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PERIODONTAL DISEASES IN TANZANIA

by

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Desire without knowledge is not good, and whoever makes haste with his feet misses his way
(Proverbs 19:2, ESV–The Holy Bible)

To my beloved wife Neema-Christine and our children Anna, David, Ruth and Andrew

ABSTRACT

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PERIODONTAL DISEASES IN TANZANIA

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School of Dentistry, Muhimbili University of Health and Allied Sciences, Tanzania.

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The aim of the study was to describe and analyse the periodontal condition and oral hygiene practices among Tanzanians.

Five individual studies in different locations between 1987 and 2003 assessed oral hygiene practices, periodontal status, risk factors, community periodontal treatment needs (CPITN), and gingival recession. Sample sizes ranged from 201 to 1,764. Subjects were recruited from a wide age range (3–95 years) by random and cluster samplings. Data were collected using questionnaires and by clinical examinations. Plaque, calculus, gingival bleeding, periodontal pocket probing depth, gingival recession, and tooth loss were recorded using a mouth mirror, Williams- and WHO periodontal probes.

Self-reported tooth-cleaning devices included plastic toothbrushes in 51.5-97.8%. The use of a chewing stick varied also: 0.9-32.0%. The prevalence of plaque was high; 65.0-100%. Most of the participants had supra- and sub-gingival calculus. Gingival bleeding (GB) on probing was found in 79-100% of the participants. GB was detected more often in males than in females, and in low educated participants. At the age ≥40 years, a periodontal pocket probing depth (PPD) of 4–5 mm was found in 82.1% and a PPD ≥6 mm in 43.8%. The CPITN indicated a very high need for oral health education (>90%), and for scaling and root planning (>80%). Tooth loss was higher among the chewing stick users than in the plastic toothbrush users. The most common risk factors for periodontal diseases were age (≥35 years), male sex, low education, plaque, calculus, gingival inflammation, and rural residency. Gingival recession (GR) ≥4 mm at the age ≥35 years was about 54%. Risk factors for gingival recession were age, calculus and gingival inflammation.

Oral hygiene status in the studied populations was very poor and gingival recession common. However, the occurrence of severe periodontal disease was low. The risk factors for periodontal diseases were age, male sex, low education, rural residence, plaque and calculus. Risk factors for gingival recession were age, male sex, calculus and gingival inflammation.

Key words: Periodontal diseases, oral hygiene practices, risk factors, treatment need, Tanzania

TIIVISTELMÄ

Elifuraha GS Mumghamba

HAMPAIDEN KIINNITYSKUDOSSAIRAUDET TANSANIASSA

Hammaslääketieteen laitos, Lääketieteellinen tiedekunta, Turun yliopisto ja
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Annales Universitatis Turkuensis. Sarja-Ser D, Medica-Odontologica. Painosalama Oy, Turku, Finland 2009.

Tutkimuksen tavoitteena oli kuvata hampaiden kiinnityskudossairauksien esiintyvyyttä ja suuhygieniatottumuksia Tansaniassa.

Viiden eri tutkimuksen avulla kartoitettiin suuhygieniatottumuksia, kiinnityskudosten tilaa, kiinnityskudossairauksien riskitekijöitä ja hoidon tarvetta (CPITN) sekä ienvetäymiä. Tutkimukset toteutettiin eri paikkakunnilla vuosien 1987 ja 2003 välillä. Tutkittavat valittiin satunnaisesti tai harkitusti; tutkittavien määrä vaihteli 201:stä 1764:ään. Aineistot kerättiin kysymyslomakkeilla ja kliinisten tutkimusten avulla. Kliinisesti mitattiin plakin, hammaskiven ja ienten verenvuodon määrä, ientaskujen syvyys, ienvetäymien laajuus ja puuttuvien hampaiden lukumäärä. Tutkimusvälineinä käytettiin peiliä, Williamsin ja WHO:n ientaskumittareita.

Muoviharjaksista hammasharjaa ilmoitti käyttävänsä 51,5-97,8% tutkituista. Ns. harjaustikun käyttö vaihteli paljon: 0,9-32,0 %. Plakkia löydettiin 65-100 %:lla tutkituista. Hammaskiveä oli suurimmalla osalla tutkituista. Myös ienverenvuotoa löytyi valtaosalta (79-100%). Ienverenvuotoa oli enemmän miehillä kuin naisilla sekä alhaisemman koulutustason omaavilla. Neljäkymmentä vuotta täyttäneiltä löydettiin 4–5 mm:n syvyisiä ientaskuja 82,1 %:lta ja ≥ 6 mm:n taskuja 43,8 %:lta. Suun terveystottumusten ohjaamiseen oli tarvetta yli 90 %:lla, hammaskiven poistoon ja juurten pinnan tasoitukseen yli 80%:lla. Yleisimmät riskitekijät kiinnityskudossairauksille olivat ikä (≥ 35 vuotta), miessukupuoli, alhainen koulutustaso, plakin, hammaskiven ja ientulehduksen määrä sekä asuminen maaseudulla. Ienvetäymiä (≥ 4 mm) löytyi noin 54%:lla tutkituista. Ienvetäymiä oli useammin miehillä kuin naisilla ja ne olivat yhteydessä ikään sekä hammaskiven ja ienverenvuodon esiintymiseen.

Suuhygieniataso tutkituilla henkilöillä oli huono ja ienvetäymien esiintyvyys korkea. Syviä ientaskuja löytyi kuitenkin harvoilta tutkituilta. Riskitekijät kiinnityskudossairauksille olivat ikä, miessukupuoli, alhainen koulutustaso, plakin, hammaskiven ja ientulehduksen määrä sekä asuminen maaseudulla. Ienvetäymien riskit olivat ikä, miessukupuoli, hammaskivi ja ienverenvuoto.

Avainsanat: Kiinnityskudossairaudet, suuhygienia, riskitekijät, hoidon tarve, Tansania

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ABBREVIATIONS

AIDS	Acquired Immuno-Deficiency Syndrome
BOP	Bleeding on Probing
CAL	Connective tissue Attachment Loss
CHD	Coronary Heart Diseases
CPI	Community Periodontal Index
CPITN	Community Periodontal Index of Treatment Needs
CPT	Complex Periodontal Treatment
DDS	Doctor of Dental Surgery
DHS	Demographic Health Surveys
DM	Diabetes Mellitus
ESI	Extent and Severity Index
ESV	English Standard Version
FINNIDA	Finnish International Developmental Agency
GDP	Gross Domestic Product
GR	Gingival Recession
HIV	Human Immuno-deficiency Virus
LE	Life Expectancy
MMC	Muhimbili Medical Centre
MUCHS	Muhimbili University College of Health Sciences
MUHAS	Muhimbili University of Health and Allied Sciences
NBS	National Bureau of Statistics
NUG	Necrotizing Ulcerative Gingivitis
NUP	Necrotizing Ulcerative Periodontitis
OHE	Oral Health Education
PDI	Periodontal Disease Index
PPD	Periodontal Pocket Probing Depth
PPP	Purchasing Power Parity
SIDA/SAREC	Swedish International Development Agency/ The Department for Research Cooperation
SRP	Scaling and Root Planing
TDHS	Tanzania Demographic and Health Survey
TN	Treatment Needs
UK	United Kingdom
USA	United States of America
WHO	World Health Organization

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications referred to in the text by their Roman numerals:

I Mumghamba EGS, Fabian FM. Periodontal Health Status and Oral Hygiene Practices among Middle-Aged Adults in Mtwara Rural, Tanzania. *African Journal of Oral Health Sciences* 2003;4:192–197.

II Mumghamba EGS, Markkanen HA, Honkala E. Periodontal Status and Treatment Needs in a Rural area of Ukonga, Tanzania. *International Dental Journal* 1996;46:156–160.

III Mumghamba EGS, Markkanen HA, Honkala E. Risk factors for periodontal diseases in Ilala, Tanzania. *Journal of Clinical Periodontology* 1995;22:347–354.

IV Mumghamba EGS, Honkala S, Honkala E, Manji KP. Gingival recession, oral hygiene and associated factors in women at the Maternity ward in Dar es Salaam, Tanzania *(East African Medical Journal – Submitted)*.

V Mumghamba EGS, Fabian FM. Tooth loss among habitual chewing-stick and plastic toothbrush users in the adult population of Mtwara, rural Tanzania. *International Journal of Dental Hygiene* 2005;3:64–69.

1 INTRODUCTION

Periodontal diseases are the diseases that involve the periodontal structures beyond the gingiva and lead to loss of connective tissue attachment (Ranney 1993). Periodontal diseases are among the most widespread diseases in mankind (WHO 1978). The oral cavity is not a sterile cavity. There are more than 500 bacterial species that are capable of colonizing in the oral cavity, and while about 150 species can be found in one individual, a number of these species are more associated with periodontal diseases than others (Socransky & Haffajee 2003). Periodontal diseases are caused not by a single oral micro-organism but by several and the list is still being refined due to the complexity of the matter. Some of the micro-organisms are considered to be more pathogenic than others.

Several methods have been developed to study the distribution of periodontal diseases in a population. These methods are usually used to determine both the occurrence of periodontal diseases and associated conditions in the community. For each or more than one of the periodontal conditions there is an index that is specifically designed to score the presence and/or extent of each condition of interest. The indices for periodontal conditions particularly the microbial plaque, calculus, gingival bleeding, gingival recession, periodontal pockets, connective tissue attachment levels have a long history of development, and modifications to improve their applications have been adopted from time to time (WHO 1987, 1997, Papapanou & Lindhe 2003, Beck & Arbes 2006). None of the indices is ideal as highlighted by Papapanou (1996). From the epidemiological and clinical findings, it has become evident that there are different types of periodontal diseases, and therefore, different classifications have been applied at different times (Armitage 2002).

The use of different methods to study periodontal diseases and even different approaches in selecting the study participants, all limit the process of interpretation of the available data from different epidemiological population-based studies around the world (Albandar & Rams 2002). However, in these studies, a close relationship between dental plaque and gingivitis has been demonstrated as was initially reported by Löe et al. (1965) in non-population-based studies. As for global epidemiological data, it is clear that there is a less pronounced relationship between dental plaque and severe periodontitis. Severe forms of human periodontitis frequently affect the minority globally, in particular, in the United States (Albandar 2002a), in Central and South America (Gjermo et al. 2002), in Europe (Sheiham & Netuveli 2002), in Asia and Oceania (Corbet et al. 2002), and in Africa (Baelum & Scheutz 2002). The risk factors for the occurrence of periodontal diseases have been confirmed to include smoking and diabetes mellitus (Albandar 2002b). In addition, from large epidemiological studies there is evidence that in some populations periodontal diseases are more prevalent in males than in females and that they increase with increasing age (Albandar et al. 1999, Albandar 2002b).

Prevention of periodontal diseases is important. Strategies for prevention and periodontal control could be high risk and whole population strategies. For populations with a low level of oral hygiene and dental care, a "whole population strategy" is recommended to reduce the periodontal treatment need in the general population (Axelsson et al. 2002, Baelum et al. 2007). The "high risk strategy" for the group of people who are at higher risk for developing periodontal diseases is appropriate for populations with moderate or high standards of oral hygiene and well-organized oral health care services (Axelsson et al. 2002). The most widely accepted methods for controlling periodontal diseases and the associated conditions are personally and professionally applied mechanical oral hygiene measures (Gift 1993, Axelsson et al. 2002).Thus, toothbrushing is the most widely used mechanical means of personal plaque control throughout the world (Axelsson et al. 2002).

For personal reasons, Tanzania will be presented in detail as a prototype of a population with a low level of oral hygiene and dental care. In principle, it is agreed that the basic etiological factors of periodontal diseases do not differ in industrialized and developing countries (Axelsson et al. 2002). However, in countries with an "emerging economy" compared to those with an "established economy", there is a higher prevalence of gingivitis in children and slight to moderate periodontitis due to poor oral hygiene standards (Axelsson et al. 2002). In Tanzania, the situation show similar trends (Lembariti et al. 1988).

Geographically, Tanzania is situated in East Africa and, in the north, is bordered by Kenya and Uganda, and in the west, by Rwanda, Burundi, and DRC Congo. Also South of Tanzania lie Zambia, Malawi, and Mozambique, while on the eastern side there is the Indian Ocean (Figure 1).

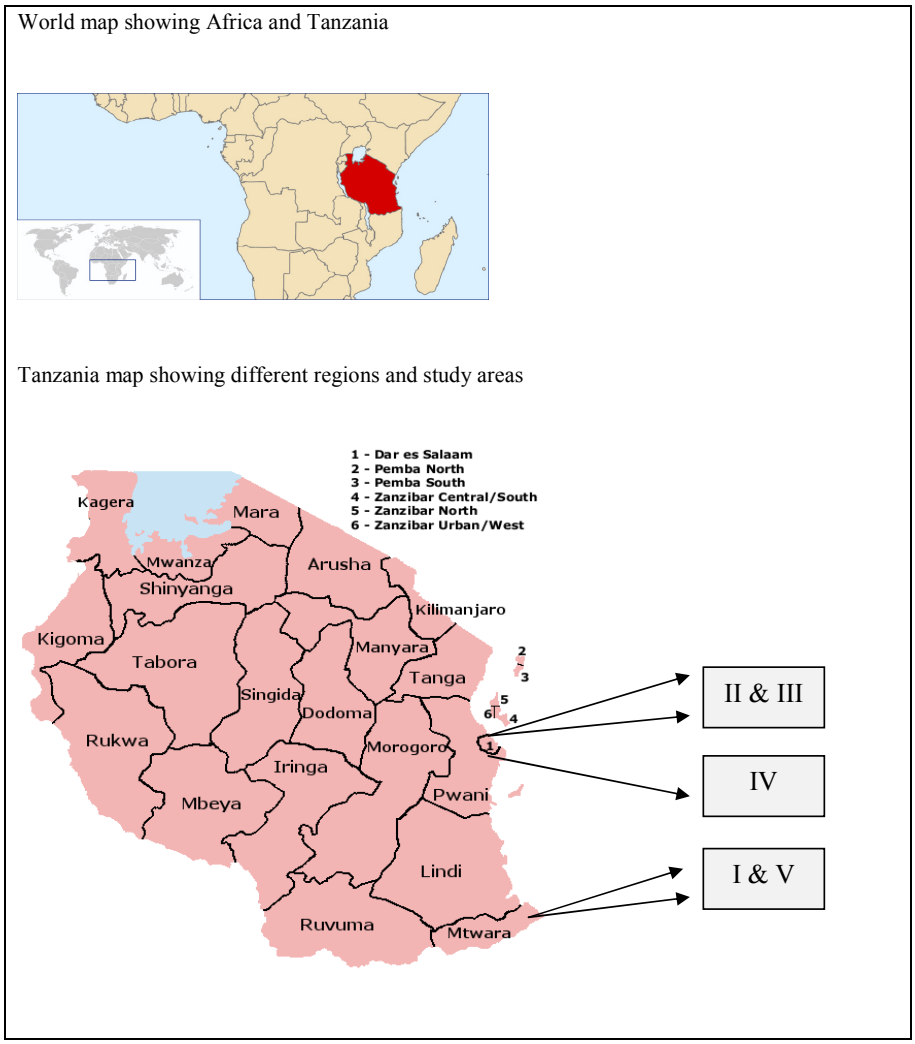

Figure 1 Tanzania map showing different regions and study areas (Wikipedia 2008b)

Tanzania is a country with an emerging economy; it has an estimated gross domestic product (GDP) at purchasing power parity (PPP) per capita at around $1,209 (rank number 146), while that of Finland was $34,411 (15), Sweden $36,365 (10), USA $45,790 (4), and Norway $53,335 (2), according to the World Bank (WB) estimates in the year 2007 (Wikipedia 2008a). Life expectancy (LE) of a Tanzanian at birth is about 51 years (50 years for males and 53 years for females) (Indexmundi 2008). While LE in Finland is on average 78.2 years (males = 74.8 years and females 81.5 years) for the new cohort born in 2002 (WHO European Office 2008). Tanzania is situated in East Africa and covers a total area of 945,087 square kilometers (Nationsencyclopedia 2008), i.e. about three times the size of Finland or Norway, twice the size of Sweden, and more than twice the size of the state of California in the United States. According to the 2002 Census report,

the total population in Tanzania was about 35 million with a growth rate of 2.9% per year. The rural population was 77% and the urban only 23%.

In 2008, the Tanzanian population was estimated to be about 40.2 million people as extrapolated from the 2002 census report. The age group of 15–64 years comprised 52% and the elderly (≥65 years) only 4% (Tanzania Government 2008). The dentist:population ratio was about 1:220,000 people (Tanzania Dental Association 2007). Health services in general follow a pyramidal shape, the base formed by the community health services followed by dispensaries, health centres, district and regional hospitals, and finally specialized/consultant hospitals (Ministry of Health 2002). The three arch enemies of Tanzania, well documented in the literature are diseases, poverty and ignorance (Nyerere 1968). The most important disease, since 1997, for people aged 5 years and above, has been malaria, but the leading cause of death is clinical AIDS which is responsible for about 17% of all deaths (Ministry of Health 2007).

Periodontal health is part of oral health and health in general. Although periodontal diseases are rarely known to cause pain; their psychosocial impact often significantly diminishes the quality of life (Petersen 2003). Oral health is a determinant factor for quality of life. Severe periodontal disease can be associated with other systemic diseases, for example, diabetes mellitus, adverse pregnancy outcomes, cardiovascular diseases and even stroke. Furthermore, some systemic diseases have oral manifestations which increase the risk of oral disease, which in turn is a risk factor for a number of general health conditions (Albander 2002b, Petersen 2009). The complications that may arise from those diseases are severe and may lead to premature death (Moore et al. 1998, Preferansow et al. 2006, Selwitz & Pihlstrom 2003). With such a relationship between oral health and general health, there is a strong reason to prevent and control periodontal diseases, to do otherwise would be irresponsible and unethical.

Periodontal diseases are a worldwide problem and Tanzania is no exception. In order to develop a feasible intervention programmes for the management of periodontal diseases, it is important to study the distribution of periodontal diseases in this population by registering the occurrence of periodontal conditions in different sub-populations, and identifying the associated risk factors.

2 REVIEW OF THE LITERATURE

2.1 Periodontal diseases – a global problem

The occurrence of periodontal diseases in man is a global problem (Albandar & Rams 2002), thus affecting all continents, for example, Europe (Sheiham & Netuveli 2002), Asia and Oceania (Corbet et al. 2002), North America (Albandar 2002a), South America, for example, Brazil (Susin et al. 2005), and Africa (Baelum & Scheutz 2002). Although periodontal diseases occur commonly among adults (Locker et al. 2001, Bourgeois et al. 2007), they are also prevalent in children and adolescents (Clerehugh & Tugnait 2001, Albandar & Tinoco 2002).

Previously, it has been reported that periodontal diseases were among the most widespread diseases in mankind (WHO 1978). On the basis of earlier epidemiological studies, it was considered that once a person suffered from inflammation in the form of gingivitis, this would progress to periodontitis with alveolar bone loss and finally cause tooth loss. It was therefore considered that the periodontal disease progresses in a "linear or continuous model" (Löe et al. 1978, 1986, Brown & Löe 1993). However, based on other studies, it was suggested that the periodontal disease may behave differently either as a "random burst model" or as an "asynchronous multiple burst model" (Socransky et al. 1984). When periodontal disease progression was considered as a multilevel system, the "linear" and "burst" models were found to be a manifestation of the same phenomenon, that "some sites with the disease improve while others progresses, in a cyclical manner" (Gilthorpe et al. 2003).

2.2 Periodontal diseases in West Africa

Many studies have been conducted in West Africa (Table 1). Most of these studies have applied the CPITN, for example, studies by Harley and Floyd (1988), Adegbembo and El-Nadeef (1995), Kubota et al. (1988), and many others, and the results show that the major problem is gingivitis and to a lesser extent periodontal disease. However, there are some studies that have shown a much higher proportion (5–80%) of participants in Gambia in need of complex periodontal treatment (Adegbembo et al. 2000). Moreover, there are some studies which have dealt with Necrotizing Ulcerative Gingivitis (NUG) (Osuji 1990) and other types of periodontal diseases such as aggressive periodontitis or juvenile periodontitis (Arowojolu & Nwokories 1997).

Table 1 Prevalence of periodontal diseases in West Africa

Country	Author & year	Study sample (n)	Age in years	Index	Prevalence
Nigeria	Harley & Floyd 1988	1,001	12–19	CPITN screening, clinical & radiological	Periodontal disease 0.8%
Nigeria	Kubota et al. 1988	673	3–20	CPITN	Gingivitis 84.2%
Nigeria	Osuji 1990	58	2–7	Clinical diagnosis of NUG	58 cases in 1 year, mostly appeared during rainy season
Nigeria	Adegbembo & El-Nadeef 1995	4,631	15–65	CPITN	57% at age of 25–29 years (max 4–5 mm)
Nigeria	Arowojolu & Nwokories 1997	34	17–34	Clinical diagnosis of juvenile periodontitis	Juvenile periodontitis 1.56%
Nigeria	Idigbe, et al. 1999	88	2–12	Clinical diagnosis	Incidence 88 cases in 1.5 years
Nigeria	Taiwo et al. 2004	690	≥65	CPITN	Periodontal pockets: 4–5 mm 21.6%, ≥6 mm 28.8%
Nigeria	Agbelusi & Jeboda 2006	1,600	12		Need for periodontal treatment 72.7%
Sierra Leone	Normark 1991	241	15 (n=135) 35–44 (106)	CPITN	Pockets ≥6 mm: children 9%, adults 53%
Cameroon	Attin et al. 1999	403	5–17	Clinical diagnosis	Gingival bleeding 37.7%
Niger	Petersen & Kaka 1999	1,473	6, 12, 18, 35–44	CPITN	12 years: gingivitis 99.8% 18 yrs: periodontitis 0.6% 35–44 years: periodontitis 12.6%
Burkina Faso	Tapsoba & Bakayoko 2000	300	12	CPITN	Gingival bleeding 93%
Gambia	Adegbembo, et al. 2000	1,235	8–35	CPITN	Complex periodontal treatment range 5–80%
Ghana	Bruce et al. 2002	1,851	4–16	Gingival Index on CPITN index teeth	Gingivitis: mild 4.2–22.5%, severe 0.4–4.3%

2.3 Periodontal diseases in North Africa

From North Africa there are only two studies that used CPITN, one in Morocco and the other in Libya (Haikel et al.1989, Omar & Pitts 1991) (Table 2). Morocco had a high proportion of study participants with gingivitis (98.7%), and the status appeared similar to that in West Africa. Howerer, the periodontal pocket depth of ≤3.5 mm (4.1%) in Libya for the age group of 15–16 years (Omar & Pitts 1991) might signal a problem of early stages of aggressive periodontitis unless the reported situation was associated with eruptional pseudo pockets.

Table 2 Prevalence of periodontal diseases in North Africa

Country	Author & year	Study sample (n)	Age in years	Index	Prevalence
Morocco	Haikel et al. 1989	2,378	7–60	CPITN	Gingivitis 98.7%, but low periodontal pockets
Libya	Omar & Pitts 1991	2,015	7–16	CPITN	Age 15–16 years: 4.1% pockets (≥3.5 mm)

2.4 Periodontal diseases in Southern Africa

The occurrence of periodontal diseases in countries that lie in the southern part of Africa is shown in Table 3. Most of the studied populations had a problem of gingival inflammation, for example in KwaZulu Natal gingival bleeding prevalence was 80% (Brindle et al. 2000), whereas in Transkei, South Africa it was 94% (Hargreaves et al. 1990) and in Swaziland it was 98% (Gugushe et al. 1993).

Table 3 Prevalence of periodontal diseases in Southern Africa

Country	Author & year	Study sample (n)	Age in years	Index	Prevalence
South Africa	Louw et al 1989	1,400	≥7	CPITN	Need for complex periodontal treatment 5%
Transkei, South Africa	Hargreaves et al. 1990	349	12	CPITN	94% gingival bleeding
South Africa	Arendorf et al. 2001	19,944 *Patients	5–12	Clinical diagnosis	3.4%
Namibia & KwaZulu	Hargreaves et al. 1990	603	11	CPITN	19–46% gingival bleeding
Swaziland	Gugushe et al. 1993	740	12	CPITN	98.1% gingival bleeding
Zimbabwe	Frencken et al. 1999	3,709	15–19, 35–44	CPITN	Complex Rx (≥6 mm) 4%
KwaZulu/ Natal	Brindle et al. 2000	500	5–6, 12, 15, 35–54, ≥55	CPITN	12 years: gingivitis >80% PD high but responds to OHI

However, most of the study populations were children between 5 and 12 years of age (Arendorf et al. 2001, Hargreaves et al. 1990). Among the adult population, the periodontal treatment needs for complex periodontal care was between 4 and 5% (Louw et al. 1989, Frencken et al. 1999).

2.5 Periodontal diseases in Ethiopia and Sudan

The prevalence of periodontal diseases using other indices than CPITN gave much higher percentages, for example, in Ethiopia and in Sudan (Table 4). At and after the age of 30 years, about 52% of the study participants were classified as having periodontitis (Olsson 1978a), while in Sudan only 8% had advanced periodontitis

(Dowty 1982). However, in populations where there was a higher (51%) proportion of people with attachment loss, the prevalence for gingival pockets remained low, at about 10% (Darout et al. 2000).

Table 4 Prevalence of periodontal diseases in Ethiopia and Sudan

Country	Author & year	Study sample (n)	Age in years	Index	Prevalence
Ethiopia	Olsson 1978a	All (n=1,700) Periodontal (n=1,300)	13–14, 19–20, 30–34, 45–54	Periodontal Index (PI) and WHO 1971	Pockets: 12% in 30–34 yrs, 52% in 45–54 yrs
Sudan	Dowty 1982	426	4–7	Not CPITN	High prevalence of intense gingivitis Advanced periodontitis 8%
Sudan	Darout et al. 2000	213	20–65 (Employees/ med. students)	CPITN	Pockets ≥4 mm 10% Loss of attachment ≥4 mm 51%

2.6 Periodontal diseases in East Africa

The occurrence of periodontal diseases in East African countries apart from Tanzania is shown in Table 5. More studies have been reported from Kenya than from Uganda. In Uganda, the subjects studied were in the age group of below or equal to 25 years and most of the problems reported were ANUG (41%) by Wandera and Twa-Twa (2003), and early onset periodontitis (28.8%) by Albandar et al. (2002). In Kenya, both the child and adult population had been studied, and among the school children studied, gingivitis prevalence was 25%. The prevalence of ANUG in Kenyan children was very low, between 0.15 and 0.28% (Wagaiyu & Wagaiyu 1992, Kaimenyi 1999). For the adult population studied, aged 15–65 years, only 20% of the surfaces had loss of attachment ≥4 mm (Baelum et al. 1988).

Table 5 Prevalence of periodontal diseases in East Africa

Country	Author & year	Study sample (n)	Age in years	Index	Prevalence
Kenya	Baelum et al. 1988	1,131	15–65	Pocket depth & loss of attachment (LA)	Pockets ≥4 mm 20% LA ≥1 mm 10–85% Minority
Kenya	Ng'ang'a & Valderhaug 1991	513	6–15	WHO (1980)	Gingivitis 25%
Kenya	Wagaiyu & Wagaiyu 1992	350	18–26	Clinical diagnosis	Juvenile periodontitis 0.28%
Kenya	Kaimenyi 1999	53,572	1.5–46	Clinical diagnosis	ANUG 0.15%
Uganda	Wandera & Twa-Twa 2003	685	5–22	CPITN	ANUG 41%
Uganda	Albandar et al. 2002	690	12–25	Pocket depth and loss of attachment	Prevalence of early onset periodontitis 28.8%

2.7 Periodontal diseases in Tanzania

The occurrence of periodontal diseases in urban and rural, as well as in child and adult populations in Tanzania is presented in Table 6. In child populations, gingivitis was the main problem and it varied between different studies (Frencken et al. 1986, Kerosuo et al. 1986, Kikwilu & Mandari 2001). Frencken et al. (1986) reported that a rural child population (61%) was affected more than the urban child population (55%). However, a much lower proportion of children with gingival bleeding (25%) has been reported from the same Morogoro region, but including a wider age span (Kikwilu & Mandari 2001). In adult population, gingival bleeding was also prevalent, for example up to 94% (Baelum 1987, Lembariti et al. 1988). Previously, in 1967, it had been reported from the Usambara Mountains, particularly from Bumbuli and Mayo villages that more than 75% of the people over 20 years had different degrees of periodontal infection (Jacobson & Kreysler 1967). Periodontal disease, among adults aged 30 years or more was 16% for the Morogoro population (Lembariti et al. 1997). In Zanzibar, loss of attachment and gingival recession were very common among the studied adult population (Baelum 1987).

Using loss of attachment to assess periodontal status, it was reported that there was visually no loss of periodontal attachment before 30 years of age, and that at the age of ≥50 years, loss of attachment affected 60% of the subjects, and mostly at buccal rather than at lingual sites (Muya et al. 1984).

When all these data are looked at altogether, it can be seen that there are some minor differences in periodontal conditions between one study and another as well as from one country to another. However, it appears that in most of the studied populations the severe form of periodontal disease affected only the minority. This finding is echoed by those from many other studies, and even the assumed differences between industrialized and non-industrialized countries with regard to periodontal diseases could not be seen in the data (Pilot et al. 1992).

Table 6 Prevalence of periodontal diseases in Tanzania

Region/ District	Author & year	Study sample (n)	Age in years (n)	Index	Prevalence
Usambara Mountains (Bumbuli and Mayo)	Jacobson & Kreysler 1967	1,976	1–10 (506) 11–19 (95) 20–40 (249) ≥41 (169)	Not specified	More than 75% over 20-year-olds had different degrees of calcium deposits and periodontal infection.
National dental health surveys 1982–1983: Mtwara, Mbeya, Mwanza, and Arusha	Muya et al. 1984	2,248	0–9 (357) 10–14 (524) 15–19 (120) 20–24 (264) 25–29 (81) 30–39 (426) 40–49 (303) ≥50 (174)	Six teeth examined (16, 11, 26, 36, 31, 46). Score: present/ absent gingival bleeding calculus, periodontal pockets (3–6 mm, ≥6 mm), loss of attachment, gingival recession, and tooth loss	High retention of teeth even in old age. At ≥40 yrs more tooth loss in rural (average 7) than in urban residents (average 4). Gingival bleeding: on average 30–40% of surfaces examined (more in rural than urban). Gingival recession: 45% at the age of ≥50 yrs. No loss of periodontal attachment before 30 yrs of age. Loss of attachment: 60% at the age of ≥50 yrs, most often on buccal than on lingual surfaces.
Morogoro	Frencken et al. 1986	762	7 (97) 8 (225) 9 (440)	Modified Papillary Bleeding Index on Ramfjord teeth	Gingivitis: urban 55% (all age groups) rural: age 7 yrs 57%, 8 yrs 56%, 9 yrs 64%, all 61%
Dar es Salaam	Kerosuo et al. 1986	640	12–14 (216) 15–18 (222)	CPITN (Ainamo et al. 1982)	Gingivitis affected > 50% of the sextants Complex treatment 5% Mean number of healthy sextants higher in girls than in boys ($p<0.01$).
Morogoro	Lembariti et al. 1988	809	15–19 (137) 20–24 (169) 25–29 (156) 30–44 (226) ≥45 (121)	WHO 1978	Prevalence of gingivitis 93.8% Periodontal pockets 3.5–5.5mm 69.3% and pockets >3.5 mm 5.2%. Higher mean number of teeth affected by pockets (3.5–5.5 mm) in subjects at age ≥45 yrs in rural than in urban areas.
Morogoro	Kikwilu & Mandari 2001	1,297	8–15	CPI (WHO 1997)	81% no gingivitis (prevalence = 19%) Mean number of sextants with gingivitis 0.25 ± 0.91 (sd)
Tanzania, National Survey	Mosha et al. 1994	6,035	5–6, 12, 18, 35–44, ≥55	WHO CPITN (1987)	Mean periodontal pocket depth 0.3 and 0.4
Morogoro	Lembariti et al. 1997	164	30–44	Pockets ≥6 mm	Periodontal disease 16%

2.8 Risk factors for periodontal diseases

The risk factors for periodontal diseases include poor oral hygiene in the form of microbial plaque, calculus or specific periodontal pathogens (Albandar 2005, Kocher et al. 2005, Petersen et al. 2005, Corraini et al. 2008, Haubek et al. 2008), male sex (Hyman & Reid 2003, Kocher et al. 2005, Bouchard et al. 2006), rural residence (Dolan et al. 1997), and smoking (Dolan et al. 1997, Norderyd et al. 1999, Tomar & Asma 2000, Amarasena et al. 2002, Hyman & Reid 2003, Kocher et al. 2005, Petersen et al. 2005, Corraini et al. 2008). Other risk factors for periodontal diseases are low socio-economic status (Dolan et al. 1997, Norderyd et al. 1999, Craig et al. 2001, Kocher et al. 2005), old age (Norderyd et al. 1999, Neely et al. 2001, Albandar 2005, Borges-Yanez et al. 2006, Corraini et al. 2008), and alcohol consumption (Pitiphat et al. 2003, Petersen et al. 2005). Diabetes mellitus is also known to be a risk factor for periodontal disease (Petersen et al. 2005, Peck et al. 2006, Al-Otaibi et al. 2008, Dakovic et al. 2008, Novak et al. 2008, Taylor & Borgnakke 2008).

In relation to the oral micro-organisms, the periodontal pathogens include, for example, *Aggregatibacter* (formerly *Actinobacillus*) *actinomycetemcomitans*, *Prevotella gingivalis*, and *Bacteroides forthysus* (*Tannerella forythia*) (Socransky & Haffajee 2003, Könönen et al. 2007, Ready et al. 2008). Although these periodontal pathogens form a part of the normal residential microflora in the oral cavity, when the ecological balance among them is disturbed, this might favour the initiation, establishment and progression of gingival diseases and thereafter at unknown time, conversion from gingival to periodontal diseases, although not always (Page 1978, Sheiham 1997, Slots 2004).

Throughout the globe, dental plaque is strongly linked to inflammation of the gingival tissue, irrespective of age, gender or racial/ethnic group. Although epidemiological data show that the occurrence of gingivitis matches the level of oral hygiene status of the population, it is by itself a poor predictor of subsequent periodontitis disease activity (Albandar 2002b). In populations where there has been a pronounced tooth loss due to severe periodontal disease, the situation has resulted in underestimation of the prevalence of periodontal disease as most of the teeth were no longer available for examination and the individuals present were either semi- or full- edentulous (Albandar & Rams 2002). In such populations, there might be a possibility of additional, unidentified risk factors related to genetics, biochemical, microbiological and/or immunological factors, that also need to be delineated.

2.9 Periodontal disease diagnostic threshold

The clinical and/or radiological features that must be registered in an individual before the individual is diagnosed as having periodontal disease are what form the periodontal

diagnosis threshold. The diagnosis of periodontal disease suffers substantially from the shortcomings due to the different criteria for diagnosis to the extent, that in some cases, comparison of the findings among the studies is rendered difficult or impossible (Savage 2007). Some diagnostic criteria use probing periodontal pocket depth, while others use loss of connective tissue attachment with different cut-off points in terms of probed depth in millimetres. To alleviate this problem, a definition of a "periodontal case" that emphasizes the importance of thresholds of probing periodontal pockets and the clinical attachment level when determining prevalence in population-based studies has been proposed (Page & Eke 2007). However, from these previous unstandardized studies, clear trends concerning the nature of human periodontal diseases across the wide range of population-based data have been recognized. Together with these indices, whether one uses a full-mouth or a partial-mouth approach, the issue of periodontal disease diagnosis threshold(s) need to be stated as different disease levels and combinations will ultimately give different prevalence values in the study populations (Linden et al. 2007). For example, the use of one, two, or three sites with ≥4 mm PPD, or connective tissue attachment loss (CAL) and involving one, two, or three teeth or a certain percentage of affected surfaces will all lead to differences in the reported data from one population to another (Thomson et al. 2004, Slade 2007).

2.10 Methods for assessing periodontal diseases and treatment needs

The method for the assessment of periodontal disease involves clinical examination of the periodontal tissues and/or radiological assessment of the alveolar bone loss. However, for the purpose of estimating the prevalence of periodontal disease in a population, radiographs are rarely used because of ethical and practical considerations (Berk & Arbes 2006).

2.10.1 Periodontal Index (PI)

The Periodontal Index (PI) was developed in the 1950s for the purpose of assessing periodontal disease (Russell 1956), and was widely used until the 1980s (Papapanou & Lindhe 2003). Using a light source, a mouth mirror and an explorer rather than a periodontal probe, the PI assessed the periodontal tissue and was scored as no overt gingival inflammation (0), mild gingivitis (1), gingivitis (2), gingivitis with pocket formation (6) and advanced destruction of the periodontal tissue with tooth mobility and loss of masticatory function (8).

2.10.2 Periodontal Disease Index (PDI)

The development of the Periodontal Disease Index (PDI) was a result of challenges faced by the World Health Organization experts in the assessment of periodontal diseases in

Asia (Ramfjord 1959). The PDI assesses the severity of gingival and periodontal tissue destruction and scores the healthy gingival tissue (G0), mild to moderate gingivitis on part of tooth (G1), mild to moderate severe gingivitis all around the tooth (G2), severe gingivitis with ulceration (G3), gingival sulcus extending 0–3 mm (G4), and periodontal pockets 3–6 mm and ≥6 mm (5) and (6), respectively. The PDI uses the six pre-selected teeth (Ramfjord teeth) rather than the full mouth examination, and the teeth include the maxillary right first molar, maxillary left first central incisor, maxillary left first premolar, mandibular left first molar, mandibular right first central incisor, and mandibular right first premolar sum of tooth scores. The PDI for the individual is the sum of the tooth scores divided by the number of teeth examined. Although the PDI is rarely used today, Ramfjord's teeth continue to be used in many epidemiological studies (Berk & Arbes 2006).

2.10.3 The Extent and Severity Index (ESI)

The Extent and Severity Index (ESI) was developed to assess separately the extensiveness and the severity of periodontal disease destruction in an individual and a population (Carlos et al. 1986). The ESI does not involve the assessment of gingival inflammation but deals with loss of attachment using an indirect approach that was used by Ramfjord whereby the loss of attachment was calculated as the distance from the gingival margin to the bottom of the pocket minus the distance from the gingival margin to the cemento-enamel junction (Berk & Arbes 2006). The extent of periodontal disease in an individual refers to the percentage of sites examined that have an attachment loss greater than 1 mm, while the severity score denotes the average loss of attachment per site among the affected sites (Carlos et al. 1986). The ESI is expressed as a bivariate statistic. For example, ESI (10, 5.0) would be interpreted as 10% of the sites examined had periodontal disease, and at the affected sites, the average loss of attachment was 5.0 mm, thus showing a minority being affected with severe periodontal destruction. The ESI for a population would be the average extent and severity scores for the individuals examined.

2.10.4 Community Periodontal Index of Treatment Needs (CPITN)

The Community Periodontal Index of Treatment Needs (CPITN) was developed by Ainamo et al. (1982). The CPITN has some features such as dichotomous scoring without further sub-categorization into gingival bleeding and calculus, as earlier seen in the Periodontal Treatment Need System (PTNS) (Johansen et al. 1973). In addition, the CPITN adopted the subdivision of the mouth into sextants rather than quadrants (O'Leary 1967). Thus, the CPITN utilizes partial-mouth examination and recording whereby the index teeth to be examined in all the surfaces comprise only ten teeth: the upper right first and second molars in sextant one, upper right central incisor in sextant two, upper left first and second molars in sextant three, lower left first and second molars in sextant

four, lower left central incisor in sextant five, and lower right first and second molars in sextant six. In accordance with the International Dental Federation (FDI), the CPI Index teeth are tooth numbers 17, 16, 11, 26, 27, 37, 36, 31, 46 and 47 (WHO 1997).

The CPITN was adopted and recommended by the WHO as a useful tool for epidemiological periodontal studies, and the specific "conditions", as well as the "disease situation" scored in a hierarchical manner include healthy periodontal tissue – score (0), gingival bleeding on probing (1), calculus (2), periodontal pocket 3.5–5.5 mm (3), and periodontal pocket >5.5 mm (4) (WHO 1987). The treatment needs were categorized as oral hygiene instruction (OHI) – Code-I for sites that have gingival bleeding, removal of calculus (scaling) – Code-II plus OHI for sites that had calculus, and complex periodontal treatment that includes periodontal surgery – Code-III plus OHI and calculus removal for sites that had shown presence of probing periodontal pockets >5.5mm (WHO 1987).

Since CPITN was recommended by the WHO, it has been widely used and has been claimed to produce comparable data (Pilot et al. 1987, Miyazaki et al. 1989, 1991a, Pilot et al. 1992, Morimoto & Miyazaki 1994). Many countries have used CPITN since its development to such an extent that by 1991, more than fifty countries had used CPITN and generated data for the adolescents (Miyazaki et al. 1991a), adults at age group 35–44 years (Miyazaki et al. 1991b), and by 1992 more than thirty countries had CPITN data on ≥45-year-olds (Pilot et al. 1992). From the use of the CPITN worldwide in more than 100 countries, there was a feeling that the system had gained wide acceptance due to its simplicity (Pilot & Miyazaki 1994). However, the CPITN was later on modified to the Community Periodontal Index (CPI) alone when the treatment needs (TN) component was excluded from the index, and for practical reasons, the categorization of periodontal probing pocket depth was changed to periodontal pocket 4–5 mm (score 3), and periodontal pocket ≥6 mm (score 4) (WHO 1997). The CPI has been applied to date in many countries, where there have often been few, if any, previous periodontal epidemiological studies, for example, in Brazil (Coelho et al. 2008), in Japan (Leung et al. 2008), in Spain (Mombiedro et al. 2008), in Libya (Fanas et al. 2008), and in Iran (Hessari et al. 2008, Kazemnejad et al. 2008).

2.11 Partial-mouth recording protocols

The assessment of periodontal status using partial recording methods or protocols particularly using the Ramfjord teeth gave acceptable results as they were as representative as those of the full-mouth examination (Silness & Roynstrand 1988, Rams et al. 1993, Owens et al. 2003, Beck et al. 2006, Kingman et al. 2008). Ramfjord teeth were first used in the "Periodontal Disease Index" (PDI), and these consisted of six pre-selected teeth (Beck & Arbes 2006). However, the Ramfjord teeth were found to underestimate the probing depth of periodontal pockets (Ainamo & Ainamo 1985), and other studies

found that the index considerably underestimated both the prevalence and the extent of periodontal disease (Dowsett et al. 2002).

Apart from the CPITN/CPI index teeth and the Ramfjord teeth, other useful partial-mouth recording systems or partial recording protocols (PRP) include the random half-mouth or the National Institute of Dental Research's (NIDCR) method that has been used in large surveys, and the National Health and Nutrition Examination Surveys (NHANES) in the United States (Dowsett et al. 2002, Berc et al. 2006, Kingman et al. 2008,). The random half-mouth assessment was found to be more representative of the full-mouth periodontal situation in terms of prevalence and severity than the Ramfjord teeth (Dowsett et al. 2002). For the purpose of addressing the issue of severity, among others, an "Extent and Severity Index" was developed and this can be applied alone with half-mouth assessment without much loss of information, if full-mouth examination of all the teeth in six surfaces can not be undertaken (Carlos et al. 1986, Beck & Arbes 2006). Even with this index, the problem of underestimation of periodontal disease is never totally eliminated (Borges-Yáñez et al. 2004).

Following the use of the indices and the periodontal disease diagnosis threshold, it should be possible to classify the type or nature of periodontal disease among the study participants in a given population. Different classifications of periodontal diseases have been applied at different times (Armitage 2002), but for the purpose of this report, the term "periodontal diseases" refers to both specific gingival diseases, as well as distinct periodontal diseases. The current classification has replaced the previous age-dependent classification of periodontal diseases with a classification that is based more on the infectious etiology of the disease (Armitage 1999). Therefore, periodontal disease entities in the past known as early onset periodontitis (prepubertal and juvenile periodontitis) have been replaced with aggressive periodontitis, and like adult periodontitis, have been reclassified as chronic periodontitis. Variations in the prevalence of periodontal diseases among and within different populations have been reported to be due to systematic (bias) and random variations (Kingman & Albandar 2002, Dye & Selwitz 2005). Determinants of the systematic variation include different disease definitions, the sampling procedures (convenient versus representative samples), the subset of periodontal sites examined within study subjects (partial versus full-mouth recording), and examiner variability. Another factor worth noting is the reliance on the measurement of probing depth as an indicator of disease status (Albandar & Rams 2002). For example, in populations that have been affected by gingival recession, the probing periodontal pocket depth does not provide an accurate measure of periodontal disease status, extent and severity as compared to the assessment of the periodontal attachment level (Löe et al. 1992, Albandar & Rams 2002).

2.12 Tooth-cleaning devices: "the chewing stick"

The use of the chewing stick has been a common tradition in African countries, for example, in Tanzania (Frenckn et al. 1991), in Kenya (Danielsen et al. 1989), in Ghana (Norton & Addy 1989), in Ethiopia (Ollson 1978), and in Nigeria (Akpata & Akinrimisi 1977). Moreover, the chewing stick has been in use among Asians, and in the Middle East, particularly in Yemen (Mengel et al. 1996), in Egypt (Eid & Selim 1994), and in Saudi Arabia (Johansson et al. 1991). Apart from the fact that chewing sticks are readily available in many of the studied African and Asian populations, extracts from the plants used as chewing sticks have been found to have an antibacterial effect against micro-organisms associated with periodontal disease (Akpata & Akinrimisi 1977, Taiwo et al. 1999, Cai et al. 2000, Almas 2001a, 2001b, Sofrata et al. 2008). In practical use, the chewing stick has been found to be as effective as the toothbrush (Olsson 1978b, van Palenstein et al. 1992, Hardie & Ahmed 1995, Al-Otaibi et al. 2003, Al-Otaibi 2004) with two exceptions: firstly, in the case of severe plaque deposit, the toothbrush was found to be more effective than the chewing stick (Ndung'u et al. 1990), and secondly, in some populations where the toothbrush had briefly been introduced, the chewing stick was more effectively used than the toothbrush and thus resulted in less gingival inflammation among the study participants (Sote 1991). However, habitual use of the chewing stick has been reported to be associated with the occurrence of gingival recession (Eid & Selim 1994, Arowojolu 2000).

2.13 Gingival recession

The occurrence of gingival recession (GR) on its own has been considered a risk predictor of periodontal disease (van der Velden et al. 2006), and is associated with connective attachment loss (CAL) in some populations (Grbic et al. 1991, Haffajee et al. 1991, Beck & Koch 1994, Schätzle et al. 2003). The presence of dental calculus on the cervical margin or supragingival calculus has been reported to be a risk factor for GR in many populations, for example, in Brazil (Susin et al. 2004), in Nigeria (Arowojolu 2000), in the United States of America (Albandar & Kingman 1999), in Tanzania (van Palenstein et al. 1998), and elsewhere (Joshipura et al. 1994). Also plaque and gingival inflammation have been associated with the occurrence of gingival recession (Goutoudi et al. 1997). There are reports showing that GR can be caused by the toothbrushing practice itself, for example, due to the hardness of the bristles (Goutoudi et al. 1997) and forceful toothbrushing (Joshipura et al. 1994), as well as increased frequency of toothbrushing (Vehkalahti 1989), and thus it can sometimes be seen as a result of toothbrush trauma (Arowojolu 2000). However, no conclusion about whether toothbrushing causes gingival recession has yet been reached as there is evidence of conflicting results in the literature (Rajapakse et al. 2007). Tobacco smoking has been associated with or considered as a risk factor for GR (Susin et al. 2004). Further reviews show that risk factors for GR include

smokeless tobacco (Cullen et al. 1986) and malposition of teeth (Kassab & Cohen 2003). However, in contrast, there are also reports showing that smokers are not at increased risk of gingival recession (Muller et al. 2002). In recent years, fashionable decisions among young people in particular, e.g. elective lip piercing and labrets (Leichter & Monteitch 2006), as well as tongue piercing (Choe et al. 2005) have been recognised as new risk factors for GR. To control GR, population-based programmes aimed largely at the prevention of periodontal diseases and other risk factors are necessary (Axelsson et al. 2002, Susin et al. 2004).

2.14 Tooth loss

Loss of permanent teeth which could not be preserved because of the nature, efficiency and extent of oral health services provide evidence for future studies to register "tooth loss" in such populations. Most of the tooth loss reported from African populations has been seen to be due to dental caries and, to a lesser extent, to periodontal diseases in the Kenyan population (Baelum et al. 1988, Manji et al. 1988, Sanya et al. 2004), as well as in Tanzania (Baelum & Fejerskov 1986, Lembariti et al. 1988, Rambush 1991) with some exceptions, for example, in Nigeria where periodontal disease has been shown to be the major cause of tooth loss (Odusanya 1987, Taiwo & Omokhodion 2006). In the study conducted in Kenya, other minor causes of tooth loss were reported to be trauma, and traditional tooth mutilation practices (Sanya et al. 2004). Tooth loss for orthodontic reasons was negligible (Sanya et al. 2004). The proportion of complete edentulousness has been reported to be high (every third person) in South Africa (Naidoo et al. 2001), while in Nigeria it was only about one percent (Taiwo & Omokhodion 2006), and in urban and rural populations in Tanzania it was less than one percent (Sarita et al. 2004, Kida et al. 2006), but in Kenya no data were available (Sanya et al. 2004).

3 AIMS OF THE STUDY

The aims of this study were to establish a preliminary picture of the periodontal condition of Tanzanians by determining the occurrence and the risk factors of periodontal diseases, community periodontal treatment needs, and oral hygiene practices.

3.1 Specific objectives

The specific objectives were to determine:

1) the occurrence of periodontal conditions in relation to oral hygiene practices (Paper I),

2) the prevalence of periodontal diseases and the treatment needs among different age groups (II),

3) the risk factors for periodontal diseases in the Tanzanian population (III),

4) the occurrence of gingival recessions as related to tooth cleaning devices and, plaque, calculus and gingival bleeding in adults (IV), and

5) the relationship between tooth cleaning devices used for oral hygiene practices and the loss of teeth among adults (V).

4 SUBJECTS AND METHODS

4.1 Background information

A systematic literature review was done using the PubMed search engine. The search terms were periodontal diseases and epidemiology, periodontal diseases and risk factors, periodontal diseases and Community Periodontal Index of Treatment Needs (CPITN). Other search terms were periodontal indices, periodontal diseases and partial mouth recordings or examination protocols, oral hygiene practices, tooth cleaning devices, toothbrushing, and chewing stick. In addition, articles on "gingival recession and epidemiology", "tooth loss and periodontal diseases" were searched as well as "periodontal diseases" and "classification'. The epidemiology was divided into global epidemiology and then Africa excluding Tanzania. The search was limited to English articles only. Up-to-date articles were preferred to old ones and therefore the years of publication were further limited to match with the time period when the current studies were conducted (I–V) as from 1987 onwards. However, a few key references published before 1987 were also selectively included, for example, the article on "experimental gingivitis in man" (Löe et al. 1965), and the natural history of periodontal disease in man (Löe et al. 1978). From the titles picked from the search items, a careful selection was done, and abstracts of relevant were collected. Further on reading the abstracts, relevant articles were selected and efforts were made to obtain the full articles. Also relevant articles that had no abstracts were collected, read and referred to accordingly, for example "global risk factors and risk indicators for periodontal diseases" (Albandar 2002a), and the world oral health report (Petersen 2003). The search of articles on periodontal diseases in Tanzania included all retrievable articles in PubMed, irrespective of year of publication because of their relevance and these included old articles for example (Jacobson & Kreysler 1967), national reports, and in particular Muya et al. (1984), and dental information reported in local national journals, especially Tanzania Dental Journal.

4.2 Place of study

This study was based on five different studies conducted in four different geographical locations in Tanzania (Figure 1). The geographical study locations included Mtwara Rural district of Mtwara Region on the south-eastern coast region in Tanzania, situated about 450 km from Dar es Salaam city (I &V). Other locations were the rural area of Ukonga administrative ward (II) and the Ilala district encompassing the three "administrative wards" of Ilala, Kariakoo and Ukonga (III). The Maternity ward of the Muhimbili National Hospital served as a study area to investigate the problem of gingival recession

among women (IV). The relationship between the study populations (I–V) is depicted in Figure 2.

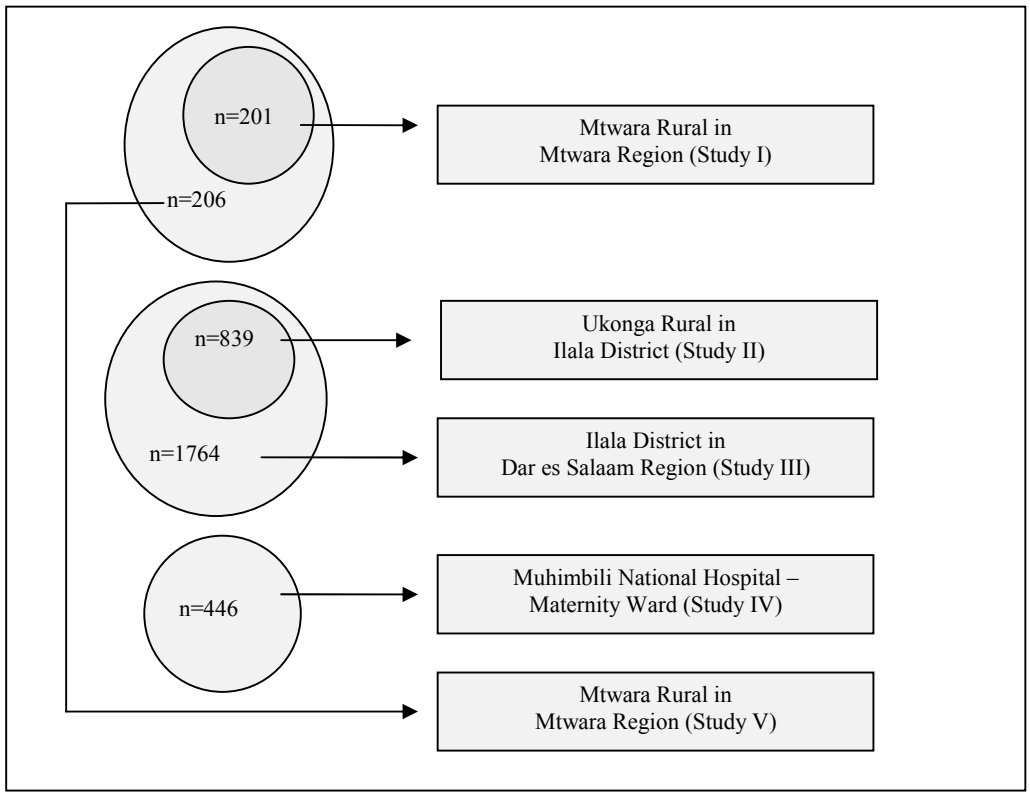

Figure 2 Distribution of the study population by study locations

4.3 Study design

The design for all the studies was basically a cross-sectional and descriptive type whereby the distribution of periodontal conditions/diseases (I–II, IV and V) together with the risk or causative factors (III–V) were studied in different populations in Tanzania.

4.4 Sample size and sampling method

The sample size, the methods used to select the study participants, their residency and year of study are shown in Table 7. The study included five different samples from four different places with the total number of study participants in each geographical location ranging from 201 to 1,764. The study participants consisted of random samples from the general population in Mtwara rural area of 201 and 206 (I & V), respectively; another 839 subjects were from Ukonga rural area (II) and 1,764 from the Ilala district (III).

Table 7 Distribution of the study participants by year of study, residency and sampling method

Year of study	Residency	Sample size (n)	Sampling method	Year of publication	Original publication
1987–1988	Mixed	1,764	Stratified, random cluster sampling	1995	III
1987–1988	Rural	839	Stratified, random cluster sampling	1996	II
2001	Rural	201	Multistage simple random sampling	2003	I
2001	Rural	206	Multistage simple random sampling	2005	V
2002–2003	Mixed	446	Cluster sampling	2009#	IV

Manuscript submitted

In the Mtwara studies (I & V), a multi-stage simple random sampling technique using a "ballot system" was used to select one district out of five, whereby on three different pieces of paper of the same colour was written the name of one district and then thoroughly folded to hide what was written on the paper. One of the local leaders at the regional administrative office was asked to pick one of the papers, and the name that was on it was selected as the district for study. The same approach was used to select the administrative wards and villages, while at the village level all the participants aged 40 years or above were eligible for the study.

For the Ukonga (II) and Ilala (III) studies, the sampling frame was the three districts in Dar es Salaam (Kinondoni, Ilala and Temeke) whereby through a stratified random cluster sampling method, Ilala as one of the districts and its administrative divisions, wards, villages, and ten-cell leaders (ten households) were selected. At the level of ten-cell leaders, all the participants from 3 years and above were eligible for the study. The children, adolescents and adults were all recruited not only for the periodontal study but also for other important oral health problems, the Ilala Oral Health Survey as described in detail elsewhere (Kikwilu et al. 1987).

To circumvent constraints in resources, a "convenience sample" approach was also considered suitable, and therefore, a total of 446 women only were recruited from the Muhimbili National Hospital (MNH) Maternity ward (IV). In the Muhimbili study, the recruitment was done by registering the study participants consecutively, one by one as they come to the maternity ward until the full sample size was attained. The field work for the five different studies was conducted between 1987 and 2003, and the findings were reported between 1995 and 2009 (I–V).

4.5 Data collection tools

Data were collected using both the structured questionnaire and clinical examination of all study participants (I–V). The subjects were interviewed and the relevant information was recorded in the questionnaire forms.

4.5.1 Periodontal status and oral hygiene practices (Study I)

In the Mtwara study of periodontal status and oral hygiene practices (I), the interview form, apart from the basic demographic information on age, sex and level of education, included questions on toothbrushing practicies, use of plastic toothbrush, use of chewing stick for tooth cleaning, frequency of tooth cleaning per day, time of tooth brushing either before or after meal, before going to bed, and the use of dentifrices such as toothpaste. Also the study participants were asked to indicate whether they had ever received oral health education (OHE), and if so, the source of that information. An estimate of the distance (in kilometres) to the nearest oral health facility was also recorded from each participant. The clinical examination data collection form in this study (I) included dichotomous scoring of the periodontal conditions as present or not-present (Yes/No) particularly the presence of plaque, calculus without further categorization into supra-, sub- or both supra- and sub-gingival types. Also gingival bleeding on gentle probing using the CPI periodontal probe was scored as either present or absent. Scoring of probing periodontal pocket depth was classified as 0–3.5 mm, 3.5–5.5 mm, and >5.5 mm. Also gingival recession as the distance from the cemento-enamel junction (CEJ) to the gingival margin was scored in millimetres and categorized as 0–3.5 mm, 3.5–5.5 mm, and >5.5 mm.

4.5.2 Periodontal treatment needs (II)

The study to objectively assess the periodontal treatment needs in a community was done in rural Ukonga (II). An interview form was used to collect information on age and gender of the participants. To avoid unnecessary duplication of the clinical examination, the same study participants were first examined for all variables that were necessary for the study on risk factors for periodontal diseases (III) and, at the same time, the findings relevant for the CPITN were recorded in the special boxes for CPITN sextants on the same original examination clinical form. The clinical variables scored were the health status of the gingival tissue, presence of gingival bleeding, presence of dental calculus, and periodontal probing depth 4–5 mm, and ≥6 mm, separately. The treatment needs were classified as no need for periodontal treatment at the sites with healthy periodontal tissues. Oral hygiene instruction was recorded as a treatment at all sites that had gingival bleeding, calculus, and/or periodontal pockets. Scaling was indicated for the sextants that showed the presence of calculus and periodontal pockets. However, for the severe type of periodontal pockets, the treatment to be recorded on the clinical form the complex periodontal therapy.

4.5.3 Risk factors for periodontal diseases (III)

The study of risk factors for periodontal diseases was done in Ilala (III) when the interview form was geared to collect demographic information and other data on toothbrushing practices, the use of a traditional tooth-cleaning device, the chewing stick, as well as the use of a modern manual plastic toothbrush, and residency, for example, rural, urban or

mixed. The periodontal conditions assessed were the presence (dichotomous approach) of plaque, calculus, gingival bleeding, periodontal pockets ≥4 mm, and gingival recession ≥4 mm.

4.5.4 Gingival recession and associated factors in women (IV)

The information gathered from the study on gingival recession and associated factors in women (IV) was carefully recorded on the questionnaire forms and it included age, sex, marital status, oral hygiene practice in terms of use of plastic toothbrush, chewing stick, time of toothbrushing, use of dental floss, tooth picks, gum bleeding upon toothbrushing, tobacco smoking, consumption of alcohol, and use of coffee. Clinical forms captured data from the study participants on the presence of plaque, calculus, gingival bleeding, and gingival recession at six sites per tooth, and the number of teeth examined.

4.5.5 Tooth loss in relation to tooth cleaning devices (V)

The questionnaire forms that dealt with the study of tooth loss in Mtwara rural (V) gathered information from the study participants on age, sex, toothbrushing practices, the use of a plastic toothbrush, as well as the use of a chewing stick for tooth cleaning. The clinical parameter assessed was "missing teeth due to extraction". The reason for extraction as self-reported by the study participants was also recorded and categorized as either due to dental caries, to periodontal/trauma, or to other reasons.

4.6 Study participants

The distribution of study participants by gender and level of education in the five different studies (I–V) is shown in Table 8. The total number of subjects studied in each study ranged from 201 to 1,764.

Table 8 Distribution of the study participants by gender and level of education

Original publication	Number of participants in each study (n)	Study participants by gender (%)		Study participants by level of education (%)	
		Male	Female	No formal	Formal
I	Mtwara rural (201)	57.2	42.8	53.7	43.3
II	Ukonga rural (839)	44.3	55.7	27.0	73.0
III	Ilala district (1,764)	46.9	53.1	27.0	73.0
IV	MNH Maternity ward (446)	–	100.0	17.5	82.5
V	Mtwara rural (206)	55.8	44.2	53.7	43.3

4.6.1. Gender composition

The study participants in each study were composed of both males and females (Table 8) except in one study where there was purposeful recruitment of a convenient sample (100%) of women only (IV). Therefore, the proportion of female study participants among the

five different studies (I–V) ranged from 44.2% to 100%. The proportion of male subjects among the remaining four samples (I–III & V) ranged from 44.3% to 57.2%.

4.6.2 Education level

The level of education of the participants, where indicated (Table 8) was categorized as formal education including primary education (1–7 years), secondary education (1–6 years), and college (2–5 years). The proportion of study participants (I–V) that had attained formal education ranged from 43.3% to 82.5%, while those who had no formal education ranged from 17.5% to 53.7% (Table 8). More than half of the study participants (53.7%) in Mtwara rural (I & V) had no formal education while in Ilala (III) and the MNH Maternity ward (IV) the corresponding figures were 27% and 17.5%, respectively.

4.6.3 Age structure

The age range of the study participants among the five different studies was from 3 to 95 years (Table 9). In the Ukonga and Ilala studies (II & III) the recruitment of the study participants involved children, adolescents and adults (3–88 years of age).

The decision to include children and adolescents in the study was based on the fact that the study was one of the few in Tanzania that involved a representative sample and that it was necessary to have a full picture of the periodontal health status in children. The Muhimbili National Hospital Maternity ward study (IV) included adolescents and adult women of 14–44 years of age, who by virtue of their reproductive role had to attend the services at the hospital. In the Mtwara rural studies (I & V), the study participants enrolled were adults aged 40 years or above.

Table 9 Distribution of the study participants by age group used in each study

Study I Mtwara rural (n=201)		**Study II Ukonga rural (n=839)**		**Study III Ilala district (n=1,764)**		**Study IV MNH Maternity ward (n=446)**		**Study V Mtwara rural (n=206)**	
Age in years	**n**	**Age in years**	**n**	**Age in years**	**n**	**Age in years**	**n**	**Age in years**	**n**
40–44	39	3–9	202	3–9	420	14–19	126	40–44	39
45–54	68	10–19	208	10–19	479	20–24	155	45–54	68
55–64	51	20–34	150	20–34	457	25–29	107	55–64	54
65–74	27	35–44	75	35–44	183	30–44	58	65–95	45
75–95	16	45–54	62	45–84	225				
		55–64	62						
		65–88	80						

4.7 Clinical examination protocol

All the study participants were clinically examined for different periodontal conditions and periodontal diseases. Three calibrated clinical examiners took part in the Mtwara

studies (I & V), whereas in Ukonga (II) and Ilala (III), five calibrated examiners took part in the clinical examinations (Table 10).

Table 10 Distribution of the study participants by clinical examination protocol

Original publication	Number of subjects	Clinical examination partial/ full-mouth protocol	Number of clinical examiners	Calibration findings on clinical examination of periodontal conditions
I	201	Full mouth (including 3rd molar) exam, partial recording according to the sextants	3	Kappa statistics: 0.4–1.0
II	839	Partial: CPITN Index teeth, maxillary buccal and mandibular lingual surfaces only (not both)	5	Inter-examiner agreement range: 51–96%
III	1764	Partial: CPITN Index teeth, maxillary buccal and mandibular lingual surfaces only (not both)	5	Inter-examiner agreement range: 51–96%
IV	446	Full mouth (including 3rd molar) exam and recording	1	Kappa statistic: 0.78
V	206	Full mouth (including 3rd molar) exam and recording	3	Kappa statistics: 0.4–1.0

The calibration data for Mtwara (I & V) were included in a separate report (Mumghamba & Fabian 2004), and details of the calibration findings (II & III) were reported in study III. The partial recording protocol was applied in two of the studies (II & III). According to this approach, all the maxillary teeth including the third molars were examined on mesio-buccal to disto-buccal surfaces only (excluding the palatal-mesial to disto-palatal surfaces), and likewise all the mandibular teeth were examined on lingual-mesial to disto-lingual surfaces only (excluding the mesio-buccal to disto-buccal surfaces). Since previous dental surveys in Tanzania have shown that third molars are frequently present in a functional stage and are valid members of the dentition in the studied populations, these teeth were included in the present studies (I, IV & V) (Gadegaard & Fejerskov 1983, Baelum et al. 1986, Baelum 1987). Only one clinical examiner performed the full-mouth examination of the study participants at the MNH Maternity ward (IV).

4.8 Calibration of the clinical examiners

Calibration exercises and reproducibility testing of the clinical examiners were carried out and the findings indicated good agreement among the examiners (Table 10). In Mtwara (I & V) the Kappa statistic for the assessed conditions was 0.4–1.0. In Ukonga (II) and Ilala (III) the inter-examiner agreement ranged from 51% (gingival bleeding) to 96% (gingival recession), whereas in the MNH Maternity study (IV) the Kappa statistic for gingival recession was 0.78.

4.9 Periodontal conditions and the scoring criteria

Each periodontal condition that was assessed was examined and scored separately as an individual entity.

4.9.1 Periodontal conditions

The periodontal conditions that were assessed include plaque, calculus, gingival bleeding, periodontal pocket depth and gingival recession. The CPITN hierarchical scoring method whereby the worst finding was the one recorded (healthy = 0, gingival bleeding = 1, calculus = 2, probing periodontal pocket depth 3.5–5.5 mm = 3, and probing periodontal pocket depth >5.5 mm = 4) was not used during the examination and recording of the study participants in any of the studies. However, in the Ukonga study, the absolute clinical findings were recorded separately in the respective sextants, plus additional recording whereby the findings were converted into the CPITN format (II). In addition to scoring the variables relevant for CPITN, the study participants were also examined for the presence of microbial dental plaque, as this is not part of the CPITN/CPI (WHO, 1987, 1997).

4.9.2 Periodontal conditions scoring criteria

The scoring criteria for the periodontal conditions studied were as follows:

4.9.2.1 Plaque

This is formed by multitudes of viable micro-organisms and was scored present if after scraping with the probe or explorer some plaque material could clearly be seen on the tip of the probe.

4.9.2.2 Calculus

This is a mineralized form of the microbial plaque and was scored as present if a hard deposit was seen supragingivally, felt through tactile sensitivity subgingivally or both supra- and subgingivally using the CPI epidemiological periodontal probe, and if not seen or felt it was recorded as absent. However, finally, it was reported as a dichotomous variable as either present or absent (III). In the other two studies (I, IV), the distinction between supra- and subgingival calculus was not made, as right from the beginning, calculus was scored either as present or absent.

4.9.2.3 Gingival bleeding on probing

Gingival bleeding on probing (BOP) subgingivally was carefully recorded using the CPI probe with an approximated pressure force of 20 gm. If the site was bleeding within 10 seconds, gingival bleeding was recorded as present and if not it was recorded as absent.

4.9.2.4 Periodontal pocket depth

Periodontal pocket probing depth (PPD) was assessed as the distance from the gingival margin to the bottom of the periodontal pocket using the CPI epidemiological periodontal probe, and the pocket depth was scored separately either as 0–3.5 mm, 3.5–5.5 mm (4–5 mm) or >5.5 mm (≥6 mm).

4.9.2.5 Community Periodontal Index of Treatment Needs

Assessment for the Community Periodontal Treatment Needs (CPITN) was done according to the WHO recommendations (WHO 1987) after the original baseline data were transformed and recoded into CPITN format.

4.9.2.6 Gingival recession

Gingival recession (GR) as the distance from the cemento-enamel junction to the gingival margin was studied in three different places: Mtwara (I), Ilala (III) and Muhimbili (IV), although this condition is not considered important by the WHO in the basic oral health surveys criteria (WHO 1987, 1997). In Mtwara (I), and Ilala (III), which were both general population-based studies, the scoring criteria for gingival recession were assessed using the epidemiological CPI probe in all the teeth on all the surfaces including the third molars (I) and the CPITN index teeth (III), on buccal surfaces only for the upper jaw, and lingual surfaces only for the lower jaw, but then the findings were recorded in the respective sextants in three categories: mild or no recession (0–3.5 mm), moderate (3.5–5.5 mm) and severe >5.5 mm. In the other study in Muhimbili (IV), the facility-based study, gingival recession was examined and recorded at six sites per tooth in absolute figures to the nearest one millimetre (mm) using the Williams periodontal probe.

4.10 Full-mouth versus partial-mouth recording

In the Mtwara periodontal study (I), a full-mouth examination including third molars was performed but the findings for each periodontal condition were recorded separately in sextants, as a unit, rather than for the individual teeth examined. For the study that involved Ilala (III) the clinical findings were recorded from the CPITN index teeth (teeth numbers 17, 16, 11, 26, 27, 37, 36, 31, 46 and 47) with the modification that the examination involved only the buccal surfaces of the maxillary teeth and the lingual surfaces of the mandibular teeth. In addition, the clinical findings were recorded separately in sextant units for each condition that was assessed. However, in the Ukonga study that reported periodontal treatment needs (II), the detailed information for each periodontal condition in separate sextant units, particularly gingival bleeding, calculus and the probing periodontal pocket depth, were converted to match the CPITN data format. Since at that time no other methods had been established to assess the periodontal treatment needs at community level, the authors justified the use of the CPITN approach (WHO 1987)

to fulfil the purposes of the study. The data set for the Muhimbili Maternity study (IV) involved full-mouth examination and recording of each individual tooth, including the third molars. In regard to the study on "tooth loss" in Mtwara (V), the clinical data used were collected from the full-mouth examination for all teeth including the third molars.

4.11 Quality of the data and data management

The data collected in all the five studies (I–V) were considered to be of high quality based on good and acceptable calibration findings (Table 10). For data management, they were entered into a personal computer (PC) and analysis was done using the Statistical Package for Social Sciences (SPSS) version 3.1, 10.0 and 13.0 The analyses included generation of frequency distributions, cross-tabulations, mean-values where appropriate (I–V), analysis of variance (II), logistic regression models: the backward stepwise (Wald) method (III & IV), Odds values were also given (III & IV), as well as the 95% confidence interval (95% CI) for the Odds ratios (III & IV) and the mean values (IV & V). The statistical tests used were chi-square test (I–V) and Student (t)-test (II, IV and V), while in all studies the level of statistical significance was set at $p<0.05$.

4.12 Ethical considerations

The ethical clearance to conduct the studies was given by the Research Committee of the Faculty of Dentistry, Muhimbili Medical Centre (MMC) for the two studies done in 1987 (II & III) and the other three done between 2001 and 2003 by the Ethical Committee of the Muhimbili University College of Health Sciences (MUCHS) of the University of Dar es Salaam (I, IV & V).

5 RESULTS

The factors assessed in all the five studies (I–V) were utilized to describe the occurrence of periodontal diseases and related conditions among the studied populations. However, direct comparison of the research findings in one study to those in another has not been attempted as the methods used were not exactly the same.

5.1 Oral hygiene

In relation to oral hygiene, oral hygiene or tooth-cleaning practices, frequency, time in relation to meals, tooth-cleaning devices, use of dentifrices, and awareness of oral health education will be presented in this section.

5.1.1 Tooth-cleaning practices

Tooth-cleaning practices among the studied populations (I, III, IV and V) were very common, with the proportions between 95% and 99% (Figure 3). The practices were higher (99%) in the mixed (III) than in the rural (95%) population (I & V).

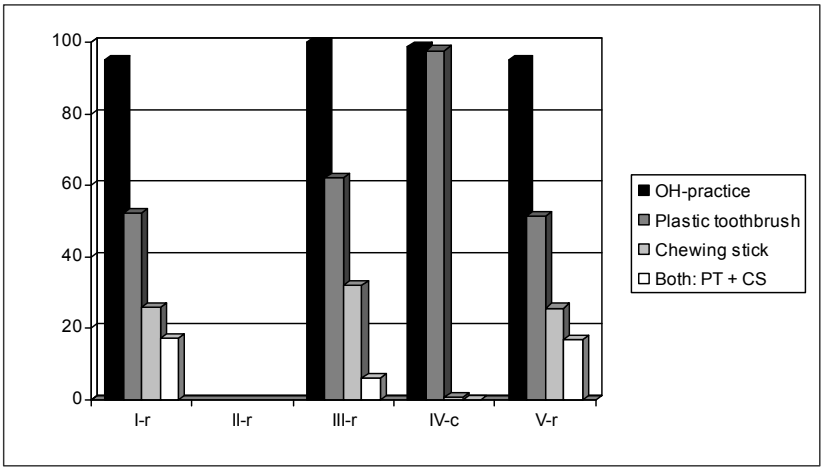

Figure 3 Oral hygiene practices and type of tooth cleaning device used by the study participants (%) in different studies (r= random, c= convenient sample)

5.1.2 Tooth-cleaning devices and toothbrushing method

The tooth-cleaning devices were mainly manual plastic toothbrushes which were more commonly used in urban (98.9%) (IV) than in rural areas (52%) (I & V). The traditional chewing stick, "miswak" was used by 26% in the rural areas (I & V), 32% in the mixed residency of Ilala (III), and very minimally (0.9%) among women at the MNH (IV). A combination of both types, the plastic toothbrush and the chewing stick was mainly used in rural areas in about 17% (I & V), and to a much lesser extent (6%) among the

mixed residency in Ilala (III). The main method of toothbrushing (IV) was reported to be of horizontal strokes (98%) and to a lesser extent, vertical brushing strokes (2%). The use of dental toothpicks was very high (99.4%), but the use of dental floss was negligible (0.6%) in the urban population, where these factors were studied (IV).

In Mtwara rural (V), the mean number of teeth lost was significantly higher among chewing-stick users (12.04 ± 8.35) compared to plastic toothbrush users (8.73 ± 7.00) (p=0.015) and among those who had non-specific means of cleaning the teeth (21.17 ± 10.55) compared to those who either used a chewing stick (12.04 ± 8.35) or aplastic toothbrush (8.73 ± 7.00) (p=0.002). Furthermore, in this study the mean number of teeth lost was higher among those who brushed once a day (8.97 ± 7.84) compared to those who brushed two times or more per day (6.83 ± 6.71) (p=0.046), as well as among those who did not brush before bed (9.64 ± 8.52) compared to those who did brush before bed (6.25 ± 6.25) (p=0.001).

5.1.3 Frequency of tooth cleaning

The frequency of tooth brushing varied between 1 and 5 times per day (I, III–V), but most of the study participants did brush twice per day or more for example in study I (58.4%), in study III (75%), in study IV (60.3%), and in study V (56.8%). Those who brushed once per day in studies I and III–V ranged from 24% to 38.8%.

5.1.4 Time of tooth cleaning

The time of toothbrushing (Figure 4) was recorded in one study only, the Mtwara Rural study (I). In this study, it was found that most of the study participants brushed their teeth before breakfast (95%), and rarely after breakfast (1%). Slightly more than one third of the study participants did brush before bed time (36.8%).

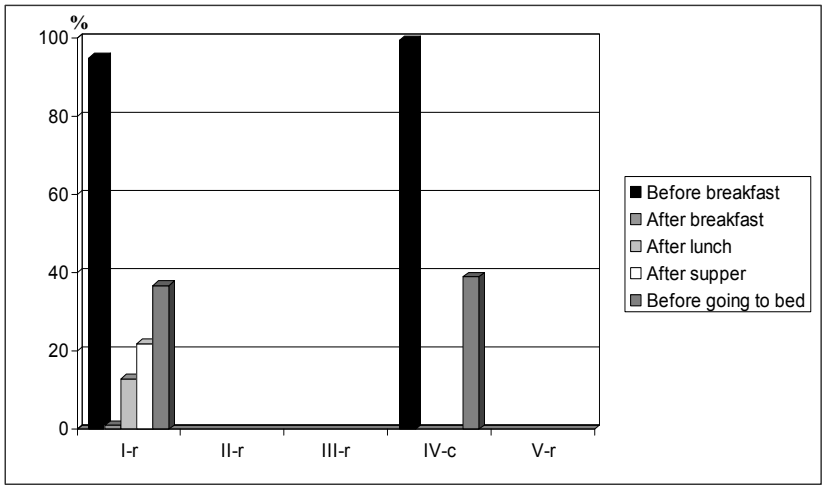

Figure 4 Time of tooth cleaning among the study participants (%) in different studies (r= random, c= convenient sample)

5.1.5 Tooth-cleaning dentifrices

Use of dentifrices included toothpaste in about 29% (I) and 94% (IV) of the study population, respectively. However, in study I, as many as 15%, compared to 0.8% in study IV used charcoal/ash. The practice of using salt for toothbrushing was reported to be about twice as frequent (2.5%) in rural residency (I) as compared to 1.3% in the mixed residency (IV).

5.1.6 Awareness of oral health education

Among all the study populations, only about 20% of the participants (I) were aware of oral health education including oral hygiene instruction, and as for the rest, none of them was aware of oral health education (IV) or they were not asked the question (II & III).

5.2 Oral hygiene status

The occurrence of plaque, calculus and gingival bleeding among the study partici-pants is shown in Figure 5.

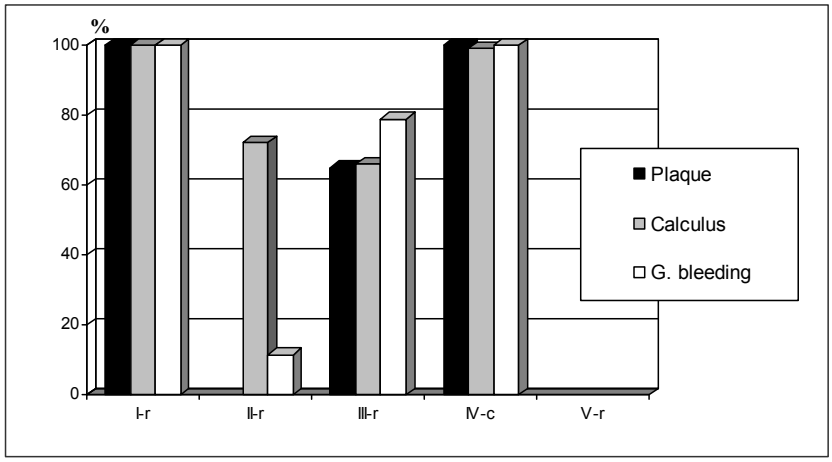

Figure 5 Occurrence of plaque, calculus and gingival bleeding among the study participants (r= random, c= convenient sample)

5.2.1 Plaque

The occurrence of microbial plaque on tooth surfaces among the studied populations (I, III & IV) was very high (65–100%), being lower (65%) in the Ilala study (III) compared to 100% in the Mtwara population-based study (I) and the Muhimbili health-facility-based women study (IV).

5.2.2 Calculus

The assessment of the presence of dental calculus as either present or absent without further categorization into supra-, sub- or both supra- and sub-gingival was also reported to be substantially high, ranging from 66–100% in all the four reports (I–IV). The occurrence of calculus among the study participants aged ≥40 years in Mtwara (I) was 100%, where 78% of all the subjects had calculus on all the six sextants examined. In the study that involved children and adults in Ukonga (II), the occurrence of calculus as the highest CPITN score on average was found in 72.2% of all study participants, while the occurrence in different age groups, for example, was 26.2% among the subjects of 3–5 years of age, among those 10–14 years of age it was 80.3%, and among those of 30–34 years of age it was 93.5%. A high occurrence of calculus was also seen in 66% of all the subjects aged 3–88 years in the Ilala study (III) while in the Muhimbili study that involved women only aged 14–44 years of age (IV), the corresponding prevalence was 99.3%.

5.2.3 Gum bleeding on toothbrushing

Gum bleeding on toothbrushing was assessed only once among women (IV) and about 31% claimed to have experienced gum bleeding during toothbrushing. As summary, tooth-cleaning practices, as well as the occurrence of plaque, calculus and gingival bleeding among the study participants are presented in Figure 6.

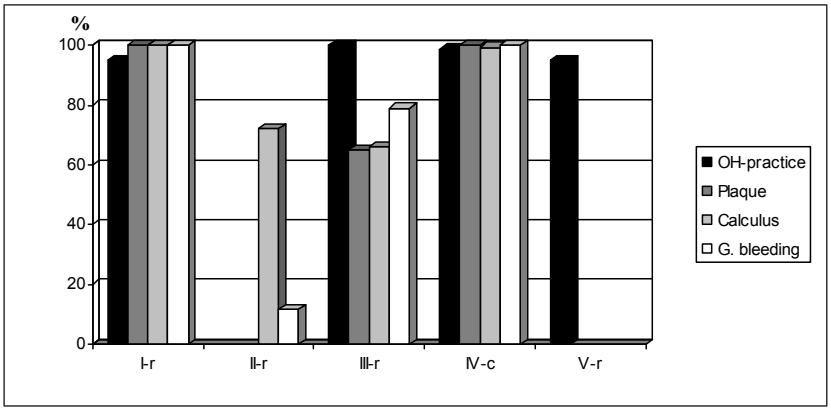

Figure 6 Oral hygiene practices and the occurrence of plaque, calculus and gingival bleeding (%) in different studies (r= random, c= convenient sample)

From the figure presented here, it can be seen that the tooth-cleaning practices and the presence of plaque and calculus were equally high.

5.3 Periodontal status

5.3.1 Healthy periodontal tissue

In the Mtwara rural study (II), more females (9%) than males (5%) aged 15 years or over had healthy periodontal sextants and did not have gingival bleeding, calculus or periodontal pockets ($p<0.05$).

5.3.2 Gingival bleeding on probing

The occurrence of gingival bleeding on gentle probing (BOP) with an estimated 20 gm force using the CPITN probe was extremely high (79–100%) in the population-based studies (I–III) and in the one health-facility-based study (IV). However, in the study that employed the CPITN index (II) the findings on gingival bleeding on probing as the highest score showed a different picture when all the subjects are taken together (11.5%). Moreover, a unique picture is portrayed when BOP is considered by age where you find that in the hierarchical scoring system, the BOP as the highest score in CPITN decreases with increasing age. For example, 31.3% had BOP as the highest score in the CPITN at the age of 5–9 years, while at the age of 15–19 years, the corresponding figure was 4.5%, at 25–29 years it was 3.6% and, at 35–44 years 1.3%. When BOP was assessed (IV) without tagging it with other indices (unlike in CPITN), the occurrence of gingival bleeding was extremely high, up to 100%. In that study (IV) gum bleeding on toothbrushing was self-reported in 30% of the study participants. In Ilala (III), the occurrence of gingival bleeding was found to be more common in males (85%) than in females (74%), ($p<0.001$). In the same study in Ilala (III), the occurrence of gingival bleeding was significantly higher among the subjects that had plaque or calculus than in those without these conditions ($p<0.001$), and higher among those who had no formal education compared to those who had formal education ($p<0.01$).

5.3.3 Periodontal pockets

The periodontal status among the study participants (I, II & III) is shown in Figure 7. In these studies, for example, the Mtwara rural study (I), where the age of the study participants was 40 years or more, the prevalence of periodontal disease as assessed mainly by probing periodontal pocket depth (PPD) was very high for both PPD 4–5 mm (82.1%) and PPD ≥6 mm (43.8%). Among the corresponding findings in similar age groups when extrapolated from the Ukonga rural study (II), the PPD 4–5 mm would not be more than 22.2%, and PPD ≥6 mm would not exceed 1.8%.

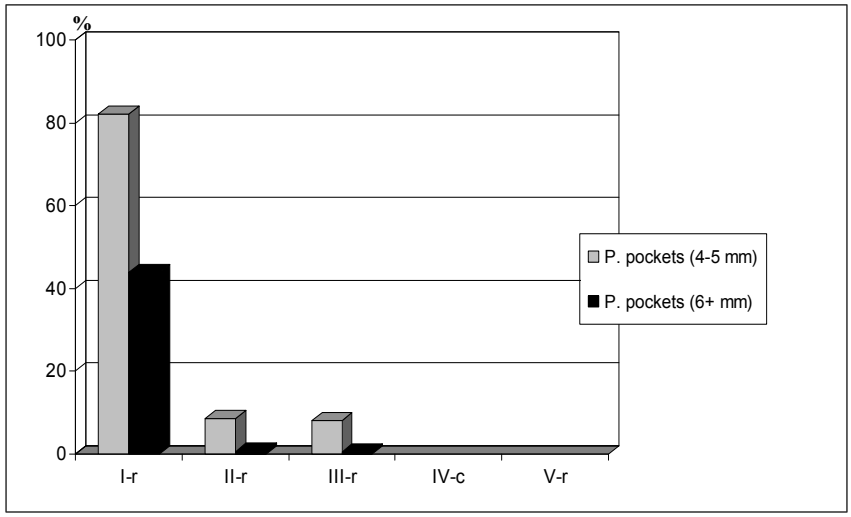

Figure 7 Occurrence of periodontal pockets (%) among the study participants in different studies (r= random, c= convenience sample)

In Ukonga rural study (II), the occurrence of PPD 4–5 mm and PPD ≥6 mm in all study participants did not exceed 8.3% and 0.6%, respectively (Table 11). In this study there were no deep gingival crevices among the child study population at 3–14 years of age. The periodontal pockets (4–5 mm) were first detected (7.6%) among the participants aged 15–19 years, and then to a lesser extent among those participants aged 25–29 years (1.8%). Among the participants in the 35–44-year age group, PPD 4–5 mm was seen in about 11%, while at 45–54 years of age the figure was 19.4% (Table 11).

Table 11 Occurrence of periodontal pockets by age groups in Ukonga, Tanzania

Age in years	No. of participants (n)	Percentage of participants with periodontal pockets as the highest CPITN score	
		4–5 mm	≥6 mm
3–4	42	–	–
5–9	160	–	–
10–14	142	–	–
15–19	66	7.6	–
20–24	49	–	–
25–29	55	1.8	–
30–34	46	4.3	–
35–44	75	10.7	–
45–54	62	19.4	–
55–64	62	27.4	1.6
65–74	58	37.9	5.2
75–88	22	13.6	4.5
All	839	8.3	0.6

Severe periodontal pockets PPD ≥6 were less common in Ukonga (II) as they were first recorded (1.6%) at 55–64 years onwards, the highest prevalence attained being 5.2% among the 55–74 years cohort. In Ilala (III), the occurrence of PPD ≥4 increased with increasing age, and it was seen that at age 10–19 years the PPD ≥4 was 4%, while at ≥45 years it was about 22%.

5.3.4 Gingival recession

The occurrence of gingival recession (GR) of 4 mm or more in the Ilala study (III) for the participants aged 35 years or over was about 54% while in the Mtwara rural study (I) a GR of 4–5 mm and ≥6 mm was found in about 82% and 44%, respectively. When women (IV) were considered separately for the occurrence of gingival recession, among the 14–44 year-olds, it was found that the prevalence of GR ≥1 mm was 33.6%. If the age-group of 30–44 years is filtered and analysed independently, the prevalence of GR ≥1 mm becomes as high as 57%. In the study population (III) the occurrence of gingival recession increased with increasing age ($p<0.001$). The occurrence of gingival recession was associated more with poor oral hygiene that was characterized by a high presence of plaque, calculus and gingival bleeding rather than the oral hygiene practices in the studied population (I, III & IV). In the Ilala study (III), gingival recession was observed more in males (16%) than in females (11%) ($p<0.01$), and also in tobacco smokers (36%) than in non-smokers (12%) ($p<0.001$). The type of gingival recession that is related to good oral hygiene practices and a good oral hygiene standard was not found in the studied population (IV).

5.4 Community periodontal treatment needs

The periodontal treatment needs were studied in only one administrative division, the Ukonga rural population (II). The needs were very high for oral health education (>90%), scaling and root planning (>80%), and extremely low for complex periodontal therapy (<1%).

5.5 Risk factors for periodontal diseases

Among the study populations, it was found that the risk factors for periodontal diseases (III) include age ≥35 years, male sex, lower education status, presence of plaque, calculus, gingival inflammation, and rural residency. These factors were also found to be possible risk factors in Mtwara (I) and Ukonga (II). Tobacco smoking (III, IV), alcohol consumption (III, IV), dental visits (III, IV), number of pregnancies or deliveries (IV) did not appear to be significant factors for the occurrence of periodontal disease. Although the type of tooth-cleaning device, either chewing stick, plastic toothbrush or both, did

not appear to be a significant factor for the occurrence of periodontal disease (III), the chewing stick was found to be highly associated with tooth loss (V).

5.6 Tooth loss

Tooth loss was a common feature in the general population-based studies (II & V) and it led to the exclusion of some sextants due to insufficient teeth for the CPITN examination. For example, in the Ukonga rural CPITN study (II) the mean number of sextants excluded in the respective age groups ranged from 0.2 of a sextant at the age of 30–34 years to 1.4 sextants at 65–74 years of age. Also tooth loss was much more evident in the health-facility-based study where some of the subjects had more than six teeth missing (IV). In the Mtwara rural study (V) the mean number of lost teeth was 8.4 ± 7.9. However, the difference in tooth loss among those who had been exposed to OHE (6.4 ± 7.9) and those who had not (8.9 ± 7.9) was not statistically significantly. Moreover, based on clinical examination, the proportion of study participants that had teeth indicated for extraction did not differ between males (53.1%) and females (46.9%), but the mean number of teeth indicated for extraction was significantly higher in females (2.9 ± 2.7) than in males (2.1 ± 2.9) ($p=0.032$). The habitual chewing-stick users had a higher mean number of teeth indicated for extraction as compared to plastic toothbrush users (V) ($p=0.036$). The mean number of lost teeth increased with the increasing age of the participants, whereby in the age group of 40–44 years the mean tooth loss was 3.6 ± 3.3, and in the age groups 55–64 years and ≥65 years of age it was 12.0 ± 9.2 and 13.3 ± 8.9, respectively (V). Tooth loss was evidently higher among habitual chewing-stick users (12.0 ± 8.4) than in plastic toothbrush users (8.7 ± 7.0) ($p=0.015$). The tooth loss was higher among those who had no formal education compared to those who had at least primary education or higher ($p<0.001$). Although there was no statistically significant difference in the mean number of teeth lost among females as compared to males, females had a significantly higher mean number of lost teeth on the lower jaw as well as on the lower left side than males did ($p=0.04$, and $p=0.008$, respectively).

6 DISCUSSION

6.1 Background

This study on the occurrence of periodontal diseases, risk factors and tooth loss was performed in Tanzanians who resided in rural and urban areas and therefore comprised rural and urban, as well as mixed populations. The study was based on data collected from five separate studies, conducted in four different places among populations of different age groups and sex at different times between 1987 and 2003, using different established methods including the basic methods for Oral Health Surveys (WHO 1987, 1997). The findings from this study collectively provide an insight into aspects of the periodontal status of Tanzanians but because of some limitations, they cannot be compared to each other and cannot be considered to represent a comprehensive epidemiological survey of periodontal diseases in Tanzania. The study was conducted in two regions of Dar es Salaam and Mtwara out of twenty-six regions in Tanzania (Figure 1). These two regions form part of the eastern coastal regions. Other regions are Tanga, Pwani and Lindi in the Tanzania mainland.

6.2 Study design

All five studies were cross-sectional and descriptive in design (I–V). The data collected from the study participants were related to the occurrence of periodontal diseases, oral hygiene practices, risk factors for periodontal diseases, periodontal treatment needs, and tooth loss. In the Mtwara study (I) which involved the collection of cross-sectional data on occurrence of periodontal diseases and oral hygiene practices of adults aged ≥40 years. The data were mainly on the presence of plaque, calculus, gingival bleeding, periodontal probing pocket depths (4–5 mm and ≥6 mm), gingival recession (4–5 mm and ≥6 mm), and tooth-cleaning devices, all of which were recorded separately to reflect the state of each condition. Since the study was not repeated at another time and nor was it duplicated in another study area, the findings cannot be compared directly with those from other studies (II–V) because each study used a different methodology. To give an example, in the study that involved periodontal treatment needs (II), the periodontal conditions were scored cross-sectionally in a hierarchical manner following the CPITN system starting with gingival bleeding, calculus, and periodontal probing pocket depths (4–5 mm and ≥6 mm). In addition, while four of the five studies were population-based cross-sectional studies that involved both males and females (I–III & V), one was a cluster study which involved women only as the study participants (IV). However, based on the aims of the study and constraints in resources, both the population-based and the cluster study approaches were considered to be useful as they provided information on the periodontal status of Tanzanians.

6.3 Sampling methods

In order to obtain representative samples, a stratified random sampling technique was applied in selecting the study participants among the targeted total population in Mtwara (I & V), Ukonga (II) and Ilala (III) areas. The administrative regions of Mtwara (I & V), and Dar es Salaam (II–IV) were initially selected for convenience. The other 21 regions in mainland Tanzania were not included. The study on periodontal status among women in the Maternity ward (IV) at the Muhimbili National Hospital in Dar es Salaam region used a convenience sample, so no inferences can be made for the general population in Tanzania. However, such studies with a convenience sampling technique may be acceptable and useful in circumstances where there is no ethical or justifided reason for a representative study. Nevertheless, it is important to take note of the limitations caused by such methods, in particular the selection bias (Fletcher et al. 1996).

6.4 Research tools

6.4.1 Questionnaires

Demographic information and some aspects of health matters, especially oral hygiene practices and other related factors were collected using the structured questionnaires by means of an interview in all studies (I–V). It is well known that the information gained through such means is valid to some extent, but has some limitations, for example, the subjects might have some difficulties in responding to some questions and this may make them respond in the way that will please the interviewer. This might be true in cases where the participants responded that they brushed their teeth three times a day, but the oral hygiene status of the same individuals was poor.

6.4.2 Clinical examination

The periodontal conditions assessed in each study were related to the key variables in the scoring criteria of the periodontal index that was used. The main variables included plaque, calculus, gingival bleeding on gentle probing, periodontal pocket probing depth, and gingival recession. Most of these variables involved probing the gingival sulcus or periodontal pocket. The probing method presents some inherent problems. In one study, full-mouth examination and recording was performed (IV), in two others it was full-mouth examination and partial recording (I & V) and in the other two partial-mouth examination and recording (II & III). In the Ukonga study, although the data were collected and recorded separately for each periodontal condition (gingival bleeding, calculus, and periodontal probing pocket depth 4–5 mm, as well as ≥6 mm), the data were thereafter converted into CPITN format in order to estimate the periodontal treatment needs for the study population and the inferred Tanzania population using an established index in

accordance to the WHO recommendation (WHO 1987). The partial-mouth recording approach has been in use for some time and evaluation reports are also available, for example, for the CPITN/CPI (Baelum et al. 1993a, Dowsett et al. 2002, Beck et al. 2006, Kingman et al. 2008). However, for periodontal studies, wherever possible, the most appropriate approach would be to use full.mouth examination and recording, as the periodontal disease is site-specific.

6.4.2.1 Conditions used to describe periodontal diseases

Most of the variables necessary to describe periodontal diseases and the predisposing factors such as plaque, calculus, gingival bleeding in a community were assessed at different times and in different groups by the different studies. However, the loss of connective tissue attachment (LA) was not included in these studies and to some extent the actual periodontal tissue damage was not fully detected, where gingival recession was prevalent, particularly in Mtwara rural (I), Ukonga rural (II), Ilala (III), and even among women the the Maternity ward (IV). In such cases, an extrapolated loss of attachment (ELA) approach has been attempted. In the "ELA" approach, for example, a tooth site that has gingival recession ≥1 mm accompanied with a probing pocket depth of ≥4 mm, was considered to have loss of attachment of ≥5 mm (Mumghamba & Manji 2007). However, instead of using an "extrapolative approach", the actual measurement of the periodontal attachment loss is considered to be of value as it also accommodates the extent and severity of the previous disease activity (Eaton et al. 2001, Susin et al. 2005).

6.4.2.2 Errors inherent in periodontal probing

Periodontal probing using different types of periodontal probes is the procedure used in the assessment of gingival bleeding on "gentle probing", periodontal pocket probing depth, and probing for the connective tissue attachment loss (Carranza & Takei 2006). Although the procedure appears to be simple, it has several complicating factors which in most cases become a source of error in the variable that is being assessed (Listgarten 1980, Grossi et al. 1996). These factors include the probing force (Mombeli et al. 1992, WHO 1997), diameter of the probe (Garnick & Silverstein 2000), probe tine (Atassi et al. 1992), angulation of the probe tine to the pocket wall (Watts 1987), and level of inflammation at the base of the pocket (Caton et al. 1981). In the present study, unfortunately there was no opportunity to use pressure sensitive probes. Although these probes are claimed to be more likely to improve the consistency of the examiners (Osborn et al. 1992), others have reported some variations (Bergenholtz et al. 2000).

6.5 Periodontal indices and partial-mouth recording

6.5.1 Community Periodontal Index of Treatment Needs (CPITN)

The Community Periodontal Index of Treatment Needs (CPITN) is one of the indices that can be used for the assessment of both the periodontal status and the treatment needs (WHO 1987). After worldwide use of CPITN in more than 100 countries, there are claims that, apart from being widely accepted, it is also effective in monitoring the magnitude, prevalence and severity of periodontal diseases globally (Pilot & Miyazaki 1994). This view is not shared by Papapanou (1996) and many others. It is significant that since 1990 no large epidemiological study in the USA or the UK has used CPITN as an epidemiological tool because of its considerable shortcomings. Its only virtue is that it is simple to use (Benigeri et al. 2000). Its limitations were clearly described by its initiators (Ainamo & Ainamo 1994) and others (Schürch et al. 1990, Holmgren & Corbett 1990, Holmgren 1994, Baelum et al. 1995). The assumption that a person having calculus will always also have gingival bleeding on probing has been disproved, as has the assumption that someone with shallow (4–5 mm) or deep (≥6 mm) PPD will also always have calculus (Takahashi et al. 1988, Grytten et al. 1989, Baelum et al. 1993b, Lewis et al. 1994). Therefore, it had been reported, for example, that CPITN/CPI scores 3 and 4 overestimate the prevalence of gingival bleeding and calculus (Grytten et al. 1989, Baelum et al. 1993a). Furthermore, the CPITN/CPI index underestimated the prevalence of deep periodontal pockets in a number of studies (Gaengler et al. 1988, Miller et al. 1990, Diamanti-Kipioti et al. 1993, Baelum et al. 1993b, Bassani et al. 2006), but overestimated the treatment needs (Lewis et al. 1994). With regard to the signs of periodontal disease, it should be pointed out that the CPITN does not assess the loss of connective tissue attachment or tooth mobility (Cutress et al. 1987), furcation involvement in multi-rooted teeth, or tooth loss. Furthermore, as unlike gingivitis and periodontitis, calculus is not in itself a disease, the score of CPITN 2 is frequently irrelevant as no one suggests that all those who have calculus present in their mouths but no gingivitis or periodontitis have any health need for it to be removed. Having realized the limitations of the CPITN, some measures taken to solve the problem were to exclude the component of "periodontal treatment needs", and therefore the scope of the index was then limited to the assessment of the periodontal disease only, the to "community periodontal index" (CPI) (WHO 1997). Furthermore, the World Health Organization had introduced in the Oral Health Surveys, Basic Methods booklet an additional index separate from CPI to assess the "loss of attachment" (WHO 1997).

6.5.2 Alternative methods for the assessment of periodontal tissue

Alternative methods to the CPITN for assessing periodontal disease have been developed with a particular modification that includes the assessment of loss of attachment and furcational involvements, for example in the Periodontal Index for Treatment (PIT) in

which calculus is not assessed (Eaton & Woodman 1989). Similarities with the CPITN include scores for healthy periodontium (PIT 0), gingival bleeding (PIT 1), but differences are the periodontal pocket probing depth 4–6 mm (PIT 2), and pocket >6 mm (PIT 3) (Eaton & Woodman 1989).

Another index is the Periodontal Screening and Recording (PSR) index which adds an asterisk to the sextant which shows the presence of furcation involvement, gingival recession and/or tooth mobility (Charles & Charles 1994). The PSR scoring criteria use the PSR periodontal probe with a 0.5 mm ball tip, 0–3.5 mm, 3.5–5.5 mm (coloured band) and the scores include: PSR Code 0: healthy gingival tissue with no gingival bleeding, no calculus and a probing periodontal pocket depth of ≤3.5 mm; PSR Code 1: minimal gingival bleeding; PSR Code 2: gingival bleeding, calculus and defective margins. The treatment includes oral hygiene instructions, removal of all plaque retentive factors and correction of the defective margins. In PSR Code 3, the probe penetrates 3.5–5.5 mm to the colour band. This indicates the need for a comprehensive periodontal examination of the affected sextants and the necessary treatment plan. In PSR Code 4, the probing depth is ≤5.5 mm, indicating the need for a comprehensive full-mouth periodontal examination and the necessary treatment plan. The asterisk Code* is added to the respective code number in the case of furcational involvement, tooth mobility, a muco-gingival problem, or gingival recession extending to the coloured band of the probe ≤3.5 (Carranza & Takei 2006). The PSR screening and recording system in clinical application is also not free of limitations (Landry & Jean 2002).

6.5.3 Partial-mouth recording

Partial recording encompasses examination and recording findings from fewer teeth and fewer surfaces than has been detected in the oral cavity. It is known that periodontal diseases affect individual teeth at different rates as the disease has a site-specific activity, whereby one or more of the periodontal site(s) may be affected, while the other sites within the same individual are never involved and that the periodontal pathogens composition differs (Socransky 1984, Mineoka et al. 2008). Therefore, the use of ten CPITN/CPI index teeth (WHO 1987, 1997), and other different partial recording protocols with a different set of index teeth to be examined, for example the Ramfjord index teeth (Dowsett et al. 2002), and a combination of different tooth surfaces (Kingman et al. 2008) mostly ends up underestimating the prevalence and severity of the disease at different levels, depending on the tooth and the site selection. However, in the present studies, for the purpose of estimating the periodontal treatment needs of the study population, it was deemed necessary to convert the raw data into CPITN format as an established index for assessing treatment needs in accordance with the WHO recommendation at the time that the first study was performed (WHO 1987).

In the current study, the partial recording used in different studies, particularly in Ukonga (II) and Ilala (III), where the examination involved the teeth used in CPITN index and the modified version in which only the buccal surfaces of maxillary teeth and the lingual surfaces of mandibular teeth were examined, probably introduced some underestimation to the occurrence and severity of periodontal diseases in the studied population. Moreover, since it appears that the periodontal diseases that affect most of the Tanzanians are of low severity and only affect a minority of the population, despite the high prevalence of plaque, calculus and gingival bleeding, the partial-mouth examination protocol leads to further underestimation of periodontal diseases in the population.

6.5.4 Periodontal disease diagnosis, classification and management

Through clinical examination of the peridontium and related structures, it has been possible to arrive at a diagnosis of some kind depending on the understanding of the natural history of periodontal diseases and its pathogenesis. With the conventional periodontal diagnostic tools, based on clinical and radiological examination using the periodontal indices that have been in use, different diagnoses such as prepubertal periodontitis, juvenile periodontitis, early onset periodontitis, adult onset periodontitis, chronic periodontitis, aggressive type of periodontitis and periodontitis associated with systemic diseases have been possible (Novak 2006). For example, in a Sri Lankan population that has never been exposed to any programmes or incidents in relation to prevention and treatment of dental diseases, three subpopulations of different susceptibility were identified based on interproximal loss of attachment and tooth mortality rates (Löe et al. 1986). The subgroups were individuals with rapid progression of periodontal disease, i.e. aggressive type of periodontitis (8%), moderate progression (81%), and a group of individuals (11%) who exhibited no progression of periodontal disease beyond gingivitis. Also, in Uganda, a study on school children showed that 28.8% had early onset periodontitis (Albandar et al. 2002). Of those in the age groups 12–16 years, 17–19 years and 20–25 years, 26.8%, 29.1% and 35.2%, respectively, had been affected by aggressive periodontitis (Albandar et al. 2002). However, with conventional diagnostic methods, it has not been possible to reliably identify the tooth sites that have ongoing periodontal destruction, the patient's susceptibility and treatment response. The current advanced diagnostic techniques, for example, in microbiological analysis, characterization of host response and radiographic assessment give a better understanding of the assessment of periodontal patients for better management of periodontal diseases and prevention (Sanz et al. 2006). Since it has been shown that not everyone with gingivitis will progress to periodontitis and that not every site with calculus has gingival bleeding, it is not justified to provide routine removal of calculus. At population level, the management of periodontal diseases may involve combating common risk factors, while at an individual level, it can take the form of clinical management of those at high risk (Axelsson et al. 2002, Baelum et al. 2007).

6.6 Reliability and validity

In the studies, a training and calibration exercise, as well as duplicate examinations during data collection, were carried out (II & III) and the results showed good agreement (gingival bleeding 51%, and periodontal pockets 91%). However, for studies I and V, the calibration and duplicate examinations results were Kappa 0.4 to 1.0, indicating that moderate to perfect agreement was not found in this study, but has been reported elsewhere (Mumghamba & Fabian 2004). The inter-examiner agreement that was recorded for studies II and III the one on periodontal pockets falls within the acceptable recommended range of 85–95% (WHO 1997). However, for gingival bleeding, the agreement was much lower than the recommended level, and this is thought to be partly caused by the differences in the pressure on probing, as well as the effect of repeated probing. It appears that further training on the calibration is necessary so adequate time must be devoted to the exercise. However, a certain level of disagreement might persist, given the fact that even when using pressure-sensitive probes, some differences have still been reported (Bergenholtz et al. 2000).

6.7 Oral hygiene practices and oral hygiene status

The practice and frequency of oral hygiene practices mostly in the form of toothbrushing as self-reported by the study participants during the face-to-face interview was found to be very high (I, III–V). Tooth cleaning is a common practice among urban and rural populations in Tanzania and the proportion of regular toothbrushing has been well over 90% and even close to 100% (Normark & Mosha 1989, Sarita & Tuominen 1992, Kikwilu et al. 2008). However, the oral hygiene status of most of the participants was very poor. This paradox was also evident in reports of other studies (Lembariti et al. 1988, Sarita & Tuominen 1992). There are reports indicating that primary school teachers preferred parents to teach their children how to do toothbrushing, and at the same time, it was found that the teachers themselves had poor knowledge of and skills in toothbrushing (Nyandindi et al. 1994). In such a situation where most of the study population also had only primary education or no formal education, then it could be expected that they would be less efficient at toothbrushing. Another approach would be needed to elucidate the real practice in daily life, either by observation or by group discussion studies. Furthermore, there is a need to reinforce the practices and to emphasize effective toothbrushing based on systematic performance with a light pressure (Wolf et al. 2004) and with a frequency of at least twice per day, for example, after breakfast and before going to bed as recommended elsewhere (Sheiham 1977). Less than one third of the rural population and more than ninety percent of the urban population used toothpaste during toothbrushing. However, depending on their availability and affordability, fluoride-containing dentifrices should be advocated for both dental caries prevention and gingivitis (Petersen 2003, Baig & He 2005, Mankodi et al. 2005, Davies 2007).

6.7.1 Oral health education and oral health promotion

In addition to the efforts to ascertain the real practice, it is also necessary to emphasize the issue of oral health education (OHE) as it was reported that only about one fifth of the rural study population (I) had heard of OHE. However, OHE alone does not guarantee change of behaviour (Croucher 1993). It is expected that oral health education is aimed at improving the performance of tooth-cleaning practices, and thus will reduce the progression of destructive periodontal disease and preserve the teeth for life (Sheiham 1979). However, there is also a need to undertake oral health promotion activities so that the people in their respective communities may empower themselves to be responsible for maintaining proper oral home care (Dickson 1993, Axelsson et al. 2002, Petersen 2004).

6.8 Tooth-cleaning devices: the plastic toothbrush and the chewing stick

The tooth-cleaning aids were mainly chewing sticks in the rural populations, while plastic toothbrushes were mostly used by the urban population; a similar trend has been reported earlier (Sarita & Tuominen 1992) in Tanzania and elsewhere (Eid & Selim 1994). Wherever appropriate, the use of a chewing stick should be promoted as it is cheap, readily available, for example, in the rural areas, and it is as effective as the conventional toothbrush (van Palenstein at al. 1992, Wu et al. 2001). Furthermore, chewing sticks have long been known to have an antibacterial effect against both periodontal pathogens and dental caries (Akpata & Akinrimisi 1977, Li et al. 1998, Cai et al. 2000, Almas & Al-Zeid 2004, Sofrata et al. 2008). However, the effective use of both tooth-cleaning devices needs to be revisited, and training undertaken with the emphasis on a "systematic tooth-cleaning" approach with a light pressure so as not to cause cervical abrasion (Wolf et al. 2004).

6.9 Gingival recession and calculus

In one of the studies (IV), gingival recession was strongly associated with calculus. Most of the study population had calculus (I–IV). Now the question is: should the participants be scheduled for scaling and root planning? Perhaps not, as this has not been a public health problem and most people retain their teeth to almost the end of their life without many problems, as reported earlier in a previous study of the Tanzanian population (Baelum & Fejerskov 1986). The same has been observed, for example, among Nigerians (Taiwo & Omokhodion 2006) and Kenyans (Manji et al. 1988). However, systematic toothbrushing should be emphasized to control the other risk factors for gingival recession, including plaque and gingival inflammation. It may be proposed, that professional periodontal care be sought, if gingival bleeding on toothbrushing does not improve after two weeks (Pattison & Pattison 2002).

6.10 Self-screening criteria for seeking periodontal care – gum bleeding on toothbrushing

Gingival bleeding on clinical gentle probing was very common in some studied populations (I, IV & V), almost 100%. In one of these studies, gum bleeding on toothbrushing was self-reported in about one third of the study participants (IV). A high level of gingival bleeding has been reported in both adult and child populations in Tanzania for many years (Nörmark & Mosha 1989, Frencken et al. 1991, Sarita & Tuominen 1992, Malisa et al. 1993, Mumghamba et al. 2006). A similar trend has been reported from other populations such as in Gambia (Adegbembo et al. 2000), in Sudan (Darout et al. 2000, in Nigeria (Savage & Arowojolu 1997), in Kenya (Kaimenyi et al. 1993), in South Africa (Chikte et al. 1990) and elsewhere (Baelum et al. 1996). It might be possible that much of this observed gingival bleeding could be controlled by instituting proper home oral care that includes systematic toothbrushing. However, if regular toothbrushing has already been established, persistent gingival bleeding during toothbrushing after, for example, two weeks, might be considered a self-assessment criterion for seeking oral health care for the population that could be provided by the established oral health services in the country. Information from Central Oral Health Unit (COHU) of the Ministry of Health in Tanzania shows that out of the ninety-four district hospitals in the Tanzania mainland, 69 of them (73.4%) were in a position to provide oral health services (Ministry of Health 2001). However, due to lack of equipment and materials in these district hospitals, the OHS may at the beginning have rely on oral health education. The use of "gum health", together with loose or mobile teeth has been considered an important condition in the self-assessment exercise in the Florida study in the United States (Gilbert & Litaker 2007).

6.11 Periodontal status: periodontal pockets

The method used to diagnose periodontal disease in these studies was probing of the periodontal pockets following the protocol recommended by the WHO (WHO 1987, 1997). The studies in Ukonga (II) and Ilala (III) involved assessment of probing pocket depth not only in adults but also among children aged 12 years or more. Usually, assessment of PPD is not recommended under 15 years of age (WHO 1987, 1997). In addition, for young people up to the age of 19 years, all second molars (17, 27, 37 and 47) are excluded in the PPD assessment to avoid inclusion of eruption gingival crevices (pseudo pockets) as real pockets (WHO 1987, 1997). However, the first encounter of PPD 4–5 mm was in the group of participants aged 15–19 years, where the prevalence was 7.6%, and PPD ≥6 mm at 55–64 years of age (1.6%) (Table 11). The relatively high prevalence of PPD 4–5 mm in the 15–19-year age group might also be partly due to the presence of pseudo pockets. In addition, the presence of real PPD 4–5 mm cannot

be ruled out in all cases as in the neighbouring country, there are reports showing an even much higher prevalence of about 29% and greater severity (Albandar et al. 2002). The results show that the occurrence of periodontal pockets, for example, among adults aged ≥35 years was high in some populations, almost as high as four in five (I), while in the other populations it was as low as one in five (II). The differences in methodology in terms of partial versus full mouth examination and recording, together with some possible intra- and inter-examiner variability might have contributed to the variations in the present study. However, the amount of variation due to real differences in the different populations studied is not known and may be assumed to be minimal. Even where it was formerly thought that there was a big difference between industrialized and non-industrializes countries in the occurrence of periodontal disease, the understanding has changed, because the Global Oral Data Bank that used CPITN worldwide has revealed that the differences are not clear (Miyazaki et al. 1991a, 1991b, Pilot et al. 1992). In addition, despite massive gingival inflammation and very poor oral hygiene, as also seen among the Kenyans, the level of loss of attachment was still quite similar to those reported among young adults in the USA, in Mexico, in Norway, in New Mexico, and in Japan, as well as in India (Baelum et al. 1996).

Despite the differences in the methodology, the low severity of periodontal disease was seen in the present study population (II & III) and also reported in other Tanzanian populations (Lembariti et al. 1988). The same has been found in countries such as Kenya (Baelum et al. 1988) and Zimbabwe, where the need for complex treatment was about 4% (Frencken et al. 1999). However, the prevalence of periodontal pockets among the studied population (I) was higher than in the other studies in Tanzania. When compared with the other African countries, the findings of this study (I) are also higher than was found in Sudan where 51% had PDD ≥4 mm (Darout et al. 2000), but lower than was reported in Sierra Leone where PPD ≥6 mm was 53% among adults (Nörmark 1991). Another factor which might have contributed to the low occurrence of periodontal diseases as diagnosed on the basis of PPD rather than loss of attachment is that a lot of gingival recession accompanied the reported periodontal pockets (Löe et al. 1992, Beck & Koch 1994, Albandar & Rams 2002). In populations where there is concomitant occurrence of periodontal pockets and gingival recession, assessment of periodontal status needs to incorporate one of the indices that assess loss of attachment (WHO 1997, Eaton et al. 2001, Susin et al. 2005).

6.12 Gingival recession

The prevalence of gingival recession in this population (I) shows some similarities with the experience of Nigerians who also used a chewing stick as a means of tooth cleaning (Arowojolu 2000). However, in the sub-group using toothbrushes, occurrence of gingival

recession (IV) appears to be higher than in Nigeria. A possible contributing factor for the differences might be the methodological differences both in GR diagnosis threshold and characteristics of the study participants (Arowojolu 2000). The risk factors for GR seen in the present study (IV) are in agreement with the other reports among Tanzanians (van Palenstein et al. 1998), and elsewhere, for example, where dental calculus was very prevalent (Joshipura et al. 1994, Albandar & Kingman 1999).

6.13 Tooth loss

Progression of severe periodontal disease to the extent that it proceeds to tooth loss was not as serious as might have been expected with very poor hygiene (I–IV). In one of the present studies (IV), use of the chewing stick was associated with greater tooth loss. The reason is not known, but it can be speculated that the chewing-stick users also had more other risk factors for tooth loss, and that the chewing stick might be a confounder (Hyman 2006, Ylöstalo & Knuuttila 2006). The greater percentage of tooth loss among Tanzanians was contributed to by dental caries rather than by periodontal disease (Baelum & Fejerskov 1986, Lembariti et al. 1988, Rambush 1991, Kida et al. 2006). Practically, many teeth, including those extracted for periodontal reasons, have been extracted in oral health care facilities rather than just falling out by themselves due to severe alveolar bone loss (van Palenstein et al. 1990, Mosha & Lema 1991, Mosha & Scheutz 1993). However, for the study participant to be able to recall that the tooth was extracted due to periodontal diseases, he/she must have experienced the tooth mobility by him/herself.

There are few published epidemiological studies that have reported on tooth mobility for population-based study samples (Sarita et al. 2003, Kida et al. 2007). However, crude tooth mobility as either present or absent might be used as important information, if the patient is asked to say whether the tooth was extracted due to advanced periodontal disease with or without dental caries, as tooth mobility, as well as tooth spacing, that have developed in adulthood are valuable practical signs of advanced periodontal disease (Grant et al. 1995). The presence of this condition, “loose or mobile tooth”, may be used to train people in self-assessment of periodontal problems (Gilbert & Litaker 2007), through well designed and validated questionnaires (Tomar 2007). At the same time, “mobile tooth” has been found to be a useful sign or symptom for patients presenting with jaw tumours in the tropics (Simon et al. 2004). The presence of periodontal diseases among Tanzanians seems to co-exist with adequate tooth retention even up to the age of 65 years, which is well above the general life expectancy in these populations (Baelum & Fejerskov 1986, Manji et al. 1988).

6.14 Risk factors for periodontal diseases

6.14.1 Common risk factors

The risk factors for periodontal disease in the study population (III) were low level of education, rural residence, plaque and calculus, and therefore these factors should be considered in the prevention of periodontal diseases. It is known that microbial plaque is the cause of gingival and periodontal diseases (Löe et al. 1965). There are also studies showing strong association between calculus and periodontal diseases (Albandar et al. 1998, Griffiths et al. 2001). The surface of calculus is always covered by viable microbial plaque with periodontal pathogens, and therefore it is considered to be a secondary etiological factor for periodontal disease (Mombeli et al. 1995, Lang et al. 2003). The proportion of study participants that exhibited these risk factors was higher in the rural than in the urban populations, and therefore population-based preventive measures (Axellson et al. 2002, Petersen 2004) should be directed to the rural population as a priority. Although tobacco smoking, alcohol consumption, and dental visits (Albander 2002, Novak & Novak 2006) have been reported as risk factors for periodontal disease in other populations, these factors did not appear to be significant for the occurrence of periodontal diseases in these baseline study populations in Tanzania. In Tanzania, tobacco smoking among males and females has been reported to be 27.0% and 5.0%, respectively (Jagoe et al. 2002). Alcohol consumption among adults at ≥15 years of age is reported to be 22.5% among males and 11.2% among females (WHO 2004). Dental visits among the study participants were mainly related to demand for pain relief rather than for dental check-ups. Such a demand has also been reported from other populations in Tanzania dental check-ups (van Palenstein et al. 1990, Kikwilu et al. 2008). In such instances, however, those who visit the oral health facility may be advised on oral health and regular dental check-ups.

6.14.2 HIV/AIDS and periodontal diseases

Another condition worthy of comment though not studied in the present research is the epidemic of HIV/AIDS and the occurrence of periodontal diseases. Studies that have been conducted in Tanzania in relation to oral manifestations of HIV/AIDS have shown that periodontal disease either in the form of necrotizing ulcerative gingivitis (NUG) or necrotizing ulcerative periodontitis (NUP), and the aggressive type of periodontitis has so far not been shown (Scheutz et al. 1997, Matee et al. 2000). It is agreed that HIV/AIDS is associated with NUG/NUP (Yin et al. 2007). Furthermore, HIV/AIDS enhances the progression of chronic adult periodontitis, and therefore it is considered to the one of the risk indicators for periodontal disease (Novac & Novac 2006). For the time being, it might be justified to say that more research is needed in this area due to the complex nature of the HIV/AIDS epidemic.

6.15 Periodontal treatment needs at a community level

The community periodontal treatment needs were assessed using the CPITN index (WHO 1987), and though they looked attractive to the professionals, the needs were far beyond their reach particularly due to constraints in resources. For this reason, the emphasis of the WHO has been on the assessment of periodontal status using CPI without treatment needs (TN) (WHO 1997). The CPITN/CPI have been used extensively globally to such an extent that it has been possible to compare the findings from different countries (Pilot & Miyazaki 1994). However, the current CPI index still bears the inherent shortcomings such as unrealistic hierarchical scoring of the periodontal conditions, in addition to the use of partial recording, where only ten CPI index teeth are considered (Baelum et al. 1993b, Diamanti-Kipioti et al. 1993). The decision to use it or not will depend on the objectives of the study which will have to weigh the benefits of the index at the cost of the information lost.

6.16 Periodontal diseases as a risk for systemic diseases and adverse pregnancy outcomes

According to some researchers (Baelum & Scheutz 2002), periodontal diseases do not pose a public health problem, at least in developing countries, including Tanzania. However, there is a concern about the risk that periodontal diseases lead to a number of systemic conditions (Klokkevold 2006, Mealey & Klokkevold 2006, Seymour et al. 2007) that include diabetes mellitus (DM) (Mealey & Rose 2008), coronary heart diseases (CHD) (Demmer & Desvarieux 2006), artherosclerosis, stroke (Scannapieco et al. 2003), preeclampsia (Conde-Agudelo et al. 2008), and adverse pregnancy outcomes such as preterm and premature infant deliveries (Goldenberg et al. 2008). In Tanzania, some of these conditions/diseases, due to their high morbidity and mortality rates, are already health problems that are of public health importance. Tanzania is among the countries with the highest maternal, perinatal and child mortality indices in the world. The maternal mortality ratio according to the Tanzania Demographic Health Survey (TDHS) 2004/05 report was 578/100,000 live births while the infant and child mortality rates during the same survey were 68/1,000 births and 112/1,000, respectively (National Bureau of Statistics 2005). Also, the non-communicable diseases such as DM, and CHD stroke which were earlier not known as problems among Tanzanians, are nowadays a matter of concern as these diseases have been reported to be increasing (Dotchin et al. 2007).

CONCLUSIONS

The oral hygiene status in this study population was very poor, and it did not match the self-reported toothbrushing practices. The majority had plaque, calculus, gingival bleeding and a moderate periodontal probing pocket depth of 4–5 mm. A minority had severe periodontal disease with a periodontal probing pocket depth of ≥6 mm, but with some geographical/population differences. Risk factors for periodontal diseases in Tanzania included age ≥35 years, male sex, low level of education, rural residence, plaque and calculus. Gingival recession, when seen in the study population, was associated with age, calculus and gingival inflammation rather than with tooth-cleaning practices. Tooth loss in general was significantly higher among those who used a chewing stick than among those using a plastic toothbrush for tooth cleaning, a matter for further research. However, for economic and accessibility reasons, for most Tanzanians, effective use of a chewing stick and systematic toothbrushing need to be promoted. Attempts to use the Community Periodontal Index of Treatment Needs for the assessment of normative periodontal treatment needs of the community resulted in estimates that were unrealistic when considering the available resources, and thus other appropriate methods which favour a whole population strategy are called for. These studies have provided an insight into the periodontal status and risk factors for periodontal diseases of selected groups of Tanzanians over a 16-year period. As such they provide valuable information to help plan a full national study, should resources be made available for such a study.

RECOMMENDATIONS

1. There is a need to reinforce the oral hygiene practices of Tanzanians and make them more effective in plaque removal using both the plastic toothbrush and the chewing stick, for example, through mass media and the health education unit of the Ministry of Health.

2. There is a need to develop a relevant "Periodontal disease diagnostic threshold" for epidemiological studies as it appears that a single pocket or two periodontal pockets raises many uncertainties about whether the subject is suffering from a periodontal disease or not.

3. There is a need to study the "self-assessment approach" to oral health to encourage self-diagnosis and raise people's awareness to seek oral health care.

4. There is a need to study the role in periodontal diseases on general health: adverse pregnancy outcomes in Tanzania. In Tanzania, the problem of infant mortality due to low birth weight, among other causes, is great. To what extent have the current prevalence and severity of periodontal diseases in Tanzania contributed directly or indirectly to the high infant mortality rate in the country?

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