bite	1.0 (10)	1.2 (7)	1.3 (8)	0.9 (9)	1.1 (17)
Transverse					
Absent	82.0 (823)	78.0 (467)	79.3 (501)	81.4 (789)	80.6 (1290)
Crossbite	4.4 (44)	6.4 (38)	4.7 (30)	5.4 (52)	5.1 (82)
Scissor bite	13.6 (136)	15.6 (93)	16.0 (101)	13.2 (128)	14.3 (229)
Midline shift					
Absent (<2 mm)	80.4 (806)	72.6 (434)	75.9 (480)	78.4 (760)	77.5 (1240)
≥2 mm	19.6 (197)**	27.4 (164)	24.1 (152)	21.6 (209)	22.5 (361)
Space					
Absent (±2 mm)	60.8 (610)	69.4 (415)	60.9 (385)	66.1 (640)	64.0 (1025)
Crowding (≥2 mm)	15.1 (151)	12.4 (74)	15.7 (99)	13.0 (126)	14.1 (225)
Spacing (≥2 mm)	24.1 (242)**	18.2 (109)	23.4 (148)	20.9 (203)	21.9 (351)

*$P < 0.05$, **$P < 0.001$.

differences were recorded (Table 3). Spacing was noted in 21.9 per cent of the subjects. This anomaly was more frequent among children in Kinondoni than in Temeke (24.1 versus 18.2 per cent, $P < 0.001$).

Dental caries, oral hygiene, socio-demographic variables, and malocclusions. The association between malocclusions, DMFT, OHI-S score, and socio-demographic variables was analysed by cross-tabulation and chi-square test (Table 4). Possible confounding factors due to strong associations between the explanatory variables were taken into consideration in a multivariate logistic regression analysis (Table 4). In the final models, the district of residence and the DMFT status varied systematically with malocclusion. After controlling for all other variables in the analysis, district varied systematically with an open bite. Compared with Kinondoni children, those from Temeke were 1.8 times more likely to have an open bite. District did not vary systematically with a midline shift in the multivariate logistic regression analysis, although it was significant in the bivariate analysis. Caries experience varied systematically with a midline shift and an open bite. Compared with children without caries experience, those with DMFT >0 were 2.1 times more likely to have a midline shift and 1.7 times more likely to have an open bite. Children with caries experience were also 2.4 and 1.7 times more likely than caries-free children to have an Angle Class II and III molar relationship and to score above zero on the sum score of malocclusion. OHI-S score was not statistically significant in the bivariate analysis but varied systematically with a midline shift in the multiple logistic regression analysis. Thus, compared with children with OHI-S score of zero, those with OHI-S score above zero were less likely to have a midline shift (Table 4).

Discussion

Methodological issues

The present research is the first large population-based study considering the prevalence of malocclusion and its relationship with socio-demographic factors, dental caries, and oral hygiene among schoolchildren in Tanzania. Comparison of the sample characteristics with the Kinondoni and Temeke child population statistics on the markers of gender and parental education suggests that the sample was representative of the population of children aged 12–14 years in those districts. None of the children had received orthodontic treatment, either by interceptive or by corrective measures. It has been noted that in studies concerning the prevalence of malocclusion, the material should be obtained from a well-defined population and be large enough and cover non-orthodontically treated children (Thilander *et al.*, 2001). The present sample seems to satisfy those requirements.

The clinical registrations were based on the method evolved by Björk *et al.* (1964) with some modifications by al-Emran *et al.* (1990). Björk's method has been used in many studies and allows objective comparisons of the presence of malocclusion between different populations. However, comparisons of the present findings with those of other studies must be cautiously undertaken because different methods and indices have been applied in varying age ranges of populations. Moreover, no radiographs or study casts were used in the present investigation. The probability of having under- or overestimated some prevalence estimates such as agenesis, supernumerary teeth, the accuracy of space analysis as well as some details on the deviations of tooth positions cannot be overlooked. It has been shown that records made on the basis of casts seem to give a higher prevalence of deviations than direct recording (Helm, 1970; Heikinheimo, 1978). Nevertheless, given the sample size and the selection criteria used in this study, the findings provide a reasonably accurate indication of the occurrence of malocclusion in 12- to 14-year-old children in Dar es Salaam.

Prevalence of malocclusion

The overall prevalence of malocclusion (63.8 per cent) registered among schoolchildren in Dar es Salaam was found to be in agreement with that reported for Saudi Arabian children of a similar age (al-Emran *et al.*, 1990), lower than that reported by Rwakatema *et al.* (2006), but much higher than those obtained in previous studies among Tanzanian children (Kerosuo *et al.*, 1991; Mugonzibwa *et al.*, 2004). Differences in the registration methods may explain the variability of the findings.

Sagittal molar occlusion. In accorance with the findings of previous studies (Lew *et al.*, 1993; Ng'ang'a *et al.*, 1996; Silva and Kang, 2001; Thilander *et al.*, 2001; Abu Alhaija *et al.*, 2005), the predominant sagittal molar relationship among Tanzanian schoolchildren was Angle Class I (93.6 per cent). The prevalence of a Class II molar relationship (4.4 per cent) was in line with the previous investigations from Tanzania (Kerosuo *et al.*, 1988; Mugonzibwa *et al.*, 1990), but was lower than that reported among Swedish adolescents and Swedish Eastern European and Asian immigrants (Josefsson *et al.*, 2007). Moreover, the prevalence of a Class III molar relationship (2 per cent) compares with that found by Mugonzibwa (1992) but lower than that reported by Josefsson *et al.* (2007).

Table 4 Percentages and number (*n*) of schoolchildren with malocclusion according to district, dental caries, and oral hygiene status; logistic regression, odds ratios (ORs), and 95% confidence intervals (CIs). Adjusted for age, gender, parental educational status, and urban/rural residency.

	Sum score of malocclusion >0		Midline shift present		Angle Class II and III		Open bite present	
	% (*n*)	Adjusted OR (95% CI)	% (*n*)	Adjusted OR (95% CI)	% (*n*)	Adjusted OR (95% CI)	% (*n*)	Adjusted OR (95% CI)
District								
Kinondoni	62.6 (549)	1	19.6 (197)	1	6.3 (57)	1	13.2 (132)	1
Temeke	66.0 (316)	1.3 (0.9–1.8)	27.4 (164)**	1.3 (0.9–1.9)	6.8 (37)	0.9 (0.5–1.7)	20.9 (125)**	1.8 (1.2–2.7)
Decayed, missing, and filled teeth = 0	62.1 (667)	1	20.2 (252)	1	5.6 (70)	1	14.4 (180)	1
decayed, missing, and filled teeth > 0	70.2 (198)*	1.7 (1.1–2.6)	31.0 (109)**	2.1 (1.5–3.2)	11.4 (24)**	2.4 (1.3–4.6)	21.9 (77)**	1.7 (1.1–2.6)
Simplified oral hygiene index score = 0	62.9 (562)	1	22.6 (238)	1	6.1 (58)	1	15.6 (164)	1
Simplified oral hygiene index score > 0	65.4 (303)	0.8 (0.6–1.2)	22.4 (123)	0.6 (0.4–0.9)	7.2 (36)	1.3 (0.7–2.3)	16.9 (93)	1.1 (0.8–1.7)

*$P < 0.05$, **$P < 0.001$.

Mandibular overjet. The occurrence of a mandibular overjet was in agreement with that observed in Colombian children (Thilander *et al.*, 2001). The differences in the prevalence between Class III (2 per cent) and mandibular overjet (8.4 per cent) observed in the present study may indicate a functional anterior crossbite (Thilander *et al.*, 2001). However, the possibility of early loss of upper primary canines, leading to palatal tipping and/or distal migration of the upper permanent anterior teeth, cannot be excluded.

Maxillary overjet. The prevalence of an increased overjet (≥5 mm, 11.5 per cent) found in the present investigation was in agreement with previous studies among Tanzanian and Kenyan children (Kerosuo *et al.*, 1988; Ng'ang'a *et al.*, 1996), lower than that reported among Saudi children (al-Emran *et al.*, 1990) but higher than that observed by Mugonzibwa (1992). Differences in the definition of an increased overjet between the studies might have contributed to the variations in the reported results.

Overbite. The majority of children in the present sample had a normal overbite. A severe deep bite that exceeded 5 mm was rare (0.9 per cent). This is in accord with a previous finding among Tanzanian children with a complete permanent dentition (ES4) (Mugonzibwa *et al.*, 2004). Most of the children in this study had full eruption of the premolars and second molars, which might have stabilized their occlusion resulting in a decreased prevalence of a deep bite (Thilander *et al.*, 2001).

Open bite. An AOB (15 per cent) was a more common vertical occlusal anomaly. Its prevalence in the present study was close to that reported by Mugonzibwa *et al.* (2004) in children in ES4. Thilander *et al.* (2001) pointed out that an AOB is more frequently observed in black than in white American adolescents, indicating that its occurrence might be genetically determined. This results in a longer lower face and a higher mandibular plane angle in black adolescents. However, environmental factors such as mouth breathing associated with a warm climate (Lamberton *et al.*, 1980) as well as prolonged sucking habits after eruption of the permanent incisors (Larsson and Bishara, 2003), might have played a role. In this study, the prevalence of an open bite was higher in girls with a sucking habit than in boys. The prevalence of prolonged sucking habits was 15.2 and 7.4 per cent in girls and boys, respectively (data not shown). Nevertheless, a lateral open bite was rare and its occurrence compares with that reported by Laine and Hausen (1983) and al-Emran *et al.* (1990).

Transverse anomalies. The prevalence of a crossbite (5.1 per cent) was in agreement with that reported in the literature (Kerosuo *et al.*, 1988), but lower and higher than those reported by Mugonzibwa (1992) and Abu Alhaija *et al.* (2005), respectively. A posterior crossbite has been considered as a consequence of sucking habits which differ between different populations (Abu Alhaija *et al.*, 2005). On the other hand, the present prevalence of a scissor bite (14.3 per cent) was much higher than reported in earlier studies (Mugonzibwa *et al.*, 1990,2004; Kerosuo *et al.*, 1991; Ng'ang'a *et al.*, 1996; Abu Alhaija *et al.*, 2005). A midline shift (22.5 per cent) was the most common anomaly in this study; its frequency was much higher than that found among Kenyan and Saudi children (al-Emran *et al.*, 1990; Ng'ang'a *et al.*, 1996). This high prevalence of a midline shift might have been caused by unilateral premature loss of primary teeth, particularly primary canines (Hollander and Full, 1992).

Space discrepancies. Spacing of 2 mm or more (21.9 per cent) was the second most common anomaly present. Its prevalence was in agreement with that reported among rural Nigerian children (Otuyemi and Abidoye, 1993) but lower than that among Tanzanian children (Mugonzibwa *et al.*, 1990). Large arches in black people might explain the occurrence of more spacing than crowding (Abu Alhaija *et al.*, 2005). The prevalence of crowding (14.1 per cent) was similar to that observed by Gábris *et al.* (2006) and Kerosuo *et al.* (1988). Furthermore, both crowding and spacing were found more often in the upper than lower arch (data not shown). This finding was in agreement with that observed among Kenyan children (Ng'ang'a *et al.*, 1996).

Dental caries, oral hygiene, socio-demographic variables, and malocclusions. By examining the relationship between malocclusions, dental caries, oral hygiene, and socio-demographic characteristics using multiple logistic regression analysis, it was possible to compare the strength of the influence from each. Children with caries experience (DMFT > 0) were almost two times more likely to have any type of malocclusion (sum score of malocclusion > 0) compared with their counterparts without caries experience (DMFT=0). Similar results were obtained by Gábris *et al.* (2006) among Hungarian adolescents. Moreover, Stahl and Grabowski (2004) reported that dental caries and premature loss of primary teeth are predisposing factors for occlusal and space anomalies in the mixed and permanent dentition. In addition, schoolchildren with DMFT >0 were two times more likely than their counterparts without caries experience to be diagnosed with a midline shift. This finding is consistent with that found in Israeli children (Ben-Bassat *et al.*, 1997). A midline shift may be a result of a unilateral loss of the primary canine or first molar due to caries (Mitchell, 2005). Dental caries was further associated with an Angle Class II/III molar relationship, where children with DMFT >0 were two times more likely to be diagnosed with an Angle Class II/III than children with no caries. A similar finding was reported by Ben-Bassat *et al.* (1997). Untreated proximal caries in primary molars or early loss

of a second primary molar may lead to forward drift of the first permanent molar, promoting the change in molar relationship (Graber, 1972; Koch and Poulsen, 2001; Mitchell, 2005). Thus, some of the children with an Angle Class II or Class III malocclusion recorded in the present investigation might, indeed, have a neutral skeletal relationship. Lastly, the likelihood of being diagnosed with an open bite was almost two times more in children with dental caries than in children without caries. Corresponding results were reported by Peres *et al.* (2007) among Brazilian children. Reduced salivary flow in children with an AOB and with a mouth breathing habit may have enhanced susceptibility to dental caries (Thylstrup and Fejerskov, 1994).

A considerable difference in the occurrence of an open bite was observed in the two districts; children from Temeke were almost two times more likely than their Kinondoni counterparts to be diagnosed with that anomaly. This result might reflect the role of environmental factors in the occurrence of an open bite, with children from Temeke being not only less socio-economically privileged but also prolonged finger suckers to a larger extent than their counterparts from Kinondoni.

Regarding oral hygiene in this study, children with fair/poor oral hygiene were less likely than their counterparts with good oral hygiene to be diagnosed with a midline shift. In contrast, Helm and Petersen (1989b) found higher scores for gingivitis and periodontal pocketing in subjects with various malocclusions.

Conclusions

The prevalence of malocclusions in Tanzanian primary schoolchildren is comparable with that observed in similar-aged children from non-industrialized communities. The most prevalent malocclusion traits were a midline shift, spacing (≥2 mm), and an open bite. The most important finding in this study was the identification of environmental factors (caries experience and residing in a less affluent district) associated with malocclusion. This information is relevant for oral health policy making i.e. planning preventive measures.

Address for correspondence

Matilda Mtaya
Department of Preventive and Community Dentistry
Muhimbili University of Health and Allied Sciences
P. O. Box 65144
Dar es Salaam
Tanzania
E-mail: matilda.mtaya@odfa.uib.no

Funding

Department of Clinical Dentistry and the Centre for International Health, University of Bergen.

Acknowledgement

The authors would like to acknowledge the local administrative authorities and Research and Publication committee of the Muhimbili University of Health and Allied Sciences in Tanzania for giving permission to conduct this study. Thanks to the teachers for logistics assistance, parents for giving permission, all pupils who volunteered to participate in this study, and Professor O. E. Bøe for statistical advice.

References

Abu Alhaija E S, Al-Khateeb S N, Al-Nimri K S 2005 Prevalence of malocclusion in 13–15 year-old North Jordanian school children. Community Dental Health 22: 266–271

al-Emran S, Wisth P J, Bøe O E 1990 Prevalence of malocclusion and need for orthodontic treatment in Saudi Arabia. Community Dentistry and Oral Epidemiology 18: 253–255

Behbehani F, Årtun J, Al-Jame B, Kerosuo H 2005 Prevalence and severity of malocclusion in adolescent Kuwaitis. Medical Principles and Practice 14: 390–395

Ben-Bassat Y, Harari D, Brin I 1997 Occlusal traits in a group of school children in an isolated society in Jerusalem. British Journal of Orthodontics 24: 229–235

Björk A, Krebs Å, Solow B 1964 A method for epidemiological registration of malocclusion. Acta Odontologica Scandinavica 22: 27–41

Brunelle J A, Bhat M, Lipton J A 1996 Prevalence and distribution of selected occlusal characteristics in the US population, 1988–1991. Journal of Dental Research 75: 706–713

Buckley L A 1980 The relationships between irregular teeth, plaque, calculus and gingival disease. A study of 300 subjects. British Dental Journal 148: 67–69

Ciuffolo F *et al.* 2005 Prevalence and distribution by gender of occlusal characteristics in a sample of Italian secondary school students: a cross-sectional study. European Journal of Orthodontics 27: 601–606

Cons N C, Jenny J, Kohout F J 1986 DAI: the Dental Aesthetic Index. College of Dentistry, University of Iowa

Dhar V, Jain A, Van Dyke T E, Kohli A 2007 Prevalence of gingival diseases, malocclusion and fluorosis in school-going children of rural areas in Udaipur district. Journal of the Indian Society of Pedodontics and Preventive Dentistry 25: 103–105

Foster T D, Day A J W 1974 A survey of malocclusion and the need for orthodontic treatment in a Shropshire school population. British Journal of Orthodontics 1: 73–78

Foster T D, Menezes D M 1976 The assessment of occlusal features for public health planning purposes. American Journal of Orthodontics 69: 83–90

Frazao P, Narvai P C 2006 Socio-environmental factors associated with dental occlusion in adolescents. American Journal of Orthodontics and Dentofacial Orthopedics 129: 809–816

Gábris K, Márton S, Madléna M 2006 Prevalence of malocclusions in Hungarian adolescents. European Journal of Orthodontics 28: 467–470

Graber T M 1972 Orthodontics: principles and practice. W B Sunders Company, Philadelphia

Greene J C, Vermillion J R 1964 The simplified oral hygiene index. Journal of the American Dental Association 68: 7–13

Greiger A 2001 Malocclusion as an etiologic factor in periodontal disease: a retrospective essay. American Journal of Orthodontics and Dentofacial Orthopedics 120: 112–115

Grimm S, Frazao P, Antunes J L, Castellanos R A, Narvai P C 2004 Dental injury among Brazilian schoolchildren in the state of São Paulo. Dental Traumatology 20: 134–138

Heikinheimo K 1978 Need of orthodontic treatment in 7-year-old Finnish children. Community Dentistry and Oral Epidemiology 6: 129–134

Helm S 1970 Prevalence of malocclusion in relation to development of dentition. Thesis, University of Copenhagen

Helm S, Petersen P E 1989a Causal relation between malocclusion and caries. Acta Odontologica Scandinavica 47: 217–221

Helm S, Petersen P E 1989b Causal relation between malocclusion and periodontal health. Acta Odontologica Scandinavica 47: 223–228

Hollander C S, Full C A 1992 Midline correction by extraction of the remaining mandibular canine: myth or reality. ASDC Journal of Dentistry for Children 59: 207–211

Josefsson E, Bjerklin K, Lindsten R 2007 Malocclusion frequency in Swedish and immigrant adolescents—influence of origin on orthodontic treatment need. European Journal of Orthodontics 29: 79–87

Katz R V 1978 An epidemiologic study of the relationship between various states of occlusion and the pathological conditions of dental caries and periodontal disease. Journal of Dental Research 57: 433–439

Kenealy P, Frude N, Shaw W 1989 An evaluation of the psychological and social effects of malocclusion: some implications for dental policy making. Social Science & Medicine 28: 583–591

Kerosuo H, Laine T, Kerosuo E, Ngassapa D, Honkala E 1988 Occlusion among a group of Tanzanian urban schoolchildren. Community Dentistry and Oral Epidemiology 16: 306–309

Kerosuo H, Laine T, Nyyssonen V, Honkala E 1991 Occlusal characteristics in groups of Tanzanian and Finnish urban schoolchildren. Angle Orthodontist 61: 49–56

Koch G, Poulsen S 2001 Pediatric dentistry: a clinical approach. Munksgaard, Copenhagen

Laine T, Hausen H 1983 Occlusal anomalies in Finnish students related to age, sex, absent permanent teeth and orthodontic treatment. European Journal of Orthodontics 5: 125–131

Lamberton C M, Reichart P A, Triratananimit P 1980 Bimaxillary protrusion as a pathologic problem in the Thai. American Journal of Orthodontics 77: 320–329

Larsson E, Bishara S 2003 The influence of oral habits on the developing dentition and their treatment: clinical and historical perspectives. 2nd edn. University of Iowa

Lew K K, Foong W C, Loh E 1993 Malocclusion prevalence in an ethnic Chinese population. Australian Dental Journal 38: 442–449

Ministry of Health 2002 The United Republic of Tanzania: oral health care policy. Ministry of Health, Dar es Salaam, Tanzania

Mitchell L 2005 An introduction to orthodontics, 3rd edn. Oxford University Press, Oxford

Mtaya M, Åstrøm A N, Tsakos G 2007 Applicability of an abbreviated version of the Child-OIDP inventory among primary schoolchildren in Tanzania. Health and Quality of Life Outcomes 5: 40 (online article)

Mtaya M, Åstrøm A N, Brudvik P 2008 Malocclusion, psycho-social impacts and treatment need: a cross sectional study of Tanzanian primary school-children. BMC Oral Health 8: 14 (online article)

Mugonzibwa E A 1992 Variations in occlusal and space characteristics in a series of 6-18-year olds, in Ilala District, Tanzania. African Dental Journal 6: 17–22

Mugonzibwa E A, Mumghamba E, Rugarabamu P, Kimaro S 1990 Occlusal and space characteristics among 12-year-old school children in Bukoba and Moshi, Tanzania. African Dental Journal 4: 6–10

Mugonzibwa E A, Eskeli R, Kuijpers-Jagtman A M, Laine-Alava M T, van' t Hof M A 2004 Occlusal characteristics during different emergence stages of the permanent dentition in Tanzanian Bantu and Finnish children. European Journal of Orthodontics 26: 251–260

National Bureau of Statistics 2004 The United Republic of Tanzania: regional profile. National Bureau of Statistics, Ministry of Planning, Economy and Empowerment, Dar es Salaam, Tanzania

Ng'ang'a P M, Ohito F, Øgaard B, Valderhaug J 1996 The prevalence of malocclusion in 13- to 15-year-old children in Nairobi, Kenya. Acta Odontologica Scandinavica 54: 126–130

Nobile C G, Pavia M, Fortunato L, Angelillo I F 2007 Prevalence and factors related to malocclusion and orthodontic treatment need in children and adolescents in Italy. European Journal of Public Health 17: 637–641

Onyeaso C O 2004 Prevalence of malocclusion among adolescents in Ibadan, Nigeria. American Journal of Orthodontics and Dentofacial Orthopedics 126: 604–607

Otuyemi O D, Abidoye R O 1993 Malocclusion in 12-year-old suburban and rural Nigerian children. Community Dental Health 10: 375–380

Peres K G, De Oliveira Latorre Mdo R, Sheiham A, Peres M A, Victora C G, Barros F C 2007 Social and biological early life influences on the prevalence of open bite in Brazilian 6-year-olds. International Journal of Paediatric Dentistry 17: 41–49

Proffit W R, Fields H W 2000 Contemporary orthodontics. 3rd edn. Mosby, Inc, St Louis

Ramfjord S P 1987 Periodontal significance of orthodontic therapy. In: Derrik D D (ed). The dental annual. Wright, Bristol, pp. 156–166.

Rwakatema D S, Ng'ang'a P M, Kemoli A M 2006 Prevalence of malocclusion among 12-15-year-olds in Moshi, Tanzania, using Bjork's criteria. East African Medical Journal 83: 372–379

Silva R G, Kang D S 2001 Prevalence of malocclusion among Latino adolescents. American Journal of Orthodontics and Dentofacial Orthopedics 119: 313–315

Stahl F, Grabowski R 2004 Malocclusion and caries prevalence: is there a connection in the primary and mixed dentitions?. Clinical Oral Investigations 8: 86–90

Thilander B, Myrberg N 1973 The prevalence of malocclusion in Swedish schoolchildren. Scandinavian Journal of Dental Research 81: 12–21

Thilander B, Pena L, Infante C, Parada S S, de Mayorga C 2001 Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Colombia. An epidemiological study related to different stages of dental development. European Journal of Orthodontics 23: 153–167

Thylstrup A, Fejerskov O 1994 Textbook of clinical cariology. 2nd edn. Munksgaard, Copenhagen

Walther D P, Houston W J B, Jones M L, Oliver R G 1994 Walther and Houston's orthodontic notes. 5th edn. Wright, Oxford

World Health Organization 1997 Oral health surveys: basic methods. World Health Organization, Geneva

World Health Organization 1999 Oral health surveys: basic methods, 4th edn, World Health Organization, Geneva